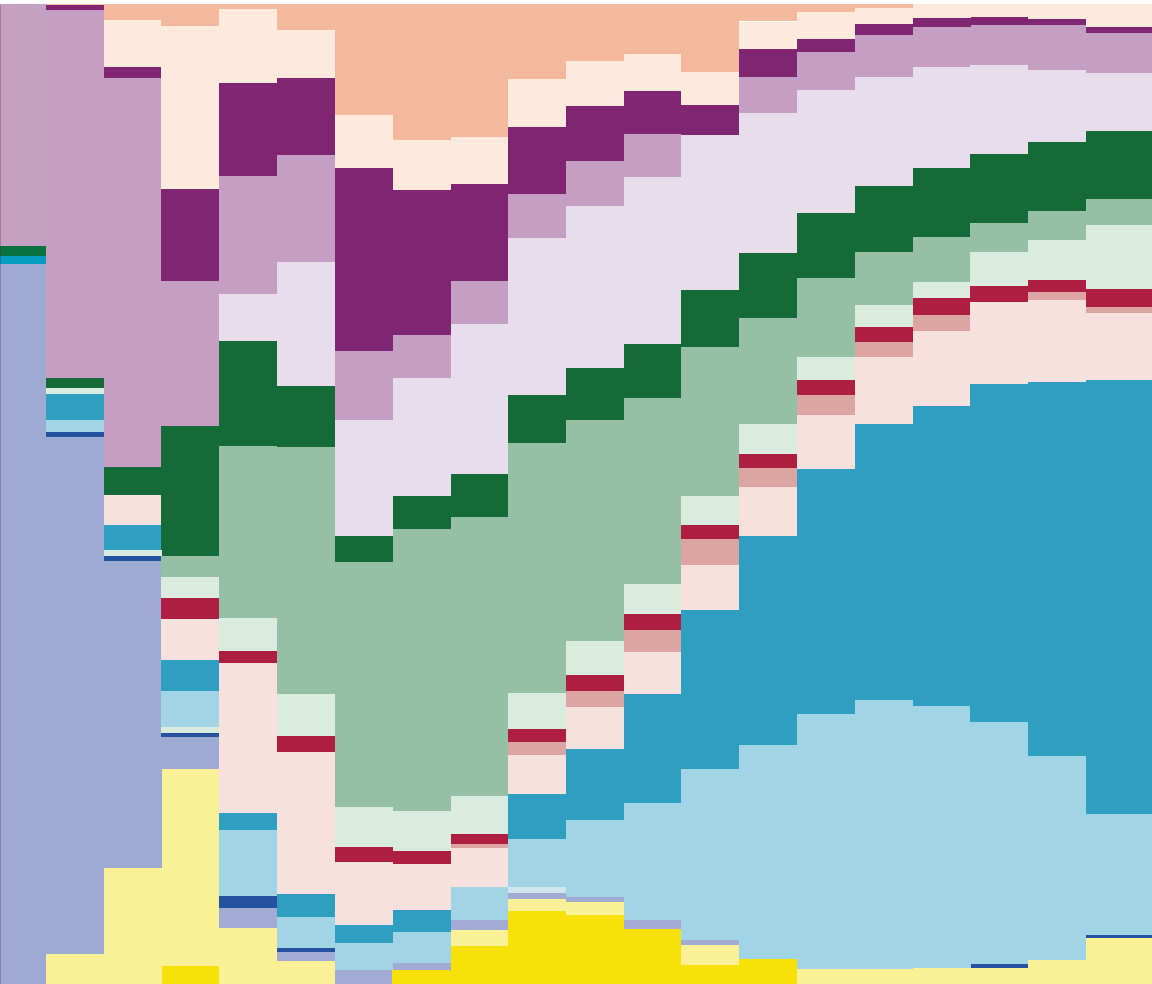
THE GLOBAL BURDEN OF DISEASE: GENERATING EVIDENCE, GUIDING POLICY

SUB-SAHARAN AFRICA REGIONAL EDITION

INSTITUTE FOR HEALTH METRICS AND EVALUATION
UNIVERSITY OF WASHINGTON

HUMAN DEVELOPMENT NETWORK
THE WORLD BANK



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This report was prepared by the Institute for Health Metrics and Evaluation (IHME) and the Human Development Network at the World Bank based on seven papers for the Global Burden of Disease Study 2010 (GBD 2010) published in *The Lancet* (2012 Dec 13; 380). GBD 2010 had 488 co-authors from 303 institutions in 50 countries. The work was made possible through core funding from the Bill & Melinda Gates Foundation. The views expressed are those of the authors.

Citation: Institute for Health Metrics and Evaluation, Human Development Network, The World Bank. *The Global Burden of Disease: Generating Evidence, Guiding Policy — Sub-Saharan Africa Regional Edition.* Seattle, WA: IHME, 2013.

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Printed in the United States of America

ISBN 978-0-9840910-7-2

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IHME GBD

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ABOUT IHME

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

To express interest in collaborating, participating in GBD training workshops, or receiving updates of GBD or copies of this publication, please contact IHME at:

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ACKNOWLEDGMENTS

The Global Burden of Disease Study 2010 (GBD 2010) was implemented as a collaboration between seven institutions: the Institute for Health Metrics and Evaluation (IHME) as the coordinating center, the University of Queensland School of Population Health, Harvard School of Public Health, the Johns Hopkins Bloomberg School of Public Health, the University of Tokyo, Imperial College London, and the World Health Organization. This summary draws on seven GBD 2010 papers published in *The Lancet* (2012 Dec 13; 380). GBD 2010 had 488 co-authors from 303 institutions in 50 countries.

IHME and the World Bank oversaw the production of this publication. In particular, we thank IHME's Board for their continued leadership. We are grateful to the report's writer, Nancy Fullman; to Christopher Murray, Michael MacIntyre, Theo Vos, Rhonda Stewart, Rafael Lozano, Mohsen Naghavi, and William Heisel at IHME, Anne-Maryse Pierre-Louis of the Human Development Network at the World Bank, and Olusoji O. Adeyi, Trina Haque, and team at the World Bank for content guidance; to Ryan Barber and Daniel Dicker for data analysis; to Brittany Wurtz and Summer Ohno for program coordination; to Brian Childress for editing; to Katherine Leach-Kemon for writing support and production management; to Rica Asuncion-Reed for editorial support; to Patricia Kiyono for publication oversight; and to Miriam Alvarado, Ian Bolliger, Roy Burstein, Emily Carnahan, Greg Freedman, Nicole Johns, Katherine Lofgren, and Richard Luning for fact checking. This report would not have been possible without the ongoing contributions of Global Burden of Disease collaborators around the world.

Finally, we would like to extend our gratitude to the Human Development Network at the World Bank for cofinancing this report, and to the Bill & Melinda Gates Foundation for generously funding IHME and for its consistent support of the Global Burden of Disease research.

GLOSSARY

Years of life lost (YLLs): Years of life lost due to premature mortality.

Years lived with disability (YLDs): Years of life lived with any short-term or long-term health loss.

Disability-adjusted life years (DALYs): The sum of years lost due to premature death (YLLs) and years lived with disability (YLDs). DALYs are also defined as years of healthy life lost.

Healthy life expectancy, or health-adjusted life expectancy (HALE): The number of years that a person at a given age can expect to live in good health, taking into account mortality and disability.

Sequelae: Consequences of diseases and injuries.

Health states: Groupings of sequelae that reflect key differences in symptoms and functioning.

Disability weights: Number on a scale from 0 to 1 that represents the severity of health loss associated with a health state.

Risk factors: Potentially modifiable causes of disease and injury.

Uncertainty intervals: A range of values that is likely to include the correct estimate of health loss for a given cause. Limited data create substantial uncertainty.

INTRODUCTION

The Global Burden of Disease (GBD) approach is a systematic, scientific effort to quantify the comparative magnitude of health loss due to diseases, injuries, and risk factors by age, sex, and geography for specific points in time. Box 1 describes the history of GBD. The latest iteration of that effort, the Global Burden of Diseases, Injuries, and Risk Factors Study 2010 (GBD 2010), was published in *The Lancet* in December 2012. The intent is to create a global public good that will be useful for informing the design of health systems and the creation of public health policy. It estimates premature death and disability due to 291 diseases and injuries, 1,160 sequelae (direct consequences of disease and injury), and 67 risk factors for 20 age groups and both sexes in 1990, 2005, and 2010. GBD 2010 produced estimates for 187 countries and 21 regions. In total, the study generated over 1 billion estimates of health outcomes.

GBD 2010 was a collaborative effort among 488 researchers from 50 countries and 303 institutions. The Institute for Health Metrics and Evaluation (IHME) acted as the coordinating center for the study. The collaboration strengthened both the data-gathering effort and the quantitative analysis by bringing together some of the foremost minds from a wide range of disciplines. Our intention is to build on this collaboration by enlarging the network in the years to come. Similarly, IHME and its collaborators hope to expand the list of diseases, injuries, and risk factors included in GBD and routinely update the GBD estimates. Continual updates will ensure that the international community can have access to high-quality estimates in the timeliest fashion. Through sound measurement, we can provide the foundational evidence that will lead to improved population health.

Over the last two decades, the global health landscape has undergone rapid transformation. People around the world are living longer than ever before, and the population is getting older. The number of people in the world is growing. Many countries have made remarkable progress in preventing child deaths. As a result, disease burden is increasingly defined by disability instead of premature mortality. The leading causes of death and disability have changed from communicable diseases in children to non-communicable diseases in adults. Eating too much has overtaken hunger as a leading risk factor for illness. While there are clear trends at the global level, there is substantial variation across regions and countries. Nowhere is this contrast more striking than in sub-Saharan Africa, where communicable, maternal, nutritional, and newborn diseases continue to dominate.

In this region, dramatic progress has been made in reducing the loss of life from many types of communicable diseases and conditions of early childhood, especially diarrheal diseases and lower respiratory infections. These diseases still account for the most health loss in the region, but their relative burdens are much lower today than 20 years ago. Deaths from measles and tetanus have also plummeted in sub-Saharan Africa since 1990. Malaria and HIV/AIDS accounted for more health loss in

2010 than in 1990, but the peak occurred for most countries between 2000 and 2005. Child mortality rates have declined for most countries, but several countries with high rates of HIV/AIDS experienced increases in childhood deaths. Mortality rates among adults in the region are more variable, with some age groups experiencing rising mortality, such as younger women of reproductive age and adult males between 25 and 39 years of age. Risk factors like childhood underweight account for far less health loss in sub-Saharan Africa today than in 1990; reductions in these risks have helped improve childhood survival throughout the region. Non-communicable diseases like stroke and diabetes are on the rise. Stroke and ischemic heart disease account for many deaths in Cape Verde, for example, while malaria and HIV/AIDS still drive much of the premature health loss in Nigeria. Nonetheless, relative to 1990, nearly every country in sub-Saharan Africa has seen improvements in their overall health outcomes, especially among children.

This publication summarizes the global GBD 2010 findings and highlights the regional findings for sub-Saharan Africa. It also explores intraregional differences in diseases, injuries, and risk factors. The overall findings for the region are summarized in the next section.

MAIN FINDINGS FOR SUB-SAHARAN AFRICA

- The sub-Saharan Africa region has made overall progress in reducing mortality and prolonging life since 1970; however, some countries showed elevated rates of death within certain age groups and for sexes, between 1990 and 2010. Mozambique, for example, has seen rising mortality rates among women aged 25 to 29.
- Over the last 20 years, the region has succeeded in decreasing premature death and disability from some communicable, newborn, nutritional, and maternal causes, especially from diarrheal diseases and lower respiratory infections. Throughout the region, deaths from measles and tetanus have substantially declined since 1990. Malaria and HIV/AIDS accounted for more health loss in 2010 than in 1990, but both diseases peaked between 2000 and 2005 in most countries.
- Although their relative burdens have declined, communicable, newborn, nutritional, and maternal causes such as diarrheal diseases, lower respiratory infections, and protein-energy malnutrition remained the top drivers of health loss in most sub-Saharan Africa countries, especially in lower-income countries like Niger and Sierra Leone.
- Between 1990 and 2010, disease burden from many non-communicable causes increased, particularly stroke, depression, diabetes, and ischemic heart disease among upper-middle-income countries in the region.
- As many countries in sub-Saharan Africa have become more developed, road injuries have taken a growing toll on human health. Many countries experienced increased levels of interpersonal violence, especially in the Democratic Republic

Box 1: History of the Global Burden of Disease and innovations in GBD 2010

The first GBD study was published as part of the *World Development Report 1993*. This original study generated estimates for 107 diseases, 483 sequelae (non-fatal health consequences), eight regions, and five age groups.

The authors' inspiration for the study came from the realization that policymakers lacked comprehensive and standardized data on diseases, injuries, and potentially preventable risk factors for decision-making. A second source of inspiration was the fact that disease-specific advocates' estimates of the number of deaths caused by their diseases of interest far exceeded the total number of global deaths in any given year. GBD authors chose to pursue a holistic approach to analyzing disease burden to produce scientifically sound estimates that were independent of the influence of advocates.

The GBD 1990 study had a profound impact on health policy as it exposed the hidden burden of mental illness around the world. It also shed light on neglected health areas such as the premature death and disability caused by road traffic injuries. Work from this study has been cited over 4,000 times since 1993.

The study also sparked substantial controversy. Many disease-specific advocates argued that the original GBD underestimated burden from the causes they cared about most. The use of age weighting and discounting also caused extensive debates. Age weighting assumed that a year of life increased in value until age 22, and then decreased steadily. Discounting counted years of healthy life saved in the present as more valuable than years of life saved in the future. Also controversial was the use of expert judgment to estimate disability weights (estimations of the severity of non-fatal conditions). As a result of this feedback and consultation with a network of philosophers, ethicists, and economists, GBD no longer uses age weighting and discounting. Also, GBD 2010 updated its methods for determining disability weights and used data gathered from thousands of respondents from different countries around the world.

GBD 2010 shares many of the founding principles of the original GBD 1990 study, such as using all available data on diseases, injuries, and risk factors; using comparable metrics to estimate the impact of death and disability on society; and ensuring that the science of disease burden estimation is not influenced by advocacy.

Despite these similarities, GBD 2010 is broader in scope and involved a larger number of collaborators than any previous GBD study. While the original study had the participation of 100 collaborators worldwide, GBD 2010 had 488 co-authors. Thanks to that network, the study includes vast amounts of data on health outcomes and risk factors. Researchers also made substantial improvements to the GBD methodology, summarized in Box 2 and described in detail in the Annex of this report and in the published studies. Among these improvements, highlights include using data collected via population surveys to estimate disability weights for the first time, greatly expanding the list of causes and risk factors analyzed in the study, detailed analysis of the effect of different components of diet on health outcomes, and reporting uncertainty intervals for all metrics. GBD 2010 researchers reported uncertainty intervals to provide full transparency about the weaknesses and strengths of the analysis. Narrow uncertainty intervals indicate that evidence is strong, while wide uncertainty intervals show that evidence is weaker.

of the Congo and Lesotho. In Somalia and Sudan, past and ongoing conflicts have resulted in higher levels of health loss due to war.

- In most of sub-Saharan Africa, a larger percentage of healthy years were lost due to disability in 2010 compared to 1990. The leading causes of disability in the region, such as depression and low back pain, were largely consistent with the leading causes at the global level; however, communicable diseases like HIV/AIDS and malaria accounted for a larger proportion of disability in sub-Saharan Africa than the world as a whole. In 2010, nutritional deficiencies, especially iron-deficiency anemia, accounted for nearly twice the health loss in sub-Saharan Africa than they did globally; this trend was primarily driven by lower-income countries and was not seen in upper-middle-income countries in the region, such as Mauritius and the Seychelles.
- Undernutrition and household air pollution were among the leading risk factors for premature death and disability in sub-Saharan Africa. In most countries, substantial progress has been made in reducing risks like childhood underweight, suboptimal breastfeeding, and vitamin deficiencies, such that their burdens have declined between 30% and 50% in the last 20 years. Nonetheless, these risk factors remain among the top three contributors to health loss throughout the region, especially among lower-income countries.
- Alcohol use, high blood pressure, and smoking were also top contributors to health loss in many countries in sub-Saharan Africa. Among upper-middle-income countries in the region, such as Gabon and South Africa, high fasting plasma glucose and high body mass index accounted for more health loss. In lower-income countries, such as the Central African Republic, childhood underweight was the primary risk factor that drove larger health burdens.

Box 2: Global Burden of Disease methodology

GBD uses thousands of data sources from around the world to estimate disease burden. As a first step, GBD researchers estimate child and adult mortality using data sources such as vital and sample registration systems, censuses, and household surveys. Years lost due to premature death from different causes are calculated using data from vital registration with medical certification of causes of death when available, and sources such as verbal autopsies in countries where medical certification of causes of death is lacking. Years lived with disability are estimated using sources such as cancer registries, data from outpatient and inpatient facilities, and direct measurements of hearing, vision, and lung function testing. Once they have estimated years lost due to premature death and years lived with disability, GBD researchers sum the two estimates to obtain disability-adjusted life years. Finally, researchers quantify the amount of premature death and disability attributable to different risk factors using data on exposure to, and the effects of, the different risk factors. For more information about the GBD methods, see the Annex of this report as well as the published papers.

THE GBD APPROACH TO TRACKING HEALTH PROGRESS AND CHALLENGES

For decision-makers striving to create evidence-based policy, the GBD approach provides numerous advantages over other epidemiological studies. These key features are further explored in this report.

A CRITICAL RESOURCE FOR INFORMED POLICYMAKING

To ensure a health system is adequately aligned to a population's true health challenges, policymakers must be able to compare the effects of different diseases that kill people prematurely and cause ill health. The original GBD study's creators developed a single measurement, disability-adjusted life years (DALYs), to quantify the number of years of life lost as a result of both premature death and disability. One DALY equals one lost year of healthy life. DALYs will be referred to by their acronym, as years of healthy life lost, and years lost due to premature death and disability throughout this publication. Decision-makers can use DALYs to quickly assess the impact caused by conditions such as cancer versus depression using a comparable metric. Considering the number of DALYs instead of causes of death alone provides a more accurate picture of the main drivers of poor health. Thanks to the use of this public health monitoring tool, GBD 2010 researchers found that in most countries as mortality declines, disability becomes increasingly important. Information about changing disease patterns is a crucial input for decision-making, as it illustrates the challenges that individuals and health care providers are facing in different countries.

In addition to comparable information about the impact of fatal and non-fatal conditions, decision-makers need comprehensive data on the causes of ill health that are most relevant to their country. The hierarchical GBD cause list, which is available on IHME's website here: http://www.ihmeuw.org/gbdcauselist, has been designed to include the diseases, injuries, and sequelae that are most relevant for public health policymaking. To create this list, researchers reviewed epidemiological and cause of death data to identify which diseases and injuries resulted in the most ill health. Inpatient and outpatient records were also reviewed to understand the conditions for which patients sought medical care. For example, researchers added chronic kidney disease to the GBD cause list after learning that this condition accounted for a large number of hospital visits and deaths.

GBD provides high-quality estimates of diseases and injuries that are more rigorous than those published by disease-specific advocates. GBD was created in part due to researchers' observation that deaths estimated by different disease-specific studies added up to more than 100% of total deaths when summed. The GBD approach ensures that deaths are counted only once. First, GBD counts the total number of deaths in a year. Next, researchers work to assign a single cause to each death using a variety of innovative methods (see Annex). Estimates of cause-specific mortality

are then compared to estimates of deaths from all causes to ensure that the cause-specific numbers do not exceed the total number of deaths in a given year. Other components of the GBD estimation process are interconnected with similar built-in safeguards, such as for the estimation of impairments that are caused by more than one disease.

Beyond providing a comparable and comprehensive picture of causes of premature death and disability, GBD also estimates the disease burden attributable to different risk factors. The GBD approach goes beyond risk-factor prevalence, such as the number of smokers or heavy drinkers in a population. With comparative risk assessment, GBD incorporates both the prevalence of a given risk factor as well as the relative harm caused by that risk factor. It counts premature death and disability attributable to high blood pressure, tobacco and alcohol use, lack of exercise, air pollution, poor diet, and other risk factors that lead to ill health.

The flexible design of the GBD machinery allows for regular updates as new data are made available and epidemiological studies are published. Similar to the way in which a policymaker uses gross domestic product data to monitor a country's economic activity, GBD can be used at the global, national, and local levels to understand health trends over time.

Policymakers in Brazil, Norway, Mexico, Colombia, Saudi Arabia, and the United Kingdom are exploring collaborations with IHME to adopt different aspects of the GBD approach. Box 3 contains decision-makers' and policy-influencers' reflections about the value of using GBD tools and results to inform policy discussions. GBD data visualization tools (see Box 4) on the IHME website allow users to interact with the results in a manner not seen in past versions of the study. Users of the visualization tools report that they provide a unique, hands-on opportunity to learn about the health problems that different countries and regions face, allowing them to explore

Box 3: Views on the value of GBD for policymaking

"While the GBD 2010 offers significant epidemiologic findings that will shape policy debates worldwide, it also limns the gaps in existing disease epidemiology knowledge and offers new ways to improve public health data collection and assessment." **Paul Farmer**, *Chair, Department of Global Health and Social Medicine, Harvard Medical School*

"If we look at sub-Saharan Africa, you've got the double burden of communicable diseases and the rising instances of non-communicable diseases. The dilemma will be how to deal with the non-communicable diseases without compromising what you've already been doing for communicable diseases." **Christine Kaseba-Sata**, *First Lady of Zambia*

"At UNICEF we've always had a focus on metrics and outcomes as a driver of the work we do. We welcome the innovation, energy, and attention that this work is bringing to the importance of holding ourselves accountable to meaningful outcomes and results." **Mickey Chopra**, *UNICEF Chief of Health/Associate Director of Programmes*

Box 4: GBD data visualization tools

For the first time in the history of GBD research, IHME has developed many free data visualization tools that allow individuals to explore health trends for different countries and regions. The visualization tools allow people to view GBD estimates through hundreds of different dimensions. Only a few examples are explored in the figures throughout this document. We encourage you to visit the IHME website to use the GBD data visualization tools and share them with others.

seemingly endless combinations of data. The following list illustrates the range of estimates that can be explored using the GBD data visualization tools:

- Changes between 1990 and 2010 in leading causes of death, premature death, disability, and DALYs as well as changes in the amount of health loss attributable to different risk factors across age groups, sexes, and locations.
- Rankings for 1990 and 2010 of the leading causes of death, premature death, disability, and DALYs attributable to risk factors across different countries and regions, age groups, and sexes.
- Changes in trends for 21 cause groups in 1990 and 2010 in different regions, sexes, and metrics of health loss.
- The percentage of deaths, premature deaths, disability, or DALYs in a country or region caused by myriad diseases and injuries for particular age groups, sexes, and time periods.
- The percentage of health loss by country or region attributable to specific risk factors by age group, sex, and time period.

In addition to promoting understanding about the major findings of GBD, these visualization tools can help government officials build support for health policy changes, allow researchers to visualize data prior to analysis, and empower teachers to illustrate key lessons of global health in their classrooms.

To use the GBD data visualization tools, visit www.ihmeuw.org/GBDcountryviz.

THE EGALITARIAN VALUES INHERENT IN GBD

When exploring the possibility of incorporating GBD measurement tools into their health information systems, policymakers should consider the egalitarian values on which this approach is founded.

The core principle at the heart of the GBD approach is that everyone should live a long life in full health. As a result, GBD researchers seek to measure the gap between this ideal and reality. Calculation of this gap requires estimation of two dif-

ferent components: years of life lost due to premature death (YLLs) and years lived with disability (YLDs).

To measure years lost to premature death, GBD researchers had to answer the question: "How long is a 'long' life?" For every death, researchers determined that the most egalitarian answer to this question was to use the highest life expectancy observed in the age group of the person who died. The Annex contains more information about the estimation of YLLs.

In order to estimate years lived with disability, or YLDs, researchers were confronted with yet another difficult question: "How do you rank the severity of different types of disability?" To determine the answer, researchers created disability weights based on individuals' perceptions of the impact on people's lives from a particular disability, everything from tooth decay to schizophrenia.

GBD REGIONAL CLASSIFICATIONS

GBD 2010 created regions based on two criteria: epidemiological similarity and geographic closeness. The GBD regional groupings differ from the World Bank regional classification system. More information about GBD regional classifications can be found on the IHME website: www.ihmeuw.org/gbdfaq.

Rather than using the GBD regional classifications, this report provides findings based on the countries in the World Bank's regional definition of sub-Saharan Africa. Unless otherwise noted, figures reflect World Bank regional classifications. GBD, however, does not produce estimates for territories or countries with fewer than 50,000 people or countries that have only recently come into existence.

RAPID HEALTH TRANSITIONS: GBD 2010 RESULTS

To help decision-makers establish health service priorities within countries when faced with limited resources, we will explore changes in disease burden around the globe, in the sub-Saharan African region, and in specific countries in this section. In another section entitled "Using GBD to assess countries' health progress," we will compare how well countries are performing in health relative to other countries in the region using a metric called age-standardized rates.

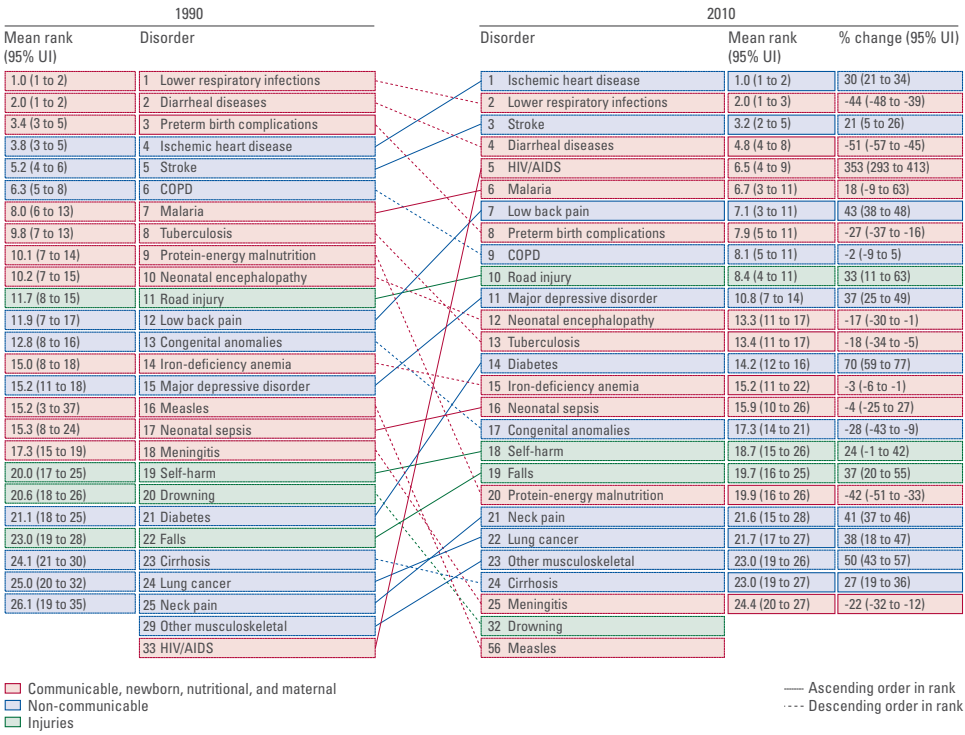
In terms of disease burden at the global level, GBD 2010 found that the leading causes of premature death and disability, or DALYs, have evolved dramatically over the past 20 years. Figure 1 shows the changes in the global leading causes of DALYs in 1990 and 2010. Communicable, newborn, maternal, and nutritional causes are shown in red, non-communicable diseases appear in blue, and injuries are shown in green. Dotted lines indicate causes that have fallen in rank during this period, while solid lines signal causes that have risen in rank.

Causes associated with ill health and death in adults, such as ischemic heart disease, stroke, and low back pain, increased in rank between 1990 and 2010, while causes that primarily affect children, such as lower respiratory infections, diarrhea, preterm birth complications, and protein-energy malnutrition, decreased in rank. Unlike most of the leading communicable causes, HIV/AIDS and malaria increased by 353% and 18%, respectively. Since 2005, however, premature mortality and disability from these two causes have begun to decline. Four main trends have driven changes in the leading causes of DALYs globally: aging populations, increases in non-communicable diseases, shifts toward disabling causes and away from fatal causes, and changes in risk factors.

To provide a closer look at the epidemiological changes occurring at the regional level, Figure 2 shows how the leading causes of premature death and disability have changed over time in sub-Saharan Africa. Figures showing changes in the leading causes of DALYs by country can be found in the Annex of this report. Figure 2 shows three of the top five causes of health loss in the region are also in the top five globally for 2010, with HIV/AIDS, lower respiratory infections, and diarrheal diseases ranking as the second, third, and fourth highest disease burdens, respectively, in the region. Malaria was the region's leading cause of DALYs in 2010; while malaria's relative burden for the region is much higher in 2010 than it was in 1990 (41%), there was a 16% decrease in DALYs caused by malaria in sub-Saharan Africa since 2005, which was the approximate peak for malaria deaths in the region. In some countries, the progress made in the fight against malaria has been steady. In Swaziland, for example, there was a 41% reduction in malaria-attributable DALYs between 2000 and 2010.

There was a drastic decline in health loss due to measles in sub-Saharan Africa, dropping an astounding 86% from 1990 (ranked fifth) to 2010 (ranked 32nd). Benin, which is considered a low-income country by the World Bank, exemplifies the region's remarkable progress against measles, achieving an 84% decline in health loss due to measles from 1990 (ranked fifth) to 2010 (ranked 21st). A similar success story is found with tetanus, with a 63% reduction in DALYs between 1990 (ranked 20th) and 2010 (ranked 43rd). While lower respiratory infections and diarrheal diseases still accounted for a substantial amount of health loss in the region, from 1990 to 2010, these diseases caused a half-million fewer deaths among children under the age of 5.

Figure 1: Global disability-adjusted life year ranks, top 25 causes, and percentage change, 1990-2010

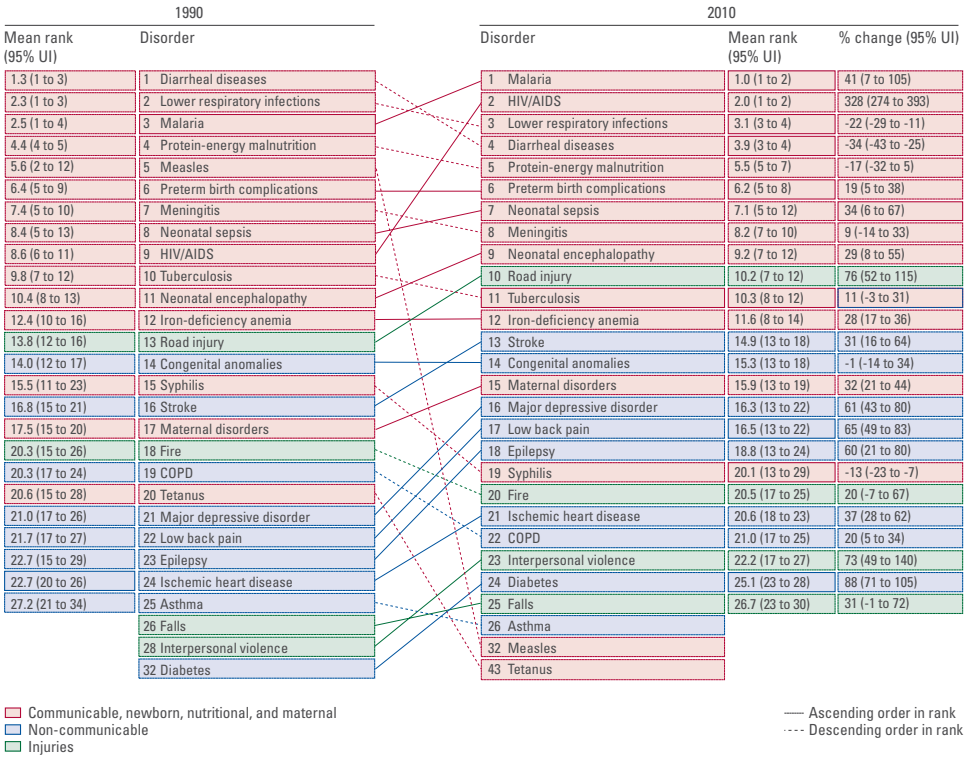


Note: Solid lines indicate a cause that has moved up in rank or stayed the same. Broken lines indicate a cause that has moved down in rank. The causes of DALYs are color coded, with blue for non-communicable diseases, green for injuries, and red for communicable, newborn, nutritional, and maternal causes of DALYs. COPD: Chronic obstructive pulmonary disease. To view an interactive version of this figure, visit IHME's website: http://ihmeuw.org/gbdarrowdiagram.

While several communicable, newborn, maternal, and nutritional causes of DALYs dropped in rank in sub-Saharan Africa, a few others, largely centered around maternal and neonatal conditions, rose in rankings. Neonatal sepsis jumped by 34%, maternal disorders increased by 32%, neonatal encephalopathy grew by 29%, and preterm birth complications climbed by 19%.

The burden associated with non-communicable diseases also rose, with diabetes, low back pain, and depression increasing by 88%, 65%, and 61%, respectively, from 1990 to 2010. This trend of heightened health loss due to non-communicable conditions is particularly striking among the upper-middle-income countries in sub-Saharan Africa; for instance, between 1990 and 2010, Namibia experienced a 123% increase in diabetes and the small island of Mauritius recorded a 186% jump in the disease.

Figure 2: Disability-adjusted life year ranks, top 25 causes, and percentage change in sub-Saharan Africa, 1990-2010

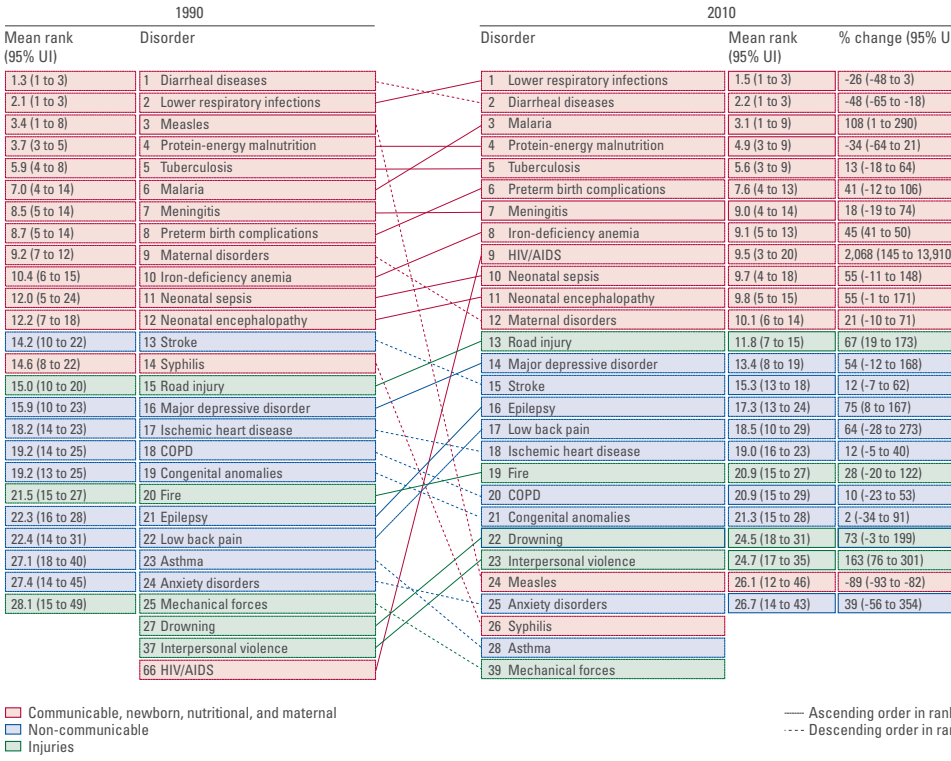


Note: Solid lines indicate a cause that has moved up in rank or stayed the same. Broken lines indicate a cause that has moved down in rank. The causes of DALYs are color coded, with blue for non-communicable diseases, green for injuries, and red for communicable, newborn, nutritional, and maternal causes.

Regionally, the health loss attributable to road injury and interpersonal violence increased by 76% and 73%, respectively, since 1990. However, these findings are far more variable across countries in sub-Saharan Africa. Congo, a lower-middle-income country in the region, reported larger increases, such that health loss from road injuries and interpersonal violence rose by 87% and 139%, respectively, between 1990 and 2010. In Cape Verde, another lower-middle-income country in sub-Saharan Africa, there was a slight increase in interpersonal violence (3%), whereas Madagascar, which is classified as low income, showed little change in road injuries between 1990 and 2010 (ranked 13th for both years, a 9% increase).

Overall, the disease burden associated with many communicable, newborn, maternal, and nutritional causes declined in sub-Saharan Africa at a similar rate to the rest of the world between 1990 and 2010; these trends hold particularly true for diarrheal

Figure 3: Disability-adjusted life year ranks, top 25 causes, and percentage change in Eritrea, 1990-2010



Note: Solid lines indicate a cause that has moved up in rank or stayed the same. Broken lines indicate a cause that has moved down in rank. The causes of DALYs are color coded, with blue for non-communicable diseases, green for injuries, and red for communicable, newborn, nutritional, and maternal causes. To view an interactive version of this figure, visit IHME's website: http://ihmeuw.org/gbdarrowdiagram.

diseases and lower respiratory infections. These conditions account for a large portion of childhood deaths and illnesses, and regional improvements in these disease areas have helped to drive down childhood mortality throughout sub-Saharan Africa.

The region experienced increases in several newborn and maternal conditions that have actually declined globally; most notably, there were increases in preterm birth complications (19%) and maternal disorders (32%), whereas health loss due to these causes dropped globally by 27% and 26%, respectively, in 2010. This trend is found across the income spectrum in sub-Saharan Africa, from upper-middle-income Gabon (with an 86% increase in maternal disorders) to low-income Chad (with a 72% increase in preterm birth complications). Non-communicable disease burdens are rising in sub-Saharan Africa at similar rates to those found globally, but unlike the rest of the world, these causes have yet to displace the persistent health loss driven by communicable conditions. This emergent "dual burden of disease" is experienced in many countries, but nowhere is it as striking as the epidemiological patterns found in the countries of sub-Saharan Africa.

Figure 3 shows changes in the leading causes of premature death and disability in Eritrea, which are consistent with regional and global trends in many ways. Eritrea has made enormous progress in reducing DALYs due to the top four ranked causes in 1990, such that health loss from diarrheal diseases (ranked first), lower respiratory infections (ranked second), measles (ranked third), and protein-energy malnutrition (ranked fourth) declined by 48%, 26%, 89%, and 34%, respectively, by 2010. Nonetheless, despite these improvements, lower respiratory infections and diarrheal diseases still accounted for the most premature death and disability in Eritrea. Overall, DALYs due to malaria and HIV/AIDS increased between 1990 and 2010; but DALYs caused by HIV/AIDS dropped by 24% between 2005 and 2010.

Mirroring regional trends, health loss due to newborn conditions and maternal causes has risen in Eritrea since 1990; for example, preterm birth complications increased by 41% and neonatal sepsis by 55%. Premature death and disability has jumped for some chronic conditions, such as depression (54% increase) and low back pain (64%), but the rise in cardiovascular diseases, like stroke and ischemic heart disease, has been much more moderate (both 12%). Akin to the rest of the sub-Saharan Africa region, health loss due to road injuries and interpersonal violence has substantially increased since 1990, by 67% and 163%, respectively. The spike in interpersonal violence is likely related to ongoing unrest within the country's borders, as well as the war with Ethiopia that ended in 2000; at this time, 48% of DALYs and 52% of all deaths in Eritrea were caused by war and disaster.

MOST OF THE WORLD'S POPULATION IS LIVING LONGER AND DYING AT LOWER RATES

In much of the world, GBD 2010 found that people are living to older ages than ever before, and the entire population is getting older. Since 1970, the average age of death has increased by 20 years globally. During this period in Asia, Latin America, and the Middle East, the average age of death increased by 30 years or more. Sub-Saharan Africa, however, has not made nearly as much progress as other developing regions, and people in this part of the world tend to die at much younger ages than in any other region. Progress in the region has been held back by the HIV/AIDS epidemic, maternal deaths, and child mortality caused by infectious diseases and malnutrition, but some of these trends have begun to improve in the past decade.

Overall, sub-Saharan Africa has made moderate progress in increasing its average age at death between 1970 and 2010 (Figure 4), achieving an average gain of about 11 years in each country. However, great variation exists within the region, with Cape Verde leading the greatest gain (about 28 years) and Chad documenting the smallest improvement (about 1.4 years). Income categorization does not appear to be a major driving force behind these differences, as upper-middle-income and lower-middle-income countries had gains averaging 9 years and 12 years, respectively, and the average gain in low-income countries in the region was about 10 years.

Figure 4: Average age of death for countries in sub-Saharan Africa, 1970 compared with 2010

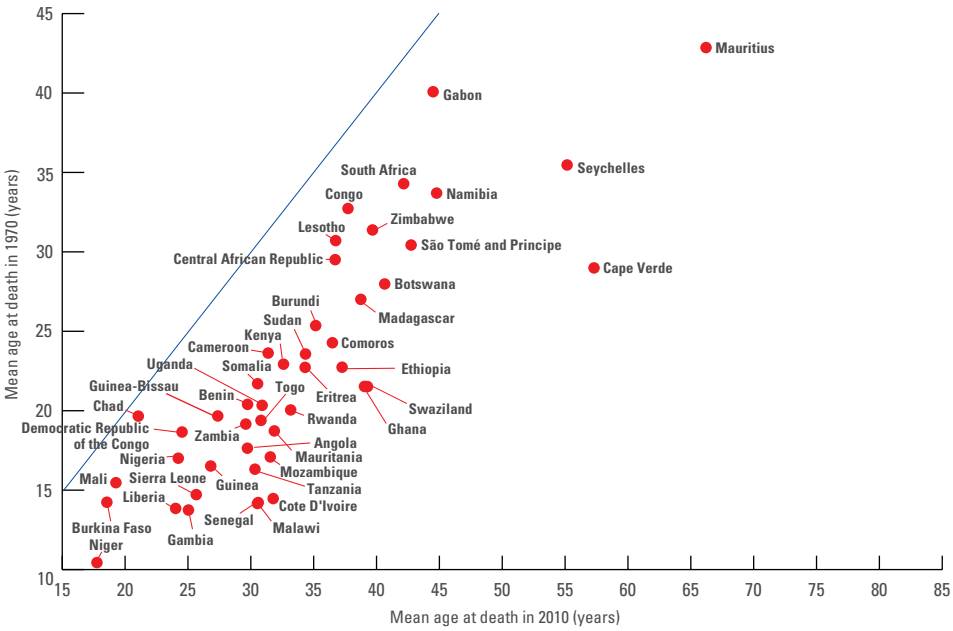
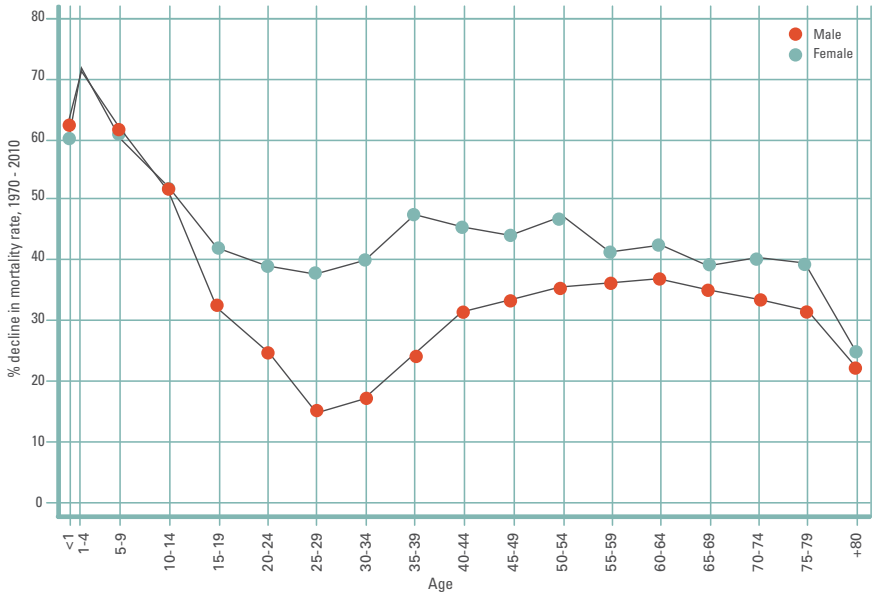


Figure 5: Global decline in age-specific mortality rate, 1970-2010



Note: Higher values indicate greater declines in mortality; lower values indicate smaller declines in mortality.

Figure 6: Decline in age-specific mortality rate in sub-Saharan Africa, 1970-2010

Note: Higher values indicate greater declines in mortality; lower values indicate smaller declines in mortality. Points below zero indicate an increase in mortality.

Another way to understand changes in global demographic trends is to explore reductions in mortality rates by sex and age group. Figure 5 shows how global death rates have declined in all age groups between 1970 and 2010. These changes have been most dramatic among males and females aged 0 to 9 years, whose death rates have dropped over 60% since 1970. Among age groups 15 and older, the decrease in female death rates since 1970 has been greater than the drop in male death rates. The gap in progress between men and women was largest between the ages of 15 to 54, most likely due to the persistence of higher mortality from injuries, as well as alcohol and tobacco use, among men.

Figure 6 depicts the same age-specific mortality trends in sub-Saharan Africa from 1970 to 2010. The largest improvements in mortality rates are seen among both males and females between the ages of 1 and 4 years, with death rates declining 65% since 1970. Mortality rates for all other age groups below 14 years old, for both sexes, decreased by at least 40% since 1970. These trends reflect the enormous progress that many countries have made in reducing early childhood deaths from communicable conditions like diarrheal diseases, lower respiratory infections, and measles.

In contrast with global trends, mortality rates for both men and women between the ages of 20 and 39 were higher in 2010 compared to 1970. There are distinct gender divides in two age groups: women between 20 and 24 experienced a more pronounced increase in mortality (18%) than men (5%); and men between 35 and 39 experienced a substantially larger increase in mortality (34%) than women (6%). Overall increases in mortality among these age groups are at least partially attributable to the region's HIV/AIDS burden, which was not a concern in 1970. Gender variations are most likely related to increases in maternal disorders since 1990, which correspond with higher rates of mortality among younger women of reproductive age, as well as heightened deaths caused by road injury for males.

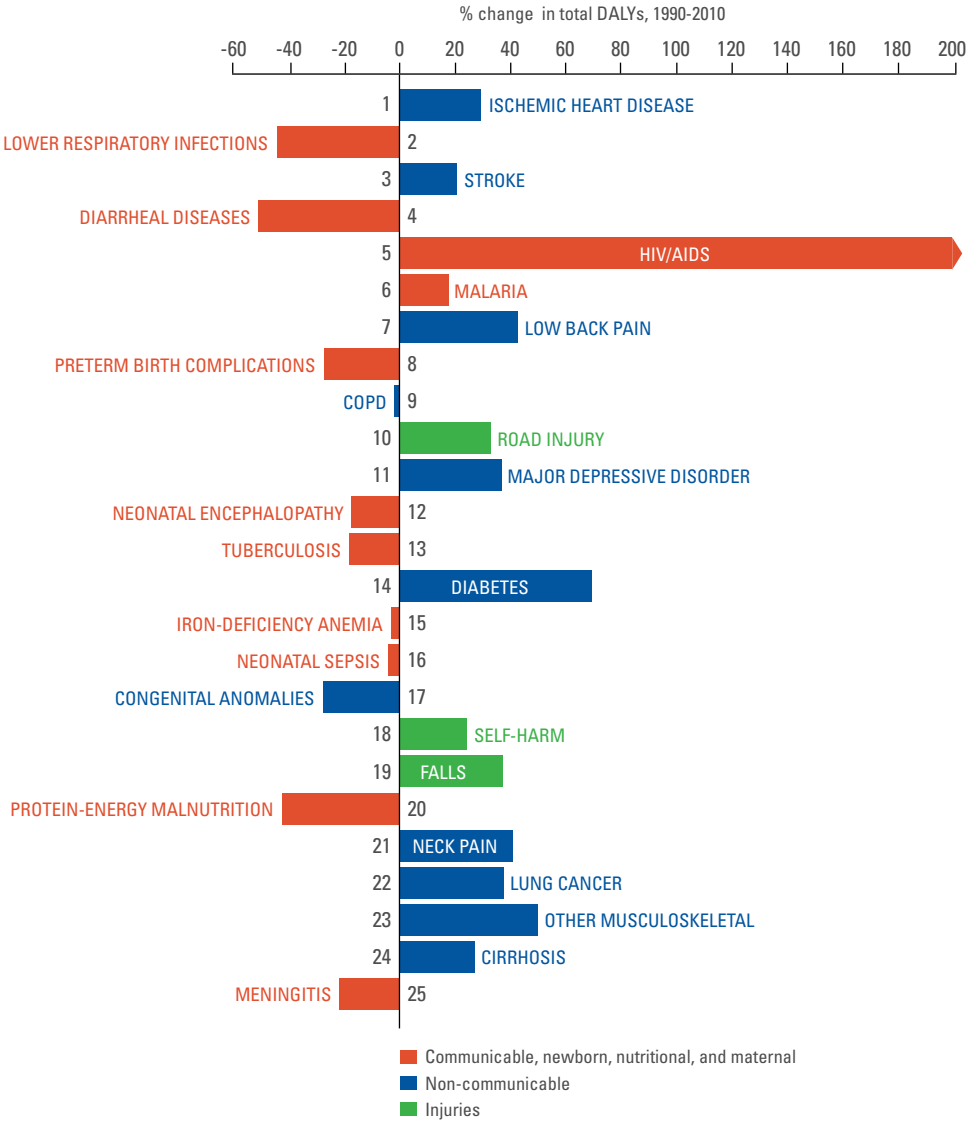
LEADING CAUSES OF DEATH ARE SHIFTING TO NON-COMMUNICABLE DISEASES

In part because many people are living longer lives and the population is growing older, the leading causes of death have changed. Worldwide, the number of people dying from non-communicable diseases, such as ischemic heart disease and diabetes, has grown by 30% since 1990. To a lesser extent, overall population growth also contributed to this increase in deaths from non-communicable diseases.

The rise in the total number of deaths from non-communicable diseases has increased the number of healthy years lost, or DALYs, from these conditions. Figure 7 shows global changes in the 25 leading causes of DALYs between 1990 and 2010 ordered from highest to lowest ranking cause from top to bottom.

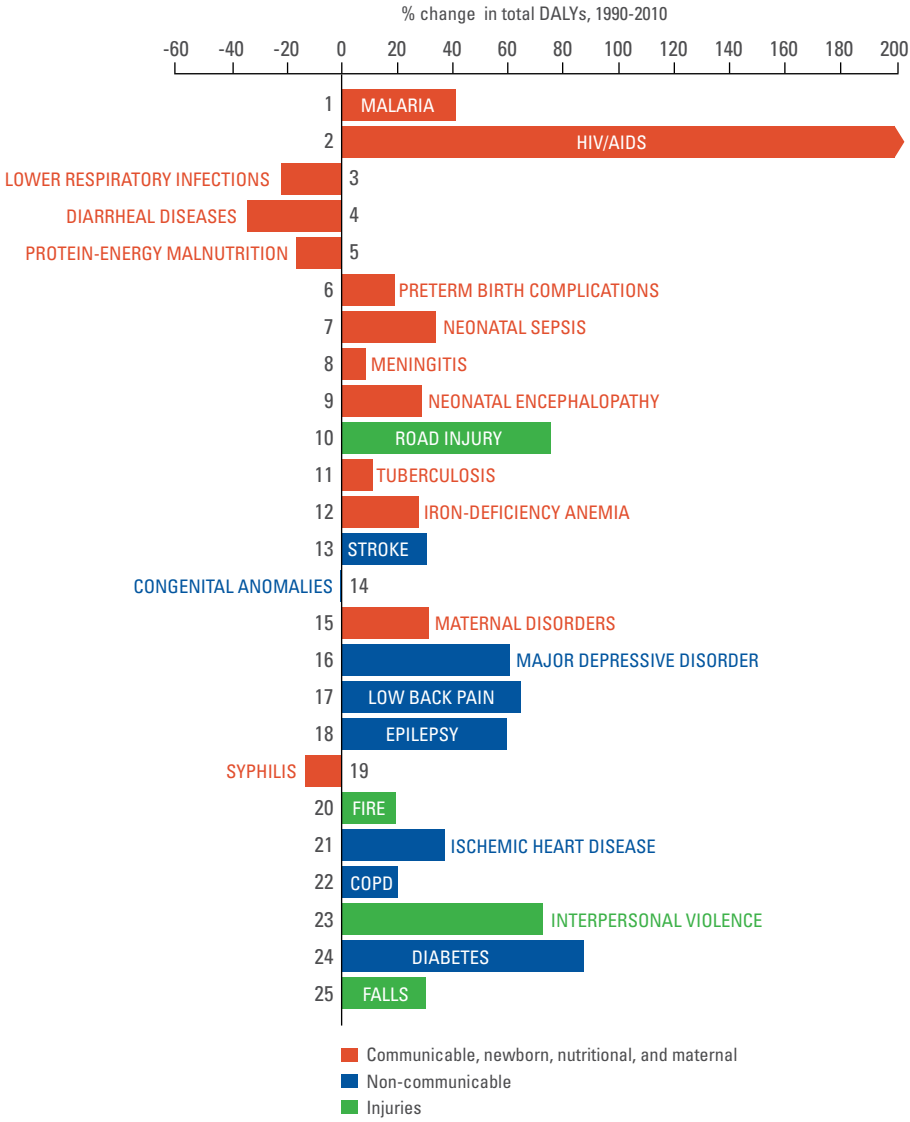
Figure 7 shows that among non-communicable diseases, diabetes as well as low back pain and other types of musculoskeletal disorders increased the most between 1990 and 2010.

Figure 7: Global shifts in leading causes of DALYs, 1990-2010



Note: The leading 25 causes of DALYs are ranked from top to bottom in order of the number of DALYs they contributed in 2010. Bars to the right of the vertical line show the percent by which DALYs have increased since 1990. Bars on the left show the percent by which DALYs have decreased. Pointed arrows indicate causes that have increased by a greater amount than shown on the x-axis.

Figure 8: Shifts in leading causes of DALYs in sub-Saharan Africa, 1990-2010



Note: The leading 25 causes of DALYs are ranked from top to bottom in order of the number of DALYs they contributed in 2010. Bars to the right of the vertical line show the percent by which DALYs have increased since 1990. Bars on the left show the percent by which DALYs have decreased. Pointed arrows indicate causes that have increased by a greater amount than shown on the x-axis.

Changes in the 25 leading causes of DALYs in sub-Saharan Africa from 1990 to 2010 are depicted in Figure 8. In the region, substantial progress has been made against many communicable and childhood conditions, as evidenced by the declines in diarrheal diseases, lower respiratory infections, and protein-energy malnutrition (34%, 22%, and 16%, respectively). Malaria and HIV/AIDS increased steadily between 1990 and 2010, demonstrating that regional improvements in communicable diseases are not always uniform. Non-communicable diseases like diabetes and depression have become greater contributors to overall regional health burdens, increasing by 88% and 61%, respectively, but relative to the health loss associated with persisting – and still rising – early childhood conditions like neonatal sepsis and encephalopathy, these more chronic ailments accounted for far less premature death and disability in sub-Saharan Africa. Exceptions include some upper-middle-income island countries, like the Seychelles and Mauritius, where non-communicable diseases have consistently accounted for the majority of DALYs for the last 20 years.

Since 1990, health loss due to road injuries and interpersonal violence has increased in sub-Saharan Africa, 76% and 73%, respectively, whereas premature death and disability from war has substantially declined (94%). These injury trends are typified by Rwanda, where the collective violence associated with the country's civil war during the 1990s declined by 93% by 2010 while interpersonal violence increased sharply during the same two decades (223%).

In many countries, non-communicable diseases accounted for the majority of DALYs. Figure 9 shows the percent of healthy years lost from this disease group by country in 2010. In most countries outside of sub-Saharan Africa, non-communicable diseases caused 50% or more of all healthy years lost, or DALYs. In Australia, Japan, and richer countries in Western Europe and North America, the percentage was greater than 80%.

Across sub-Saharan Africa, fewer than 25% of all DALYs in 2010 were caused by non-communicable diseases; this percentage has increased by just under 20% since 1990. Within the region, substantial variation exists for 2010, ranging from 37% of DALYs attributable to non-communicable conditions in Botswana to about 18% in Niger.

An in-depth look at the country-level data reveals the specific diseases driving some of these shifts, especially the emerging dual burden of disease in many sub-Saharan African countries. As an example, Figure 10 displays the changes in the top 20 causes of DALYs in Ghanaian females between 1990 and 2010. The top causes are organized by ranking from top to bottom. Nearly all non-communicable diseases rose over time, while only a few communicable diseases declined in overall burden. Among these communicable, nutritional, newborn, and maternal conditions, diarrheal diseases and lower respiratory infections experienced the most dramatic declines, falling by 69% and 27%, respectively. Among the fastest growing burdens in 2010, HIV/AIDS increased the most (188%), followed by road injury and ischemic heart disease, which grew 122% and 72%, respectively.

Figure 9: Percent of global DALYs due to non-communicable diseases, 2010

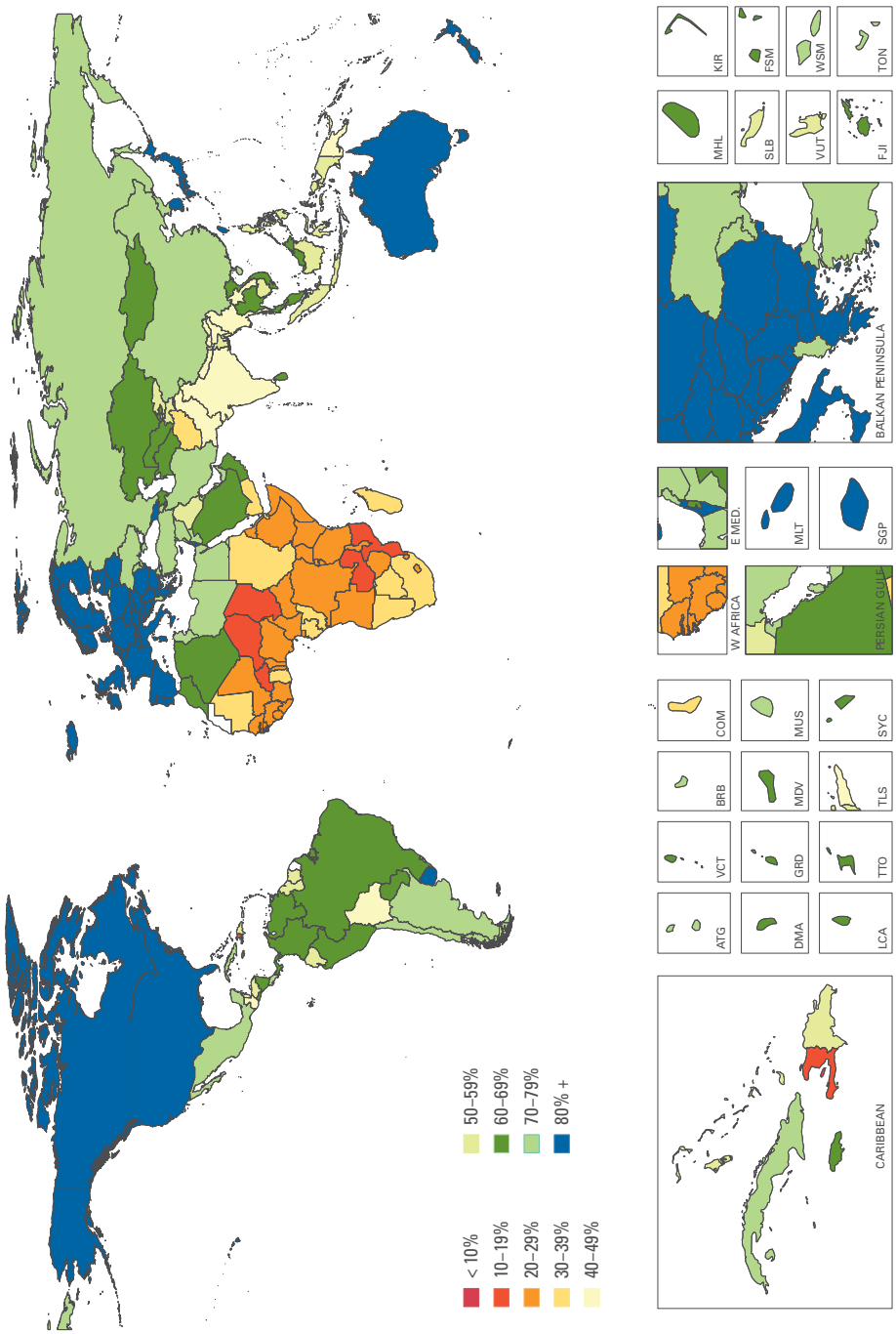
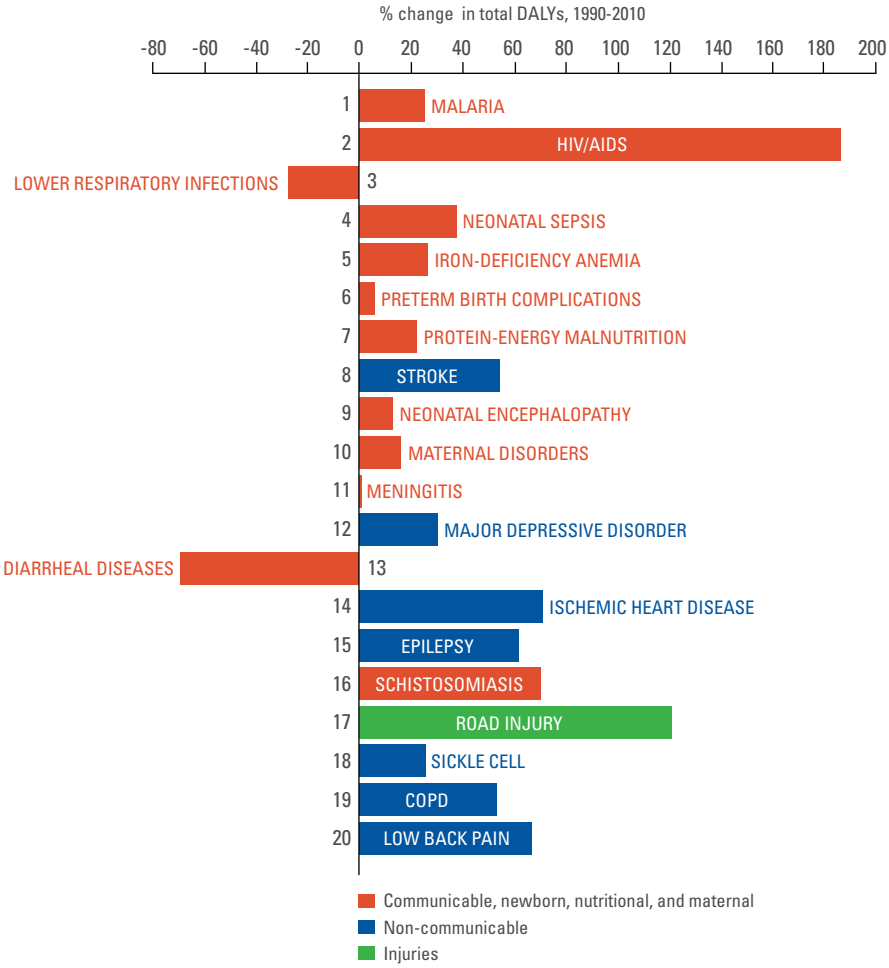


Figure 11 similarly shows declines in DALYs among Ghanaian males of a few communicable, nutritional, and newborn conditions coupled with universal increases in non-communicable diseases and injuries between 1990 and 2010. The greatest improvements were seen for diarrheal diseases and lower respiratory infections, with declines of 61% and 27%, respectively, from 1990 to 2010. Out of all the non-communicable diseases shown in this figure, cirrhosis increased the most over the period (232%). Other leading causes of DALYs increased dramatically; ischemic heart disease increased by 130%, diabetes grew by 110%, and stroke by 100%. In addition to displaying the rising prominence of non-communicable diseases, this visualization shows that injuries were among the most dominant causes of health

Figure 10: Shifts in leading causes of DALYs for females, Ghana, 1990-2010

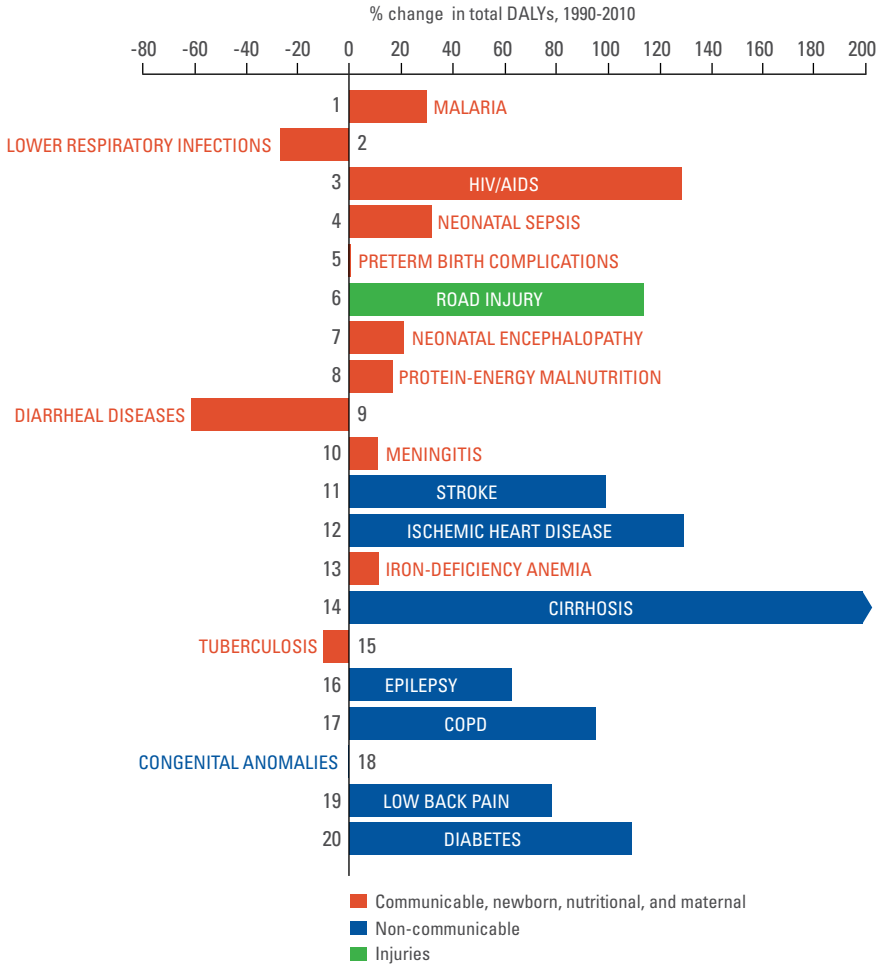


Note: The leading 20 causes of DALYs are ranked from top to bottom in order of the number of DALYs they contributed in 2010. Bars to the right of the vertical line show the percent by which DALYs have increased since 1990. Bars on the left show the percent by which DALYs have decreased.

loss in men in Ghana. DALYs caused by road injuries increased by 115% and was ranked sixth highest in 2010.

Another visualization tool, GBD Compare, displays proportional changes in disease patterns over time using a treemap diagram, which is essentially a square pie chart. Causes of DALYs, or numbers of healthy years lost, are shown in boxes. The size of each box represents the percentage of total DALYs due to a specific cause. Figure 12a and 12b show how DALYs changed in Tanzania between 1990 and 2010. In 1990, non-communicable diseases accounted for 16% of DALYs in both sexes, while communicable, nutritional, maternal, and newborn causes accounted for

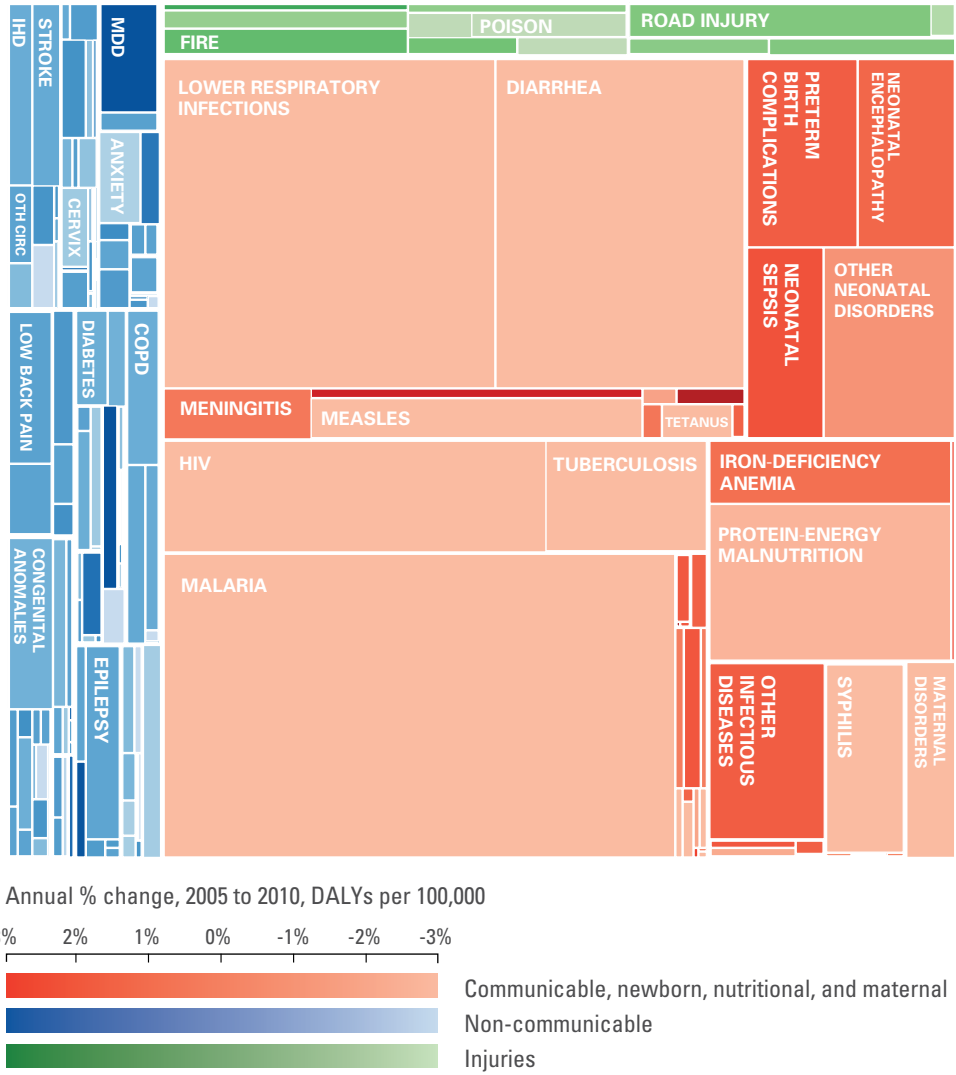
Figure 11: Shifts in leading causes of DALYs for males, Ghana, 1990-2010



Note: The leading 20 causes of DALYs are ranked from top to bottom in order of the number of DALYs they contributed in 2010. Bars to the right of the vertical line show the percent by which DALYs have increased since 1990. Bars on the left show the percent by which DALYs have decreased. Pointed arrows indicate causes that have increased by a greater amount than shown on the x-axis. Congenital anomalies decreased by 0.1% between 1990 and 2010.

78%. By 2010, they represented 23% and 70% of total disease burden, respectively. Health loss from injuries slightly increased between 1990 and 2010, from 6% to 7%. Premature death and disability from several communicable, nutritional, maternal, and newborn causes decreased during this period, with large declines found for measles (88%), diarrheal diseases (56%), lower respiratory infections (33%), protein-energy malnutrition (35%), and malaria (28%). However, health loss from HIV/AIDS, maternal disorders, and neonatal encephalopathy increased markedly, nearly 293%, 89%, and 74%, respectively.

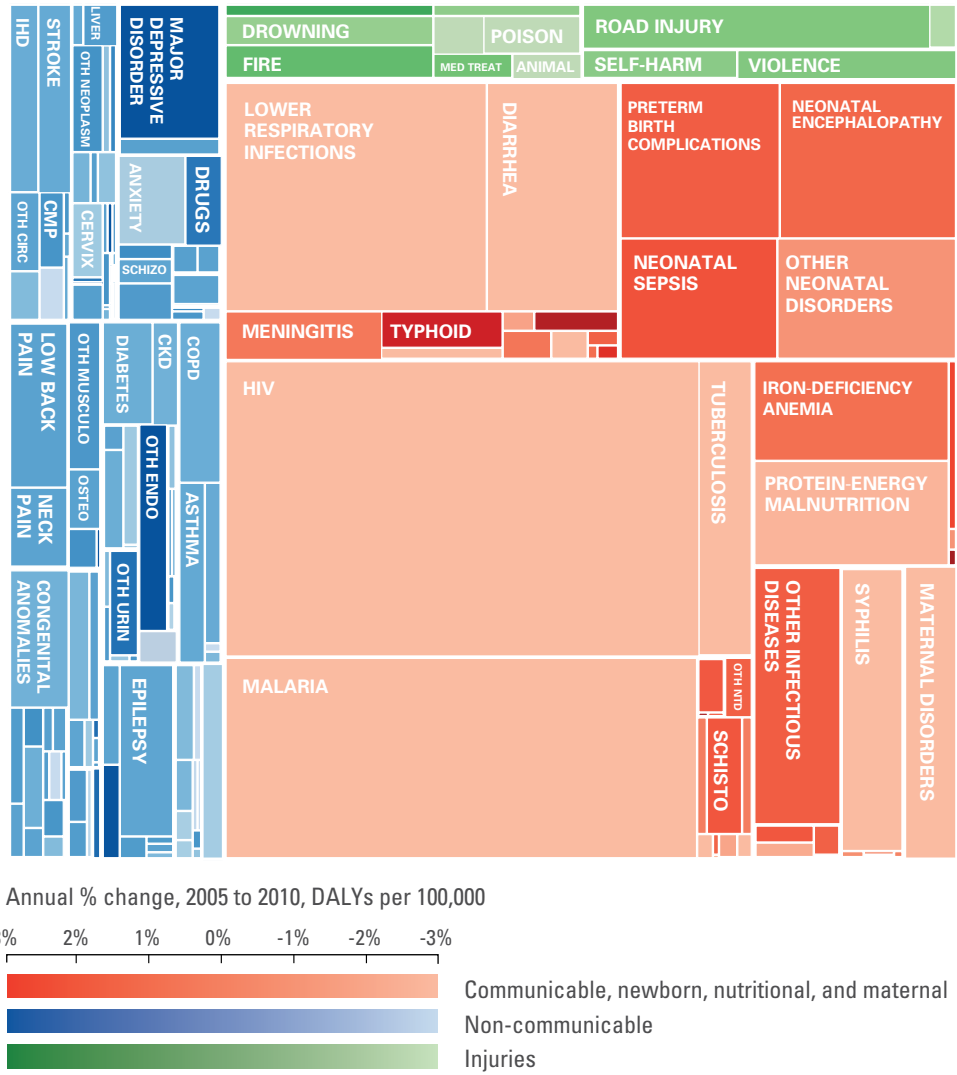
Figure 12a: Causes of DALYs, both sexes, all ages, Tanzania, 1990



Note: The size of each box in this square pie chart represents the percentage of total DALYs caused by a particular disease or injury. To view an interactive version of this figure, visit IHME's website: http://ihmeuw.org/gbdcompare.

DALYs from many non-communicable causes rose considerably from 1990 to 2010. Sharp increases occurred in causes such as major depressive disorder (154% increase), anxiety disorders (95% increase), and diabetes (102% increase). In 2010, major depressive disorders caused nearly 482,344 lost years of healthy life, or DALYs, the largest number of any non-communicable cause in Tanzania. In addition to rising non-communicable disease burdens, injury-related health loss also rose dramatically from 1990 to 2010, with a 122% jump in interpersonal violence, a 109% increase in self-harm, and an 81% rise in road injuries.

Figure 12b: Causes of DALYs, both sexes, all ages, Tanzania, 2010



Note: The size of each box in this square pie chart represents the percentage of total DALYs caused by a particular disease or injury. To view an interactive version of this figure, visit IHME's website: http://ihmeuw.org/gbdcompare.

DISABILITY INCREASES IN MIDDLE- AND HIGH-INCOME COUNTRIES

Most countries in the world have succeeded in reducing deaths early in life. To a growing extent, longer lives are redefining "old age" in many countries, and people in all age groups are dying at lower rates than in the past. Simply living longer does not mean that people are healthier. Little progress has been made in reducing the prevalence of disability, so people are living to an older age but experiencing more ill health. Many people suffer from different forms of disability throughout their lives, such as mental and behavioral health problems starting in their teens, and musculoskeletal disorders beginning in middle age. These findings have far-reaching implications for health systems.

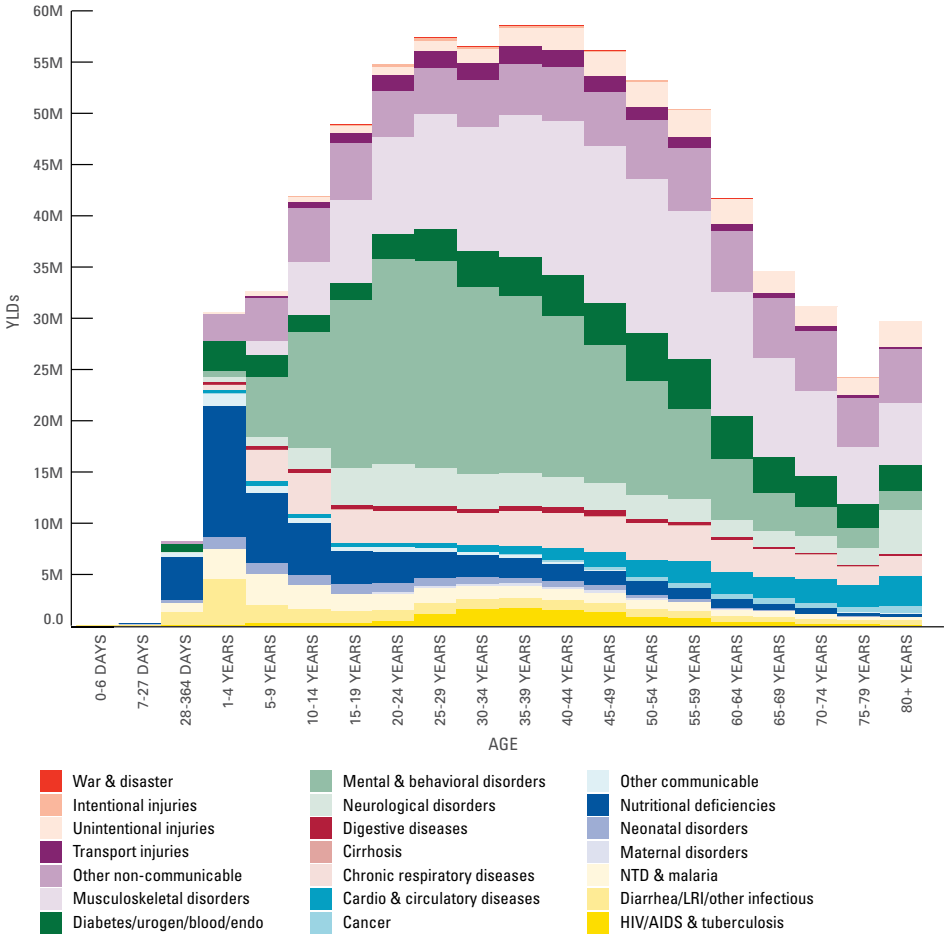
DALYs, or healthy years lost, are calculated by adding together years lived with disability (YLDs) and years of life lost (YLLs), also known as years lost to premature death. Between 1990 and 2010, YLDs increased as a percentage of total DALYs in all areas of the world except Eastern Europe, southern sub-Saharan Africa, and the Caribbean. This disability transition has been most dramatic in parts of Latin America, the Middle East, North Africa, and many areas in Asia. The percentage burden from YLDs also increased in sub-Saharan Africa with the exception of the southern part of the region.

Figure 13 tells a detailed story about the different conditions that cause disability globally. It is important to keep in mind that these estimates reflect both how many individuals suffer from a particular condition as well as the severity of that condition. Mental and behavioral disorders, such as depression, anxiety, and drug use, were the primary drivers of disability worldwide and caused over 40 million years of disability in 20- to 29-year-olds. Musculoskeletal conditions, which include low back pain and neck pain, accounted for the next largest number of years lived with disability. People aged 45 to 54 were most impacted by these conditions, as musculoskeletal disorders caused over 30 million years of disability in each of these age groups.

Figure 14 shows trends in disability by age group in 2010 for the sub-Saharan Africa region. Some trends are similar to those seen worldwide. For example, the dominant cause of disability between the ages of 0 to 9 were nutritional deficiencies, and the leading cause of disability among populations aged 10 to 44 years were mental and behavioral disorders. Beyond the age of 45, musculoskeletal disorders became the largest drivers of disability in sub-Saharan Africa, which was similar to global trends.

However, sub-Saharan Africa features disability patterns that diverge from global trends. In contrast to the world as a whole, the greatest disability was experienced among younger age groups (1 to 4 years and 10 to 14 years) in sub-Saharan Africa. At the global level, those aged 35 to 44 had the largest number of years lost due to disability.

Figure 13: Global disability patterns by broad cause group and age, 2010

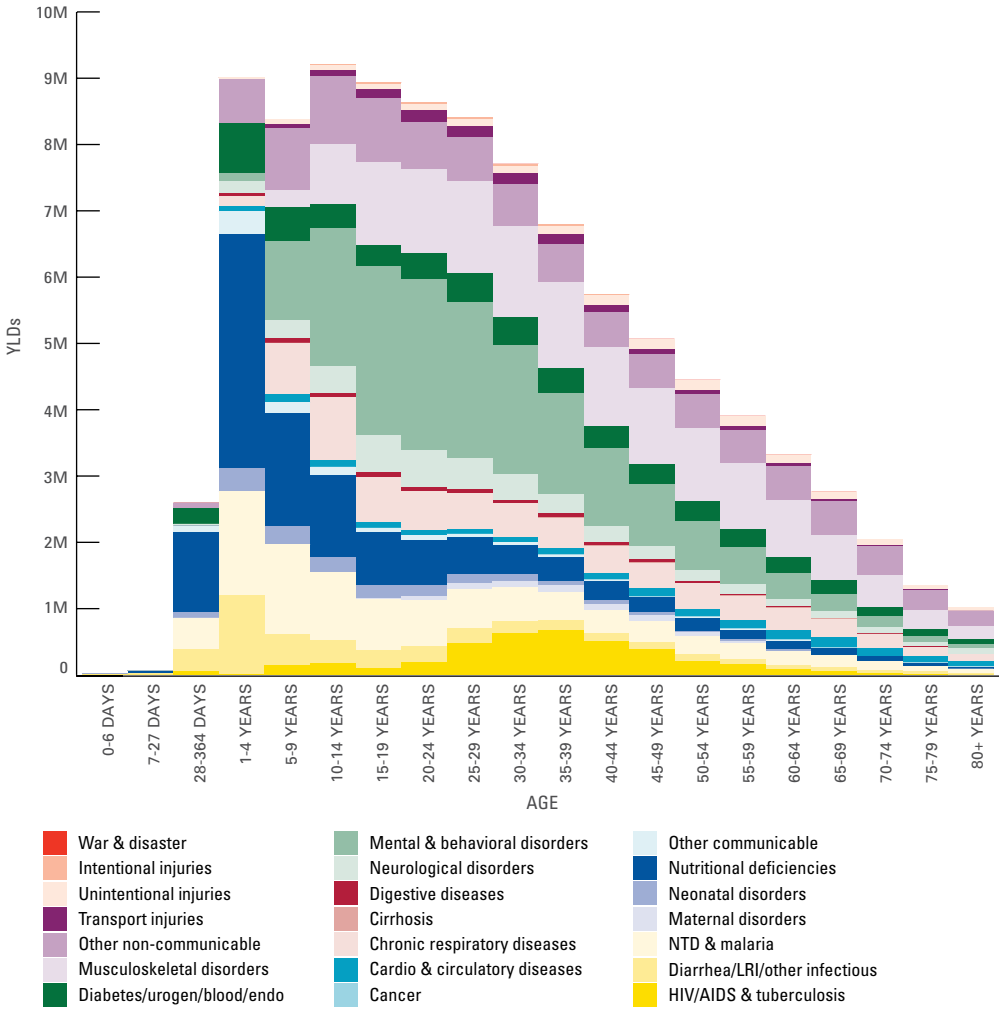


Note: The size of the colored portion in each bar represents the number of YLDs attributable to each cause for a given age group. The height of each bar shows total YLDs for a given age group in 2010. The causes are aggregated. For example, musculoskeletal disorders include low back pain and neck pain. To view an interactive version of this figure, visit IHME's website: http://ihmeuw.org/gbdcausepattern.

Another way to view the world's health challenges is by comparing how different conditions rank. Figure 15 ranks the leading causes of disability globally and in each of the six World Bank regions, using color coding to indicate how high a condition ranks in a region. Depression was a major cause of disability across regions and was one of the top three causes of disability in every region. This disorder can cause fatigue, decreased ability to work or attend school, and suicide. Anxiety, a different type of mental disorder, was one of the top 10 causes of disability across all regions. Additionally, two other mental disorders, schizophrenia and bipolar disorder, appeared among the top 20 causes of disability in most regions.

Low back pain causes the most disability in East Asia and the Pacific, Europe and Central Asia, and in the Middle East and North Africa. It ranked second in South Asia and Latin America and the Caribbean and third in sub-Saharan Africa. This condition can inhibit people's ability to perform different types of work both inside and outside the home and impair their mobility. In addition to low back pain, neck pain and other musculoskeletal disorders ranked in the top 10 causes of disability across all World Bank regions. Another musculoskeletal disorder, osteoarthritis, appeared in the top 20 causes of disability in every region.

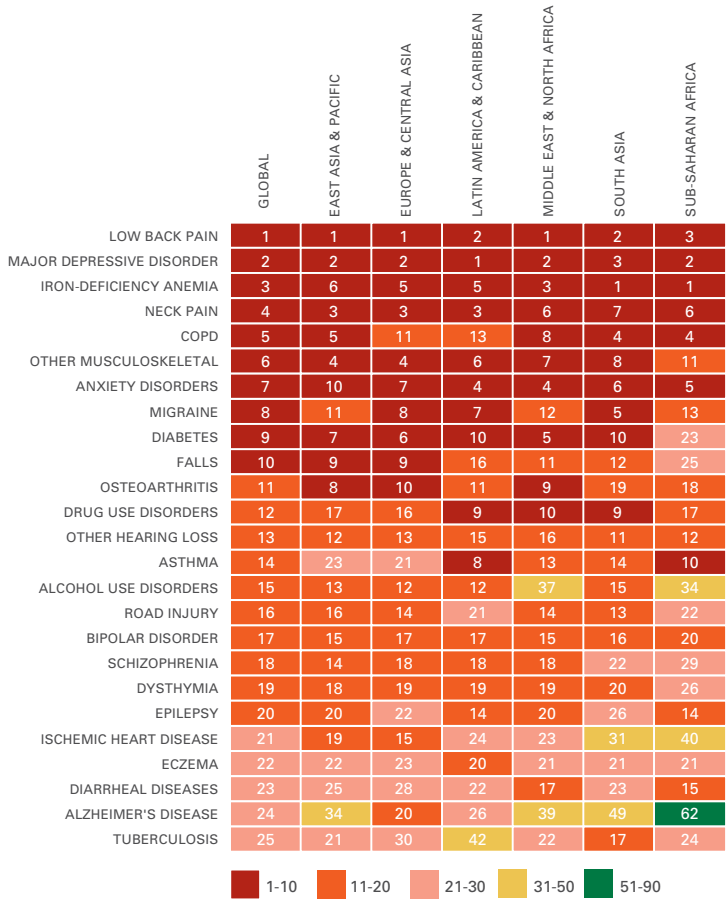
Figure 14: Disability patterns by broad cause group and age in sub-Saharan Africa, 2010



Note: The size of the colored portion in each bar represents the number of YLDs attributable to each cause for a given age group. The height of each bar shows total YLDs for a given age group in 2010. The causes are aggregated. For example, musculoskeletal disorders include low back pain and neck pain.

While mental and musculoskeletal disorders ranked high among causes of disability across regions, Figure 15 also reveals substantial regional variation among other causes. Iron-deficiency anemia was the leading cause of disability in sub-Saharan Africa and South Asia but was less important as a cause of disability in the other regions. The substantial burden in these two regions contributed to iron-deficiency anemia's ranking as the third leading cause of disability at the global level. Iron-deficiency anemia can lead to fatigue and lowered ability to fight infection and may decrease cognitive ability.

Figure 15: Rankings of leading causes of disability by region, 2010



Note: In this figure, shading is used to indicate the ranking of each cause of disability in a particular region.

Chronic obstructive pulmonary disease (COPD), a term used to describe emphysema and other chronic respiratory diseases, was among the top five causes of disability in East Asia and Pacific, South Asia, and sub-Saharan Africa and was the eighth-leading cause of disability in the Middle East and North Africa.

For the sub-Saharan Africa region, a majority of the causes of disability were similar to global rankings in 2010; six of the top 10 causes of disability regionally were also within the 10 highest-ranked global causes (albeit with different relative burden ranks). However, key differences merit further discussion. Malaria and HIV/AIDS ranked as the seventh and eighth top causes of disability, respectively, in sub-Saharan Africa, while these diseases ranked well below the top 25 causes of disability worldwide. Diabetes and falls, which were the ninth- and 10th-leading drivers of disability globally, failed to make the top 20 in sub-Saharan Africa (23rd and 25th, respectively).

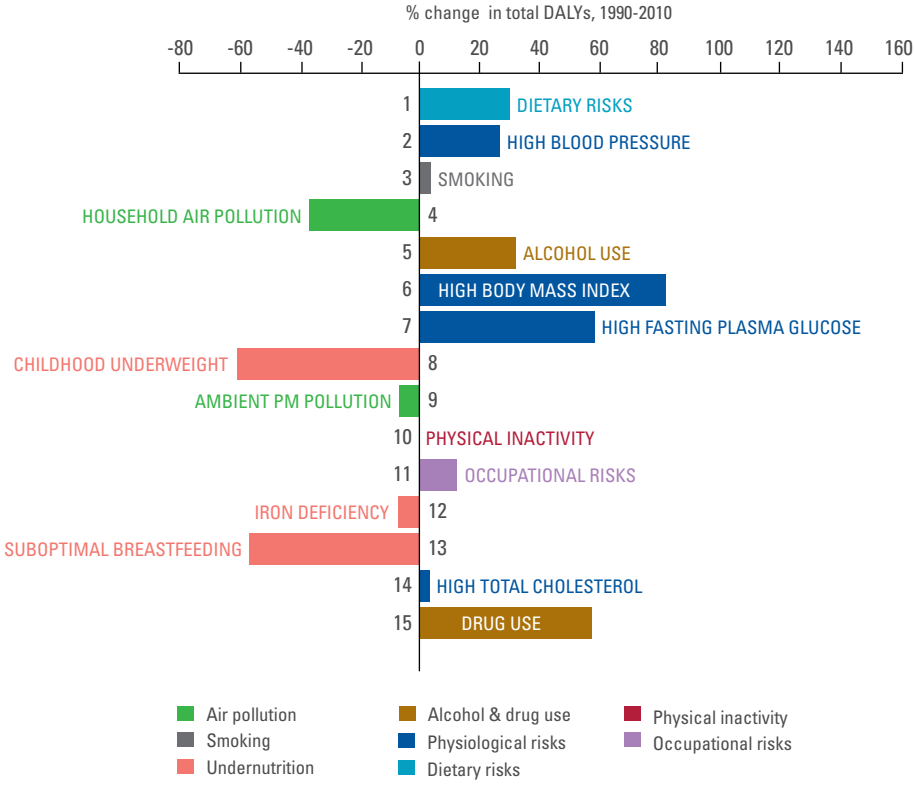
Greater variation is revealed when individual countries within the sub-Saharan Africa region are examined. In most southern sub-Saharan African countries, such as Botswana, Lesotho, and South Africa, malaria was not ranked among the top 50 causes of disability, while parasitic disease was the third-leading driver of disability in Mali. Sickle cell anemia ranked as the 16th-leading cause of disability regionally, but was not among the top 65 in many countries in sub-Saharan Africa, such as Comoros and Somalia, and was only ranked 45th worldwide. In Nigeria, however, sickle cell anemia was the seventh top driver of disability in 2010. Tuberculosis remained a top 10 cause of disability in several countries (Eritrea, Guinea-Bissau, Mauritania, and Namibia), but was ranked 24th in YLDs regionally and 25th globally. While epilepsy was ranked 14th in sub-Saharan Africa and 20th worldwide for its disability burdens, the condition was among the top 10 drivers of disability for many countries in the region (sixth for Liberia; seventh for Cameroon; ninth for Zambia; 10th for Cape Verde, Comoros, Madagascar, and Uganda). Country-level disability rankings can be viewed on IHME's website: http://ihmeuw.org/gbdheatmap.

Using GBD tools to identify leading causes of disability, such as mental and behavioral disorders and musculoskeletal disorders, can help guide health system planning and medical education. Decision-makers can use GBD's findings to ensure that health care systems are designed to address the primary drivers of disability in a cost effective way.

THE GLOBAL RISK FACTOR TRANSITION

Data on potentially avoidable causes of health loss, or risk factors, can help policymakers and donors prioritize prevention strategies to achieve maximum health gains. GBD tools estimate the number of deaths, premature deaths, years lived with disability, and DALYs attributable to 67 risk factors worldwide. This study benefited from the availability of new data, such as newly available epidemiologic evidence about the health impacts of different risk factors; population, nutrition, health, and medical examination surveys; and high-resolution satellite data on air pollution.

Figure 16: Global shifts in rankings of DALYs for top 15 risk factors, 1990-2010



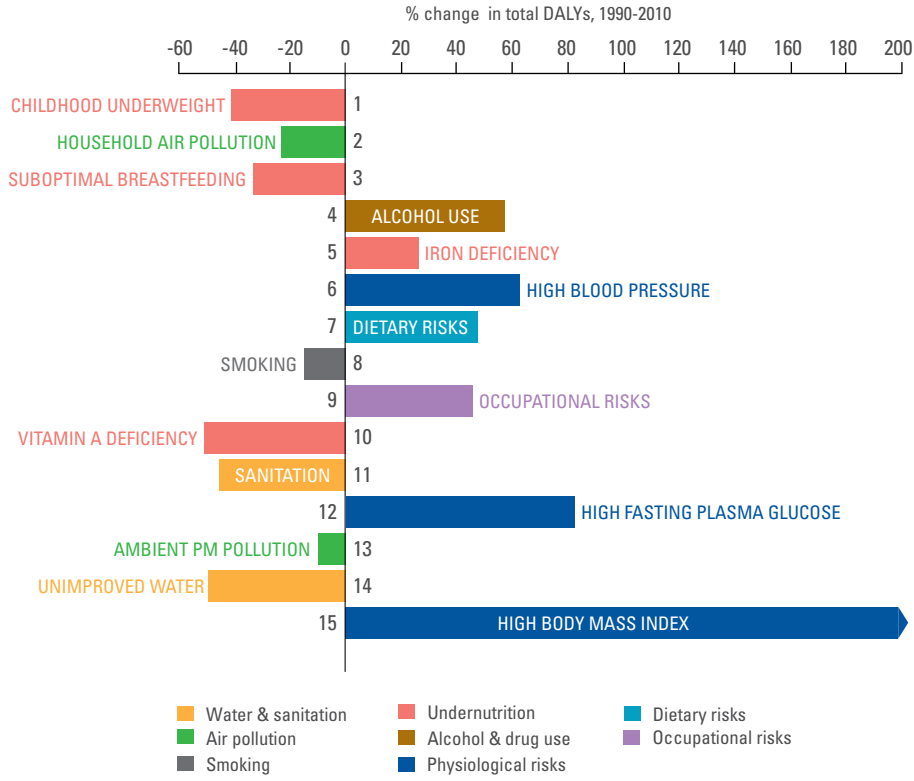
Note: The leading 15 risk factors are ranked from top to bottom in order of the number of DALYs they contributed in 2010. Bars to the right of the vertical line show the percent by which DALYs attributable to different risk factors have increased since 1990. Bars on the left show the percent by which DALYs attributable to different risk factors have decreased. Attributable DALYs were not quantified for physical inactivity for 1990.

Figure 16 shows changes in the 15 leading global risk factors for premature death and disability, or DALYs, between 1990 and 2010. Over this period, many risk factors that primarily cause communicable diseases in children declined. Examples of these risk factors are childhood underweight and suboptimal breastfeeding, which dropped by 61% and 57%, respectively, from 1990 to 2010. Childhood underweight is commonly used to measure malnutrition, and was formerly the leading risk factor for DALYs in 1990, but ranked eighth in 2010. DALYs attributable to household air pollution, which contributes to lower respiratory tract infections in children, dropped by 37% between 1990 and 2010. Unlike other risk factors that primarily cause DALYs from communicable diseases, progress in reducing premature death and disability from iron deficiency was much lower, declining by just 7% between 1990 and 2010. Slow progress in reducing iron deficiency helps explain why iron-deficiency anemia ranked as the third-leading cause of disability globally.

As most risk factors for communicable diseases in children have declined, many risks associated with non-communicable diseases have grown. As the leading global risk factor for premature death and disability in 2010, dietary risks increased 30% between 1990 and 2010. Dietary risks include components such as high sodium intake and lack of fruit, nuts and seeds, and whole grain intake. GBD found the diseases linked to dietary risks and physical inactivity are primarily cardiovascular diseases as well as cancer and diabetes. While many public health messages about diet have stressed the importance of eating less saturated fat, GBD 2010's findings indicate that these messages should emphasize a broader range of dietary components.

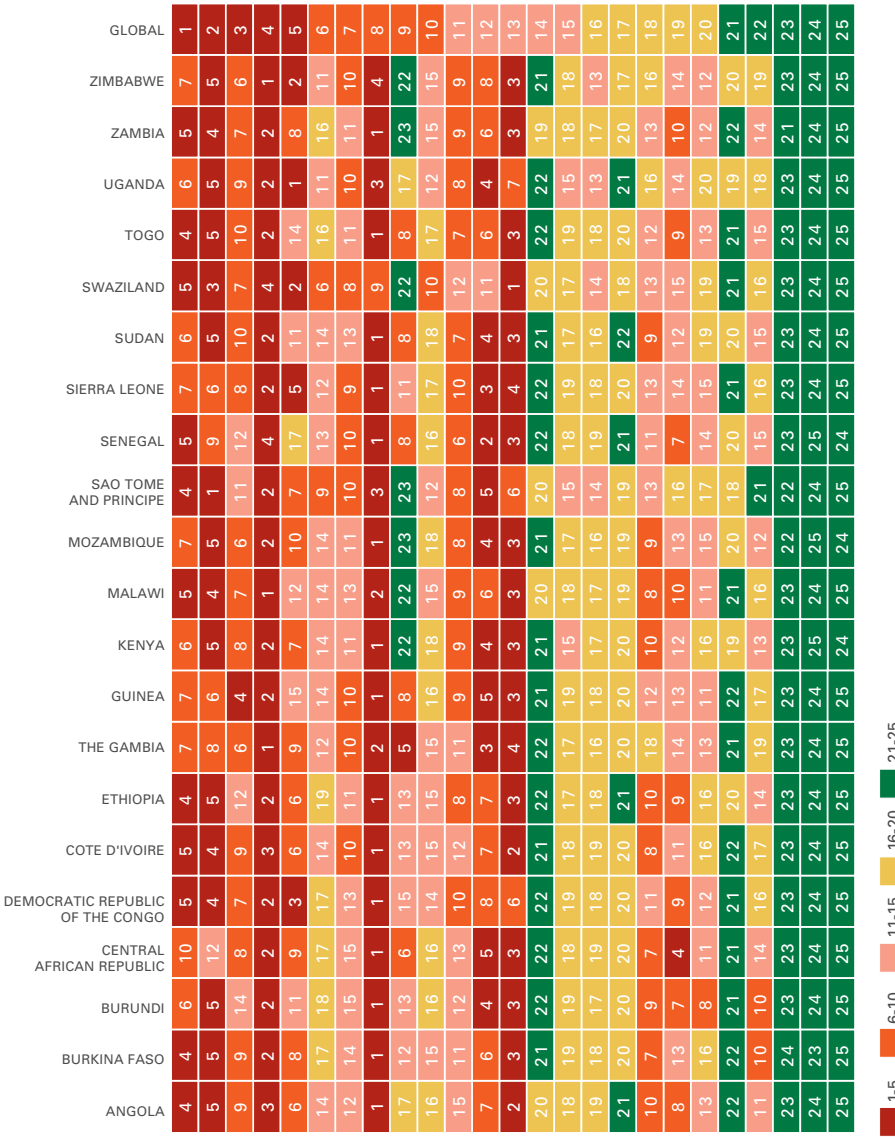
GBD 2010 used the most recent data available on the effects of different dietary risk factors. It is important to note that these data are constantly evolving as new studies on diet are conducted. Compared to data on the negative health impacts of smoking, which have been well understood for decades, the scientific evidence surrounding dietary risk factors is much newer. Future updates of GBD will incorporate new data on risk factors as they emerge.

Figure 17: Shifts in rankings of DALYs in sub-Saharan Africa for top 15 risk factors, 1990-2010



Note: The leading 15 risk factors are ranked from top to bottom in order of the number of DALYs they contributed in 2010. Bars going right show the percent by which risk factors have increased since 1990. Bars going left show the percent by which risk factors have decreased. Pointed arrows indicate causes that have increased by a greater amount than shown on the x-axis.

Figure 18: Rankings of DALYs attributable to leading risk factors across select countries in sub-Saharan Africa, 2010



Note: In this figure, shading is used to indicate the ranking of each risk factor in a particular region. To view an interactive version of this figure, visit IHME's website: http://ihmeuw.org/gbdheatmap.

The second-leading global risk factor, high blood pressure, increased by 27% as a cause of DALYs between 1990 and 2010. High blood pressure is a major risk factor for cardiovascular and circulatory diseases. DALYs attributable to another risk factor for non-communicable diseases, tobacco smoking, increased slightly by 3% between 1990 and 2010. Smoking increases the risk of chronic respiratory diseases, cardiovascular and circulatory diseases, and cancer. DALYs attributable to another substance, alcohol use, increased 32% during this period. Alcohol use contributes to cardiovascular and circulatory diseases, cirrhosis, and cancer. In addition to being a contributor to non-communicable diseases, alcohol increases the risk of injuries.

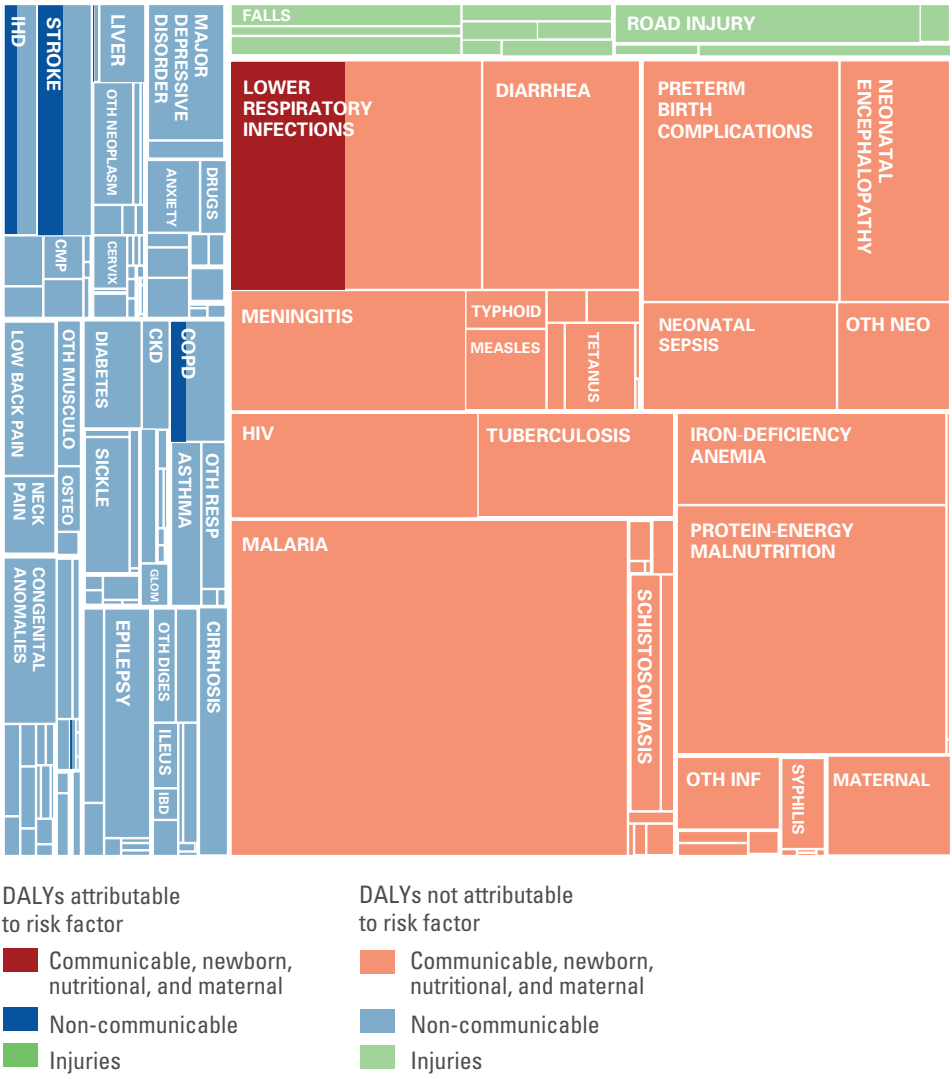
High body mass index (BMI) was another major contributor to DALYs in 2010 and was the sixth-leading risk factor. High BMI is typically used as an indicator of overweight and obesity. It increased by a dramatic 82% over the period 1990 to 2010. High BMI is a leading risk factor for cardiovascular and circulatory diseases as well as diabetes. It is striking that high BMI was a more important cause of poor health worldwide than childhood underweight in 2010, whereas childhood underweight was a much more prominent risk factor than high BMI in 1990.

Based on trends sub-Saharan Africa, Figure 17 shows changes in the 15 leading risk factors for premature death and disability between 1990 and 2010 in the sub-Saharan Africa region. Akin to worldwide trends, substantial improvements in childhood underweight, suboptimal breastfeeding, and vitamin A deficiency were documented from 1990 to 2010; in sub-Saharan Africa, however, these declines in DALYs occurred at a lesser magnitude than the trends found at the global level. As risk factors, high BMI escalated much faster in sub-Saharan Africa than globally.

Global and regional rankings of risk factors mask important differences across countries. Figure 18 shows the leading risk factors for DALYs in a selection of countries in the sub-Saharan Africa region in 2010.

Childhood underweight ranked as the top risk factor for most countries of the region featured in Figure 18, and was within the top 10 risk factors contributing to health loss for all countries (i.e., second in Gambia and Malawi; third in São Tomé and Principe and Uganda; fourth in Zimbabwe; ninth in Swaziland). Other leading risk factors included suboptimal breastfeeding in Swaziland; household air pollution in Gambia, Malawi, and Zimbabwe; high blood pressure in São Tomé and Principe; and alcohol use in Uganda. Ambient particulate matter (PM) pollution was among the top 10 risk factors for several countries (fifth in Gambia; sixth in Burkina Faso; eighth in Guinea, Senegal, Sudan, and Togo), but failed to rank above the top 20 for another cluster of countries (Kenya, Malawi, Mozambique, São Tomé and Principe, Swaziland, Zambia, and Zimbabwe). Of the selected countries, the majority did not have vitamin A deficiency as a top 10 risk factor; however, lack of proper amounts of vitamin A remained an important cause of health loss in Burkina Faso (ranked fourth), Democratic Republic of the Congo (ranked seventh), and Senegal (ranked seventh). Alcohol use as a risk factor was immensely variable; it was among the top three drivers of ill health in four countries (Burundi, Swaziland, Uganda, and Zimbabwe), but was only ranked 15th and 17th in Guinea and Senegal, respectively.

Figure 19: DALYs attributable to household air pollution, both sexes, all ages, Sierra Leone, 2010

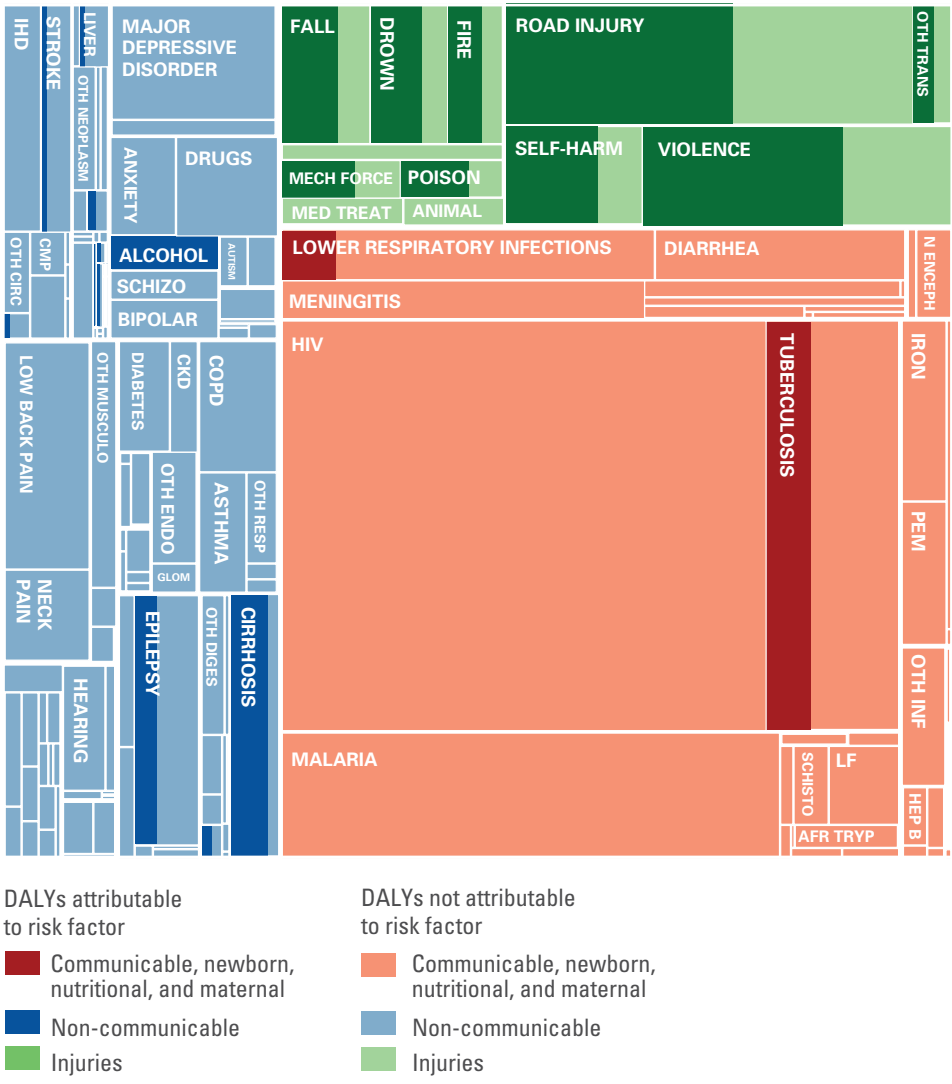


Note: The size of each box represents the percentage of total DALYs caused by a particular disease or injury, and the proportion of each cause attributable to the risk factor is shaded. To view an interactive version of this figure, visit IHME's website: http://ihmeuw.org/gbdcompare.

In addition to allowing users to explore how different risk factors rank across countries, decision-makers can use GBD visualization tools to understand how many DALYs could potentially be averted by addressing different risk factors. Figure 19 shows the number of DALYs attributable to household air pollution that contributed to different diseases in Sierra Leone. The percentage of DALYs that could be averted by reducing this risk factor is shown in dark shading.

Household air pollution consists of exposure to air-based pollution resulting from burning solid fuels. Figure 19 depicts how reducing this exposure is likely to prevent substantial amounts of premature death and disability from cataracts, ischemic heart disease, stroke, and COPD, as indicated by the portion of these causes that are shaded in dark blue. Reduction of household air pollution could also lower DALYs from lower respiratory infections, indicated by the area shaded in dark red.

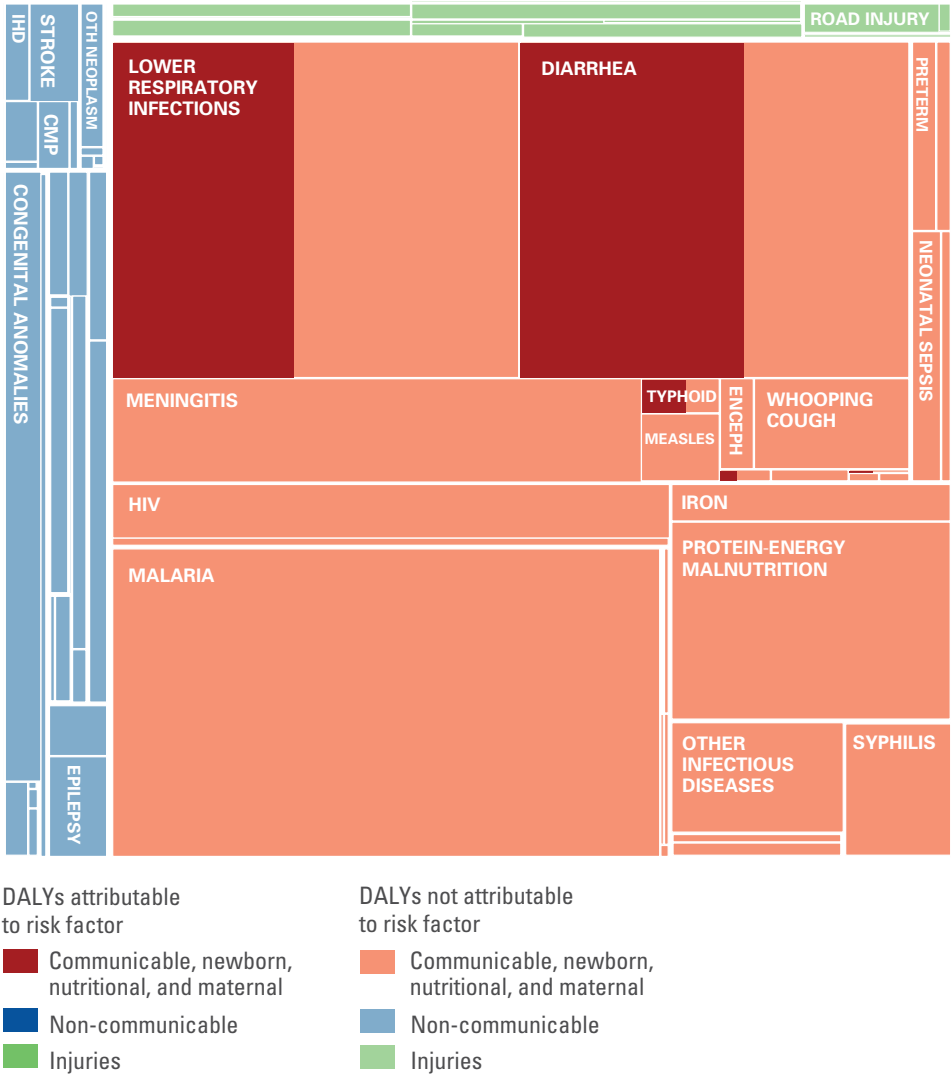
Figure 20: DALYs attributable to alcohol use, males, ages 15-49, Uganda, 2010



Note: The size of each box represents the percentage of total DALYs caused by a particular disease or injury, and the proportion of each cause attributable to the risk factor is shaded. To view an interactive version of this figure, visit IHME's website: http://ihmeuw.org/gbdcompare.

Figure 20 shows how, in Uganda, many DALYs could be averted by reducing alcohol use among men aged 15 to 49. For example, an estimated 35% and 79% of DALYs caused by epilepsy and cirrhosis, respectively, could be averted through reduced alcohol use. Among causes of injuries, approximately 56% of DALYs from road injury and 67% of DALYs from self-harm could be prevented from less alcohol use in Uganda.

Figure 21: DALYs attributable to suboptimal breastfeeding, both sexes, ages 1-11 months, Cameroon, 2010



Note: The size of each box represents the percentage of total DALYs caused by a particular disease or injury, and the proportion of each cause attributable to the risk factor is shaded.To view an interactive version of this figure, visit IHME's website: http://ihmeuw.org/gbdcompare.

As the third-leading risk factor for health loss in Cameroon, Figure 21 shows the number of DALYs attributable to suboptimal breastfeeding in children aged 1 to 11 months.

This figure can be used to understand the number of years of healthy life that could potentially be gained by ensuring that all Cameroonian children in this age group are adequately breastfed. Adequate breastfeeding is defined as exclusive breast-feeding of children for the first six months of life, and continued breastfeeding after the child reaches 6 months of age until age 2. About 58% of the DALYs attributable to diarrhea could potentially be prevented in this age group, as indicated by the dark shading in the boxes representing this cause. Adequate breastfeeding would also reduce illness from lower respiratory infections (LRIs) among these children, as it would prevent about 45% of DALYs from LRIs.

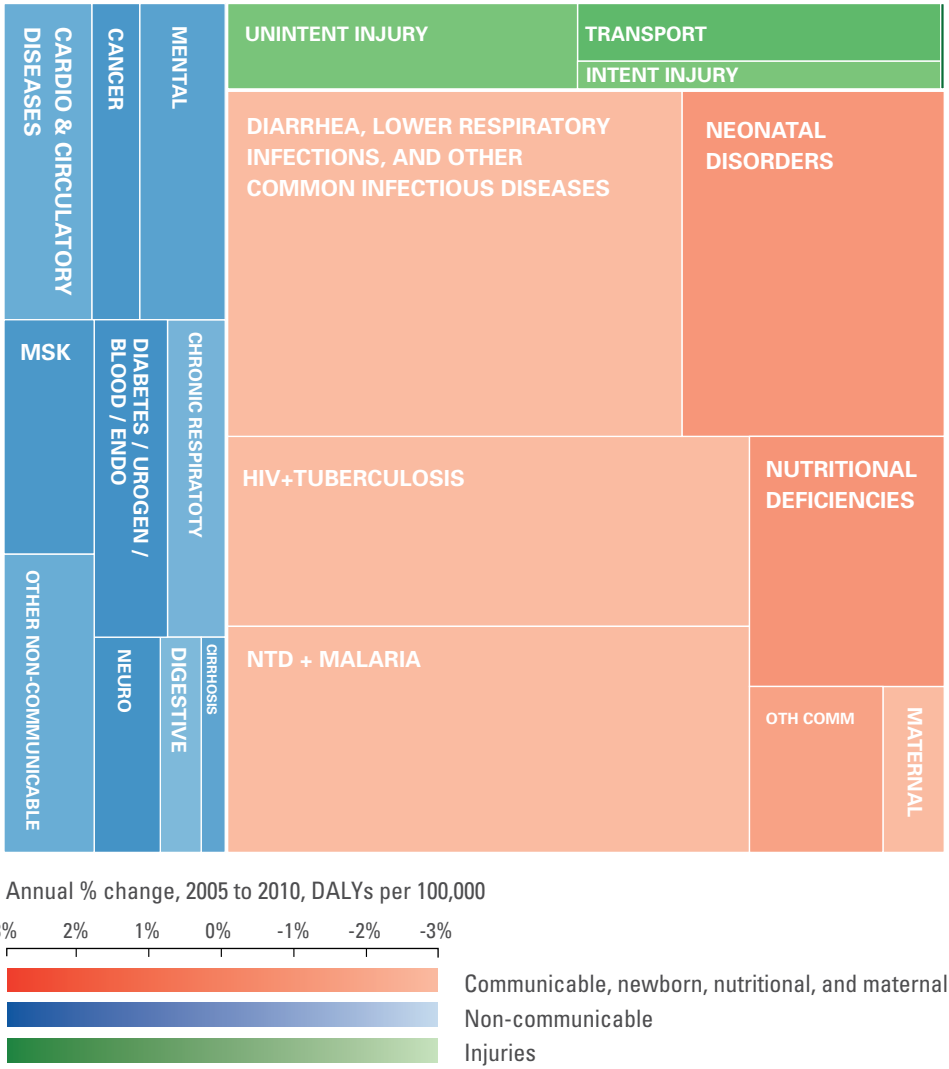
TREMENDOUS PROGRESS IN SUB-SAHARAN AFRICA, BUT MAJOR CHALLENGES REMAIN FOR MILLENNIUM DEVELOPMENT GOALS 4, 5, AND 6

The rapid transition away from communicable, maternal, newborn, and nutritional conditions toward non-communicable diseases at the global level has not been universal. Communicable diseases that primarily affect children and young adults remained top causes of premature death and disability, or DALYs, in sub-Saharan Africa, as shown in Figure 22.

As 2015 is fast approaching, the Millennium Development Goals (MDGs) remain highly relevant for sub-Saharan Africa. The target issues of MDGs 4, 5, and 6 accounted for 60% to 70% of DALYs in this area of the world in 2010, as shown in Figure 23. MDG 4 is intended to reduce by two-thirds, between 1990 and 2015, the under-5 mortality rate, while MDG 5 aims to reduce by three-quarters the maternal mortality ratio. The purpose of MDG 6 is to halt and begin reversing the spread of HIV/AIDS in that same period. In other regions, MDGs 4, 5, and 6 accounted for less than 40% of DALYs and, in some, the percentage was less than 20%.

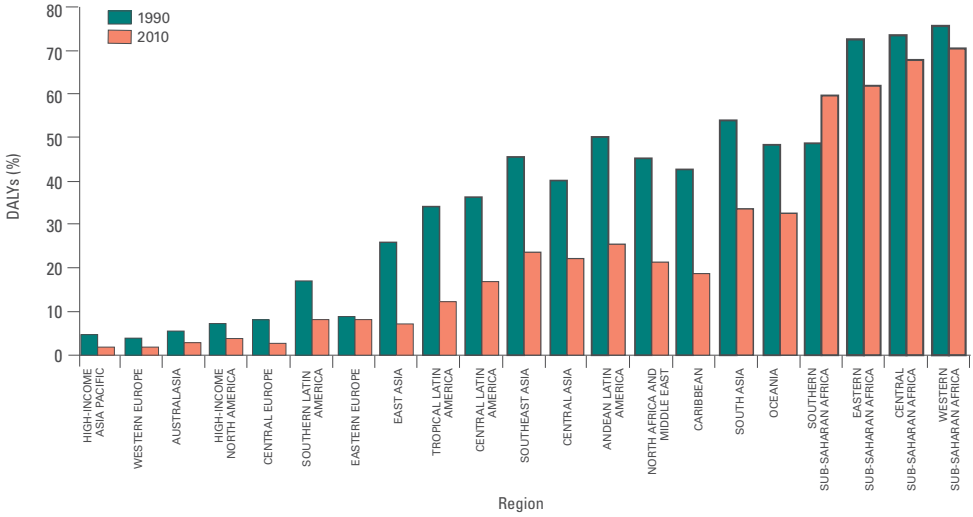
Despite the fact that disease patterns in sub-Saharan Africa have changed less than in other parts of the world over the past 20 years, most African countries have made impressive progress in reducing mortality rates for children under the age of 5. Figure 24 shows the annualized rate of decline in under-5 mortality in sub-Saharan African countries between 1990 and 2000 compared to 2000 to 2010. World Bank income designations are depicted in red (low income), orange (lower-middle income), and green (upper-middle income). All countries that appear on the right side of the diagonal line had accelerated declines in child mortality rates between 2000 and 2010. Countries such as Botswana, Rwanda, Senegal, Sierra Leone, and Uganda made the most rapid progress out of all the sub-Saharan African countries. Other countries including Angola, Eritrea, Kenya, Republic of the Congo, and Swaziland also made substantial strides in this area. In contrast to the majority of countries in sub-Saharan Africa, multiple countries in western sub-Saharan Africa had higher rates of under-5 mortality between 1990 and 2000 compared to 2000 and 2010, such as Burkina Faso, Côte d'Ivoire, Liberia, and Togo. Unlike other countries with high HIV prevalence rates, rates of under-5 mortality in Lesotho and Zimbabwe increased in the later period compared to the earlier period. In general, many lower- and upper-middle-income countries posted the greatest gains for under-5 mortality within the region; however, the wealthier countries with substantial HIV/AIDs burdens documented far less progress, if not heightened childhood mortality, between 2000 to 2010 (e.g., Lesotho and Côte d'Ivoire). Low-income countries featured far more heterogeneity, with Rwanda recording some the most impressive improvements in reducing under-5 mortality region-wide in contrast to Zimbabwe's persistent rises in childhood death rates.

Figure 22: Causes of DALYs, both sexes, all ages, sub-Saharan Africa, 2010



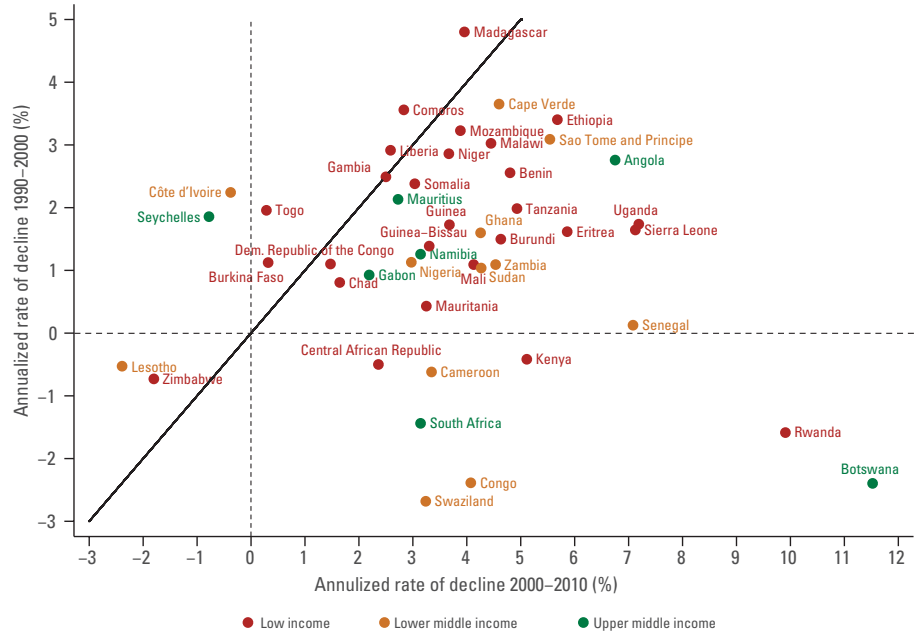
Note: The size of each box represents the percentage of total DALYs caused by a particular disease or injury. MSK: musculoskeletal, Diabetes/urogen/ blood/ endo: diabetes, urogenital, blood, and endocrine disorders, Neuro: neurological disorders, Unintent Injury: unintentional injuries other than transport injuries, Intent Injury: self-harm and interpersonal violence, Oth Comm: other communicable, maternal, newborn, and nutritional disorders, NTD: neglected tropical diseases. Figure 22 is based on GBD regional classifications rather than those of the World Bank. To use this interactive data visualization, visit IHME's website: http://ihmeuw.org/gbdcompare.

Figure 23: Percent DALYs related to Millennium Development Goals 4, 5, and 6 as a proportion, by GBD region, 1990 and 2010



Note: The regions depicted in Figure 23 are based on GBD region designations rather than those of the World Bank.

Figure 24: Annualized rate of decline in under-5 mortality, 1990-2000 compared to 2000-2010

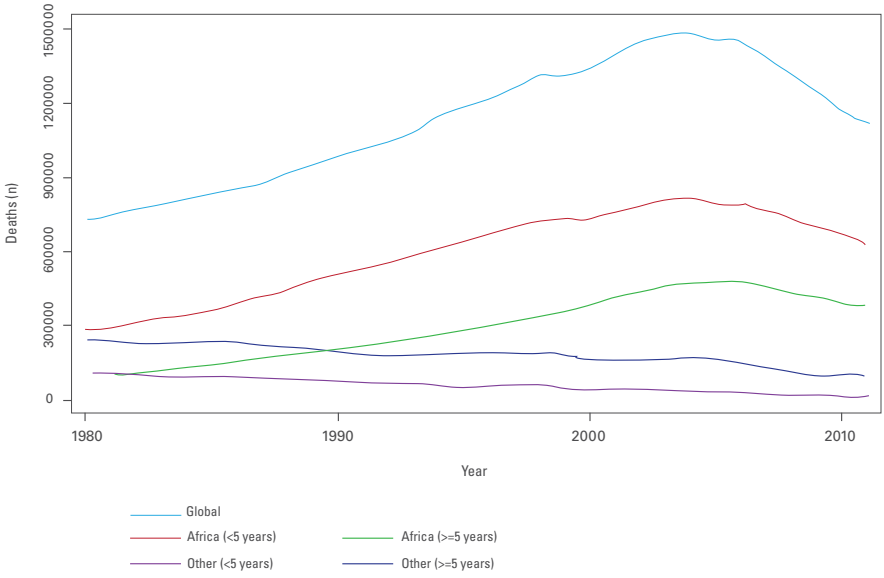


Note: Countries falling on the right side of the 45 degree angle had a greater annualized rate of decline in under-5 mortality between 2000 and 2010 and compared to 1990 to 2000.

While HIV/AIDS has exacted a devastating toll on many countries in sub-Saharan Africa, increasing by 328% in terms of healthy years lost from 1990 to 2010, the epidemic appears to have peaked in 2004. The number of years lost to premature death and disability declined by 22% between 2005 and 2010. This success is largely attributable to the massive scale-up in antiretroviral therapy over the past decade.

Another encouraging area of progress is the reduction in the number of deaths from malaria in sub-Saharan Africa. Figure 25 shows how malaria deaths in children under 5 in sub-Saharan Africa started to decline rapidly in 2005. That same year, the number of malaria deaths in the over-5 age group in this region also began a steep decline. Increased availability of insecticide-treated bed nets and artemisinin combination therapy contributed to these declines. These interventions have been financed primarily by the Global Fund to Fight AIDS, Tuberculosis and Malaria as well as the United States President's Malaria Initiative. GBD 2010 echoes findings of past IHME research studies in highlighting the life-saving role of development assistance in sub-Saharan Africa.

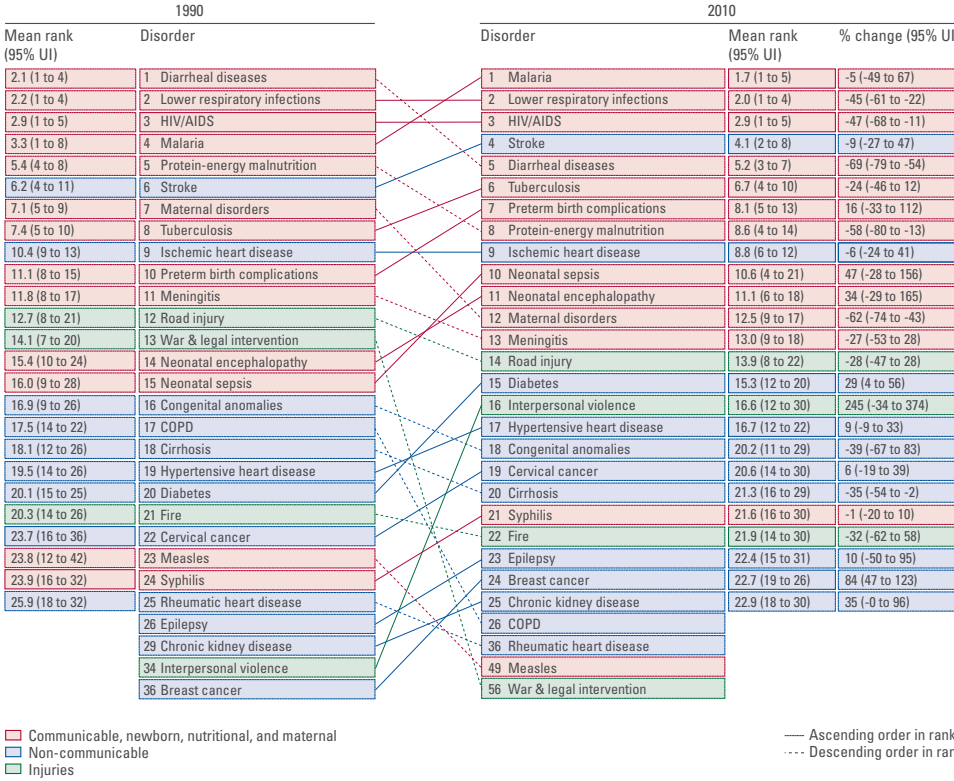
Figure 25: Trends in global malaria deaths by age and region, 1980-2010



Reduction of maternal deaths in sub-Saharan African countries is yet another positive finding of GBD 2010. Between 2005 and 2010, maternal mortality declined by 11.4%, in part due to scale-up of antiretroviral therapy. Delving deeper into trends at the country level, Rwanda stands out as a major success story. While other countries in sub-Saharan Africa have made progress in saving mother's lives, Rwanda is the only country on track to achieve MDG 5. Between 1990 and 2010, Rwanda reduced maternal deaths by 62%, as seen in Figure 26.

Most countries in sub-Saharan Africa made tremendous strides in reducing child mortality between 1990 and 2010. The success of the fight against malaria has contributed to this reduction in child deaths. Finally, while the devastating impact of HIV/AIDS appears to be declining, many challenges remain in combating this disease. Future updates of GBD will closely monitor developments in health in this and other regions.

Figure 26: Changes in leading causes of death among females, all ages, Rwanda, 1990 and 2010



Note: Solid lines indicate a cause that has moved up in rank or stayed the same. Broken lines indicate a cause that has moved down in rank. The causes of DALYs are color coded, with blue for non-communicable diseases, green for injuries, and red for communicable, newborn, nutritional, and maternal causes of DALYs. To view an interactive version of this figure, visit IHME's website: http://ihmeuw.org/gbdarrowdiagram.

USING GBD TO ASSESS COUNTRIES' HEALTH PROGRESS

Differences in population growth and ages across countries can make a country with a younger population appear better in terms of health performance than a country with an older population. Similarly, countries with low population growth will add less disease burden over time than countries with a fast-growing population. Researchers can remove the impact of these factors to isolate what is important for comparisons of health performance using age-standardized rates of DALYs and YLLs.

GBD can be used to compare and contrast disease patterns across countries. Figure 27 shows age-standardized causes of DALYs per 100,000 people in select countries in sub-Saharan Africa. The leading causes of premature death and disability are aggregated. For example, causes such as low back pain and neck pain are grouped into the category musculoskeletal disorders. For some of the poorer countries, like Guinea-Bissau and Liberia, rates of communicable, newborn, nutritional, and maternal conditions exceeded 40,000 age-standardized DALYs for every 100,000 people in 2010, with malaria accounting for most of the burden rates.

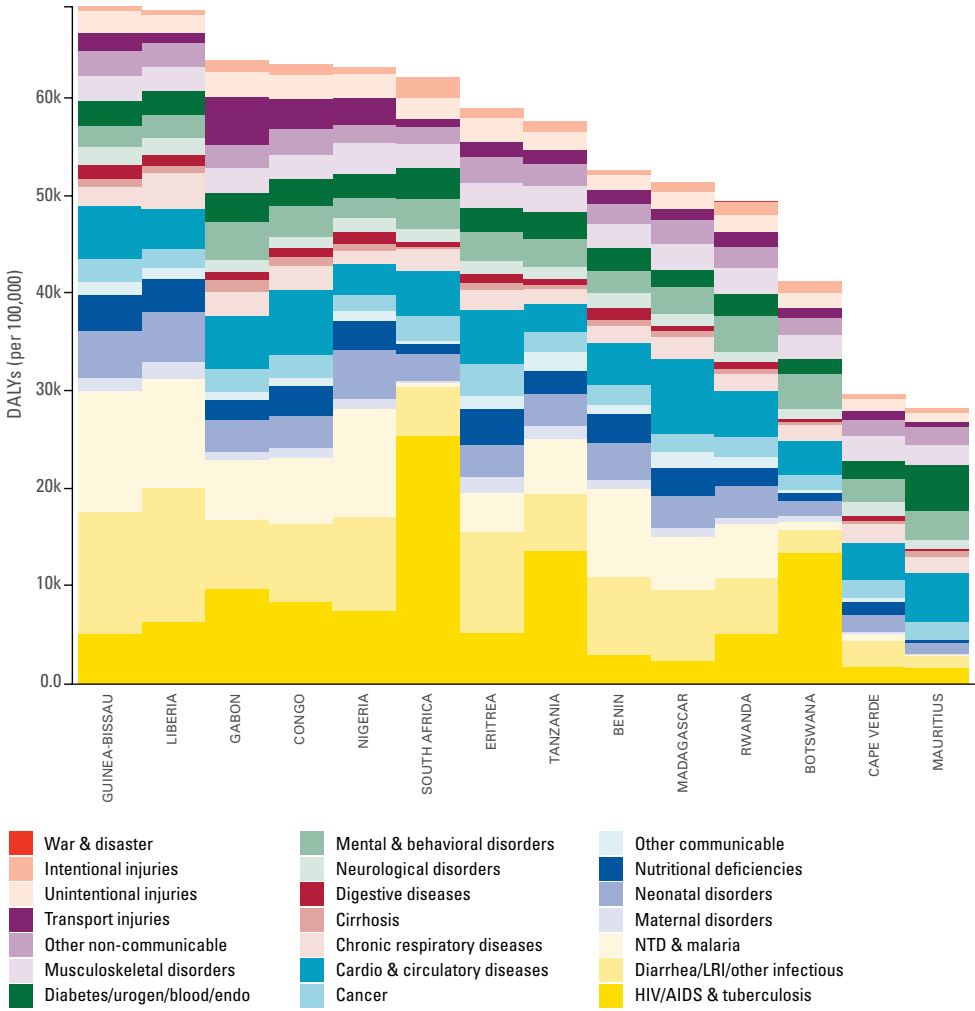
For countries classified as upper-middle income, such as Botswana and South Africa, if their rates exceed 10,000 age-standardized DALYs per 100,000 people, usually they are experiencing particularly severe HIV/AIDS epidemics, which account for a substantial amount of health loss. Otherwise, upper-middle-income countries feature much lower rates of communicable, newborn, nutritional, and maternal conditions, with Cape Verde and Mauritius both having age-standardized DALY rates less than 8,000 per 100,000 people. Notably, several countries record relatively high age-standardized rates of DALYs due to transport injuries; Gabon, for example, had about 4,500 age-standardized DALYs associated with transport injuries per 100,000 people. For context, more DALYs were caused by road injuries in Gabon in 2010 than diarrheal diseases and meningitis combined. All countries had sizeable rates of DALYs from non-communicable diseases, underscoring the double burden of disease from both communicable and non-communicable diseases that many sub-Saharan Africa countries now face.

The GBD approach affords countries a unique opportunity to explore their success in improving health outcomes over time. GBD can also be used to better understand how fast a country's health is improving relative to similar countries. This type of progress assessment is called benchmarking. Benchmarking is a tool that can help countries put their health achievements in context and identify areas for improvement. IHME invites countries interested in collaborating on benchmarking exercises to contact us.

As examples of a benchmarking exercise, Figures 28 and 29 show levels of years of life lost, or YLLs, in countries of the region, ranked relative to regional averages in 2010. Figure 28 includes countries within sub-Saharan Africa that have received a

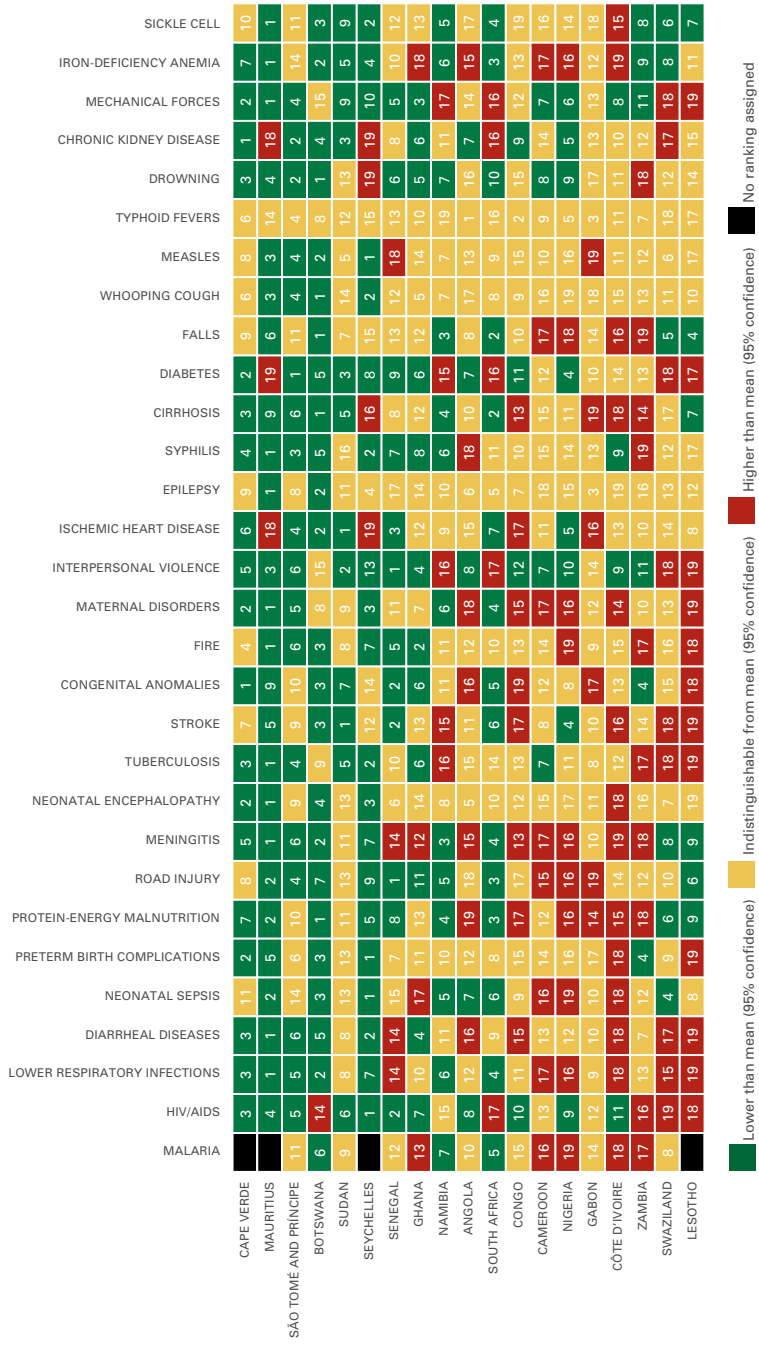
lower- or upper-middle-income designation, while Figure 29 features all countries categorized as low income by the World Bank. For these figures, regional averages are based on income categories, such that the average for Figure 28 is computed from trends in lower- and upper-middle-income countries and Figure 29 rankings are generated based on the "subregional" average for low-income countries in sub-Saharan Africa. The columns are arranged by the top 30 causes of YLLs in this subset of sub-Saharan African countries. For each cause, rankings are coded to reflect each country's level of age-standardized YLLs relative to the others. The best performers

Figure 27: Age-standardized DALY rates across select countries in sub-Saharan Africa, 2010



Note: The size of the colored portion in each bar represents number of age-standardized DALYs per 100,000 people attributable to each cause. The causes are aggregated. For example, musculoskeletal disorders include low back pain and neck pain. To view an interactive version of this figure, visit IHME's website: http://ihmeuw.org/gbdcausepattern.

Figure 28: Causes of leading years of life lost, lower- and upper-middle-income countries in sub-Saharan Africa, relative to region average, 2010



Note: The columns are ordered by the absolute number of YLLs for that particular year. The numbers indicate the rank across countries for each cause in terms of age-standardized YLL rates, with 1 as the best performance and 19 as the worst.

for each cause are in green while the worst performers for each cause appear in red; yellow indicates that for the given cause, the country's rank is not statistically distinguishable from the subregional average in 2010. Black indicates no ranking was assigned due to zero YLLs from a given cause.

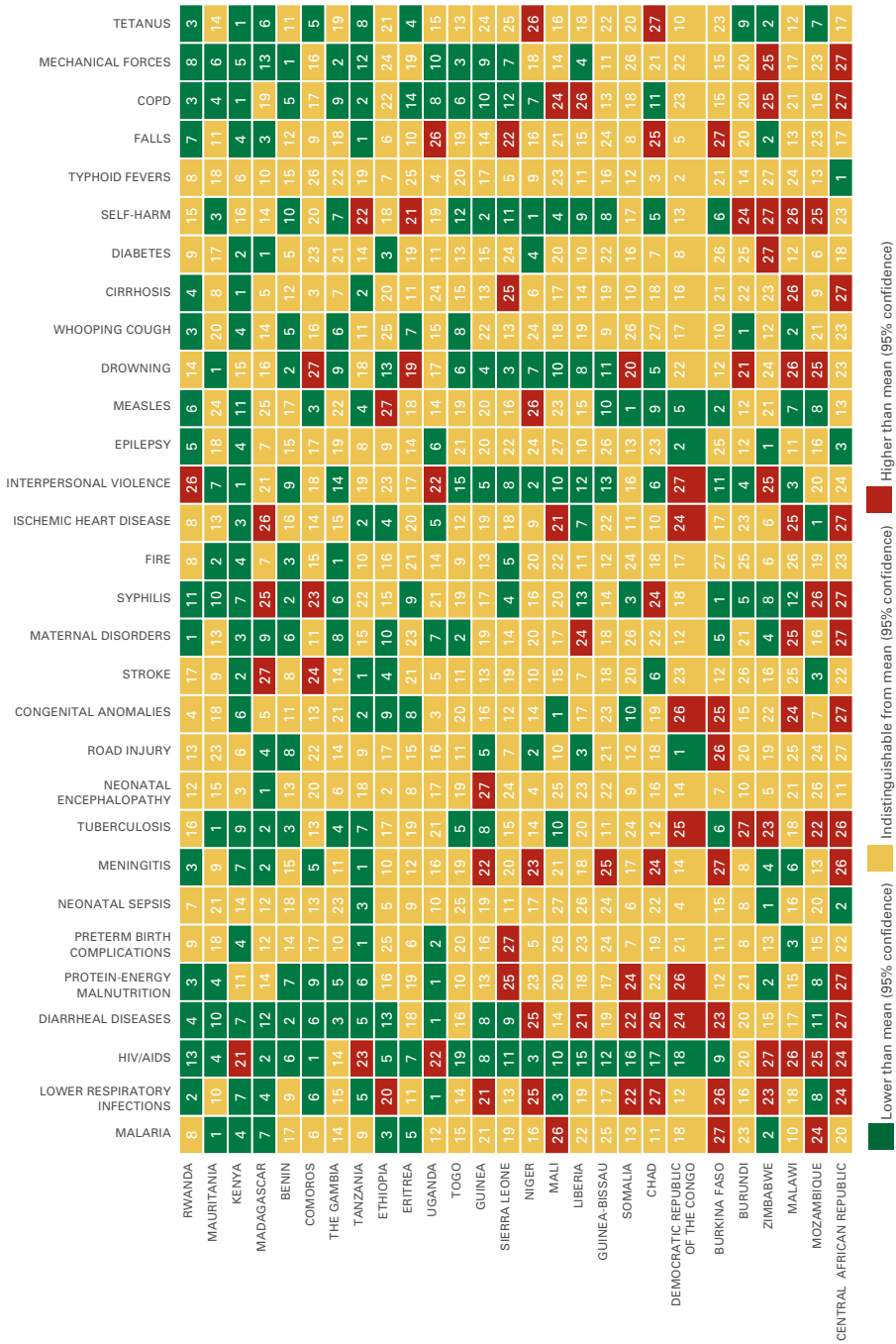
Among the lower- and upper-middle-income countries in Figure 28, the smaller island countries like Cape Verde, São Tomé and Principe, and the Seychelles generally performed better than the lower- and upper-middle-income subregion as a whole. The exceptions are ischemic heart disease, cirrhosis, drowning, and chronic kidney disease in the Seychelles, for which the country performed significantly worse than the rest of subregion. Conversely, the Seychelles performed significantly better than the rest of the subregion for HIV/AIDS. None of these lower- and upper-middle-income countries universally performed worse than the rest of the subregion; however, by comparison, Côte d'Ivoire and Lesotho each feature far more red designations, indicating that significantly more years of life are lost in these countries than the region as a whole for conditions like lower respiratory conditions, diarrheal diseases, and stroke. Interestingly, no significant differences were found across countries for typhoid fevers.

Of the low-income countries featured in Figure 29, Kenya, Mauritania, and Rwanda generally performed better than the rest of the low-income subregion, posting significantly fewer years of life lost for most conditions except for interpersonal violence in Rwanda and HIV/AIDS in Kenya. Mauritania and Comoros performed the best in the subregion on malaria and HIV/AIDS, respectively. When looking at sub-Saharan Africa's greatest driver of premature death, Burkina Faso, Mali, and Mozambique had significantly more years of life lost to malaria than the rest of the subregion. Similarly, a number of countries experienced significantly more health loss due to HIV/AIDS than the rest of subregion: Central African Republic, Kenya, Malawi, Tanzania, Uganda, and Zimbabwe. For neonatal sepsis, fire, whooping cough, and typhoid fevers, no country performed significantly worse than subregional averages for YLLs.

Among increasingly burdensome non-communicable diseases like stroke and ischemic heart disease, four countries consistently documented significantly less health loss than the rest of the subregion: Ethiopia, Kenya, Mozambique, and Tanzania. Madagascar, however, performed significantly worse than the rest of the subregion for these two cardiovascular conditions. Across all low-income countries in sub-Saharan Africa, the Central African Republic appeared to have the most population health challenges, with significantly more life lost to 13 diseases than the regional average, most of which were either communicable conditions or injuries. Nonetheless, this country still performed better than average across the subregion for three diseases: neonatal sepsis, typhoid fevers, and epilepsy.

To further illustrate how benchmarking can be implemented at the country level, IHME is currently working with public health experts in the United Kingdom to explore changes in population health over time and to compare its health performance

Figure 29: Causes of leading years of life lost, low-income countries in sub-Saharan Africa, relative to region average, 2010



Note: The columns are ordered by the absolute number of YLLs for that particular year, with greatest burden on the left. The numbers indicate the rank across countries for each cause in terms of age-standardized YLL rates, with 1 as the best performance and 27 as the worst.

to other countries with similar and higher levels of health spending. Through close collaboration with decision-makers at the National Health Service and Public Health England, the IHME-UK benchmarking project is examining the context in which health progress has occurred, such as the UK's provision of universal health coverage and its implementation of numerous public health interventions.

For the UK, GBD estimates of life expectancy and healthy life expectancy (HALE), YLLs, YLDs, and DALYs will provide a detailed and comprehensive picture of changes in health outcomes over time. Comparing GBD estimates across countries will elucidate areas of health where the UK performs both better and worse than its peers. In addition, analysis of potentially modifiable risk factors can shed light on ways that public health policy could address major causes of ill health and premature death. The IHME-UK benchmarking study aims to identify key opportunities to speed up the pace of health improvements in the nation.

CONCLUSION

The Global Burden of Disease (GBD) provides detailed data on diseases, injuries, and risk factors that are essential inputs for evidence-based policymaking. This collaborative project shows that the world's health is undergoing rapid change.

Global Burden of Diseases, Injuries, and Risk Factors Study 2010 (GBD 2010) identified major trends in global health that can be summarized by the three Ds: demographics, disease, and disability. As most countries have made great strides in reducing child mortality, people are living longer and the population is growing older. These demographic changes are driving up premature deaths and disability, or DALYs, from non-communicable diseases. Health problems are increasingly defined not by what kills us, but what ails us. In 1990, childhood underweight was the leading risk factor for ill health, but high body mass surpassed it in 2010 as a more important cause of premature death and disability. This finding illustrates global shifts away from risk factors for communicable disease in children toward risk factors for non-communicable diseases.

GBD 2010 found that non-communicable diseases and disability caused a greater share of health loss in 2010 compared to 1990 in most regions of the world. At the same time, the study revealed that the leading causes of DALYs in sub-Saharan Africa have changed little over the past 20 years. Still, GBD 2010 provides evidence of encouraging progress in this region, such as reductions in mortality from malaria, HIV/AIDS, and maternal conditions.

In sub-Saharan Africa, GBD 2010 documented important regional trends that reveal remarkable declines in health loss due to a subset of communicable, maternal, and childhood diseases over the last 20 years; the reductions in premature death and disability from diarrheal diseases, lower respiratory infections, and measles are particularly laudable. Despite this great progress, many of these conditions still top many countries' health burdens and account for a large portion of childhood death and illness. Malaria and HIV/AIDS continue to drive substantial health loss throughout the region, and do so at rates higher than those two decades earlier; it appears, however, that the total health burdens caused by these diseases peaked between 2000 and 2005 for most countries.

While most countries in sub-Saharan Africa still face large health burdens due to communicable, neonatal, maternal, and nutritional conditions, many have also experienced an increasing disease burden due to injuries and non-communicable diseases from 1990 to 2010. These dual burdens of communicable and non-communicable diseases are largely found among the lower- and upper-middle-income countries, but even low-income countries, such as Madagascar, are now seeing ailments like stroke among their top 10 drivers of premature death and disability. Road injuries have become an increasingly dominant cause of health loss in the region,

with many countries, such as Ghana, Kenya, and Nigeria, documenting at least twice the health burden caused by road injuries in 2010 than in 1990.

War and conflict affected many countries in sub-Saharan Africa in 1990, accounting for a substantial amount of health loss in countries like Ethiopia and Liberia; by 2010, these causes were no longer primary drivers of premature death and disability. Overall, many risk factors, such as suboptimal breastfeeding, vitamin deficiencies, childhood underweight, and others associated with undernutrition, have declined throughout sub-Saharan Africa, which has likely contributed to the regional progress in reducing health loss caused by several childhood conditions. However, risk factors associated with growing burdens of chronic diseases, such as high body mass index and physical inactivity, have become important threats to public health in many countries in the region.

While GBD 2010 provides key information about health trends at global and regional levels, its tools also allow users to view data specific to 187 countries. Similar to the ways in which governments use financial data to monitor economic trends and make necessary adjustments to ensure continued growth, decision-makers can use GBD data to inform health policy. Continual updates of GBD will incorporate the most recent data on disease patterns as well as the latest science about the effects of different risk factors on health.

Future updates of GBD will be enriched by widening the network of collaborators. Expanded collaboration between researchers, staff of ministries of health, and the Institute for Health Metrics and Evaluation (IHME) on national and subnational burden of disease studies will ensure that GBD tools are used to understand causes of premature death and disability at the community level. Despite similarities of epidemiological trends in most regions, GBD illustrates the unique patterns of diseases, injuries, and risk factors that exist in different countries. Local epidemiological assessment is crucial for informing local priorities. The GBD approach to health measurement can help guide the design of public health interventions to ensure they are tailored to countries' specific needs.

IHME is seeking partners interested in conducting in-depth studies of the burden of disease in countries. Through such partnerships, IHME is helping governments and donors gain insights into localized health trends to inform planning and policymaking. IHME is committed to building capacity for GBD analysis in countries around the world, and will be conducting a variety of training workshops. Information on these trainings can be found at http://www.healthmetricsandevaluation.org/gbd/training.

GBD data visualization tools can display regional and national data from burden of disease studies. These user-friendly tools are helpful for planning, presentations, and educational purposes. Also, IHME has designed a variety of data visualization tools to compare trends between various raw data sources at the national level. By visualizing all available data, ministry of health officials and researchers can quickly identify unexpected trends in the data that they may wish to flag for further investigation.

Currently, IHME is working to expand GBD to track expenditure for particular diseases and injuries. Also, IHME is estimating utilization of outpatient and inpatient facilities and other health services for specific diseases and injuries. Side-to-side comparisons of these estimates to the number of DALYs from myriad causes will allow decision-makers to evaluate health system priorities. Data on disease-specific expenditure and disease burden are essential for policymakers facing difficult decisions about how to allocate limited resources.

ANNEX

METHODS

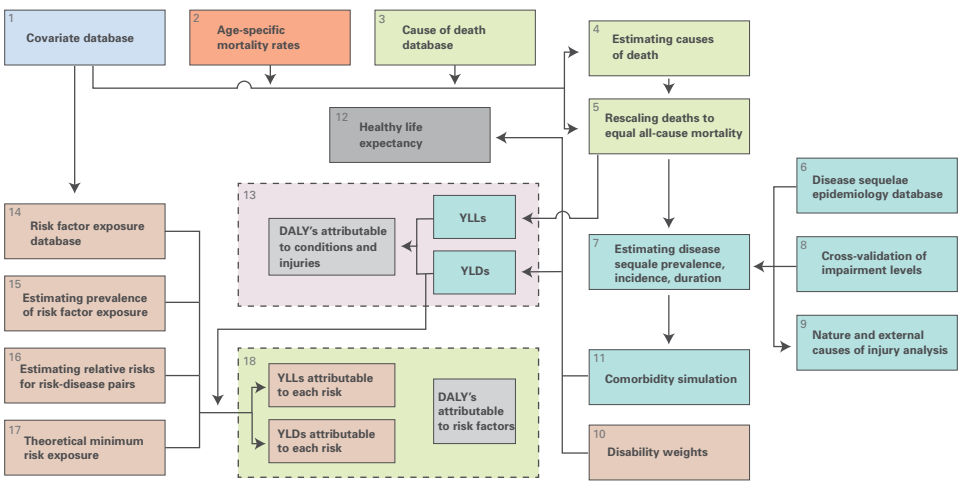
The analytical strategy of GBD

The GBD approach contains 18 distinct components, as outlined in Figure A1. The components of GBD are interconnected. For example, when new data is incorporated into the age-specific mortality rates analysis (component 2), other dependent components must also be updated, such as rescaling deaths for each cause (component 5), healthy life expectancy or HALE (component 12), YLLs (component 13), and estimation of YLLs attributable to each risk factor (component 18). The inner workings of key components are briefly described in this publication, and more detailed descriptions of each component are included in the published articles.

Estimating age- and sex-specific mortality

Researchers identified sources of under-5 and adult mortality data from vital and sample registration systems as well as from surveys that ask mothers about live births and deaths of their children and ask people about siblings and their survival. Researchers processed that data to address biases and estimated the probability of death between ages 0 and 5 and ages 15 and 60 using statistical models. Finally, researchers used these probability estimates as well as a model life table system to estimate age-specific mortality rates by sex between 1970 and 2010.

Figure A1: The 18 components of GBD and their interrelations



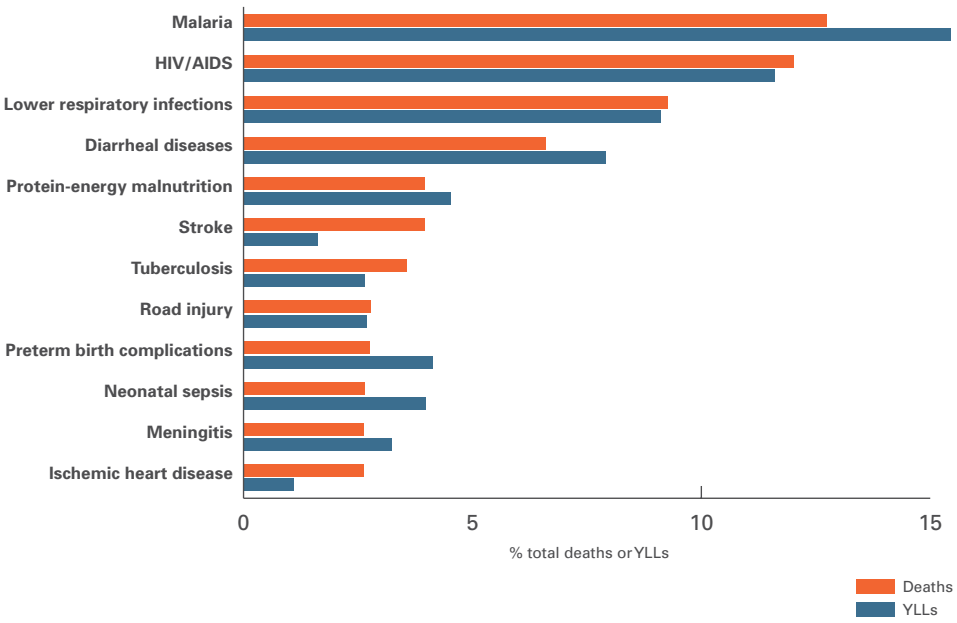
Estimating years lost due to premature death

Researchers compiled all available data on causes of death from 187 countries. Information about causes of death was derived from vital registration systems, mortality surveillance systems, censuses, surveys, hospital records, police records, mortuaries, and verbal autopsies. Verbal autopsies are surveys that collect information from individuals familiar with the deceased about the signs and symptoms the person had prior to death. GBD 2010 researchers closely examined the completeness of the data. For those countries where cause of death data were incomplete, researchers used statistical techniques to compensate for the inherent biases. They also standardized causes of death across different data sources by mapping different versions of the International Classification of Diseases coding system to the GBD cause list.

Next, researchers examined the accuracy of the data, scouring rows and rows of data for "garbage codes." Garbage codes are misclassifications of death in the data, and researchers identified thousands of them. Some garbage codes are instances where we know the cause listed cannot possibly lead to death. Examples found in records include "abdominal rigidity," "senility," and "yellow nail syndrome." To correct these, researchers drew on evidence from medical literature, expert judgment, and statistical techniques to reassign each of these to more probable causes of death.

After addressing data-quality issues, researchers used a variety of statistical models to determine the number of deaths from each cause. This approach, named Cause of Death Ensemble modeling or CODEm, was designed based on statistical tech-

Figure A2: Leading causes of death and premature death in sub-Saharan Africa, 2010



niques called "ensemble modeling." Ensemble modeling was made famous by the recipients of the Netflix Prize in 2009, BellKor's Pragmatic Chaos, who engineered the best algorithm to predict how much a person would like a film, taking into account their movie preferences.

To ensure that the number of deaths from each of cause did not exceed the total number of deaths estimated in a separate GBD demographic analysis, researchers applied a correction technique named CoDCorrect. This technique makes certain that estimates of the number of deaths from each cause do not add up to more than 100% of deaths in a given year.

After producing estimates of the number of deaths from each of the 235 fatal outcomes included in the GBD cause list, researchers then calculated years of life lost to premature death, or YLLs. For every death from a particular cause, researchers estimated the number of years lost based on the highest life expectancy in the deceased's age group. For example, if a 20-year-old male died in a car accident in South Africa in 2010, he has 66 years of life lost, that is, the highest remaining life expectancy in 20-year-olds, as experienced by 20-year-old females in Japan.

When comparing rankings of the leading causes of death versus YLLs, YLLs place more weight on the causes of death that occur in younger age groups, as shown in Figure A2. For example, malaria represents a greater percentage of total YLLs than total deaths since it is a leading killer of children under age 5. Ischemic heart disease, by contrast, accounts for a smaller percentage of total YLLs than total deaths, as it primarily kills older people.

Estimating years lived with disability

Researchers estimated the prevalence of each sequela using different sources of data, including government reports of cases of infectious diseases, data from population-based disease registries for conditions such as cancers and chronic kidney diseases, antenatal clinic data, hospital discharge data, data from outpatient facilities, interview questions, and direct measurements of hearing, vision, and lung function testing from surveys and other sources.

Confronted with the challenge of data gaps in many regions and for numerous types of sequelae, they developed a statistical modeling tool named DisMod-MR (for Disease Modeling – Metaregression) to estimate prevalence using available data on incidence, prevalence, remission, duration, and extra risk of mortality due to the disease.

Researchers estimated disability weights using data collected from almost 14,000 respondents via household surveys in Bangladesh, Indonesia, Peru, Tanzania, and the United States. Disability weights measure the severity of different sequelae that result from disease and injury. Data were also used from an Internet survey of more than 16,000 people. GBD researchers presented different lay definitions of sequelae grouped into 220 unique health states to survey respondents, and respondents were then asked to rate the severity of the different health states. The results were similar

across all surveys despite cultural and socioeconomic differences. Respondents consistently placed health states such as mild hearing loss and long-term treated fractures at the low end of the severity scale, while they ranked acute schizophrenia and severe multiple sclerosis as very severe.

Finally, years lived with disability, or YLDs, are calculated as prevalence of a sequela multiplied by the disability weight for that sequela. The number of years lived with disability for a specific disease or injury are calculated as the sum of the YLDs from each sequela arising from that cause.

Estimating disability-adjusted life years

Disability-adjusted life years (DALYs) were calculated by adding together YLLs and YLDs. Figure A3 compares the 10 leading diseases and injuries calculated as percentages of both regional deaths and regional DALYs. This figure also shows the top 10 risk factors attributable to deaths and DALYs in the sub-Saharan Africa region. DALYs are a powerful tool for priority setting as they measure disease burden from non-fatal, as well as fatal, conditions. Yet another reason why top causes of DALYs differ from leading causes of death is that DALYs give more weight to death in younger ages, as illustrated by the case of neonatal encephalopathy. In contrast, stroke causes a larger percentage of total deaths than DALYs, as it primarily impacts older people.

Estimating DALYs attributable to risk factors

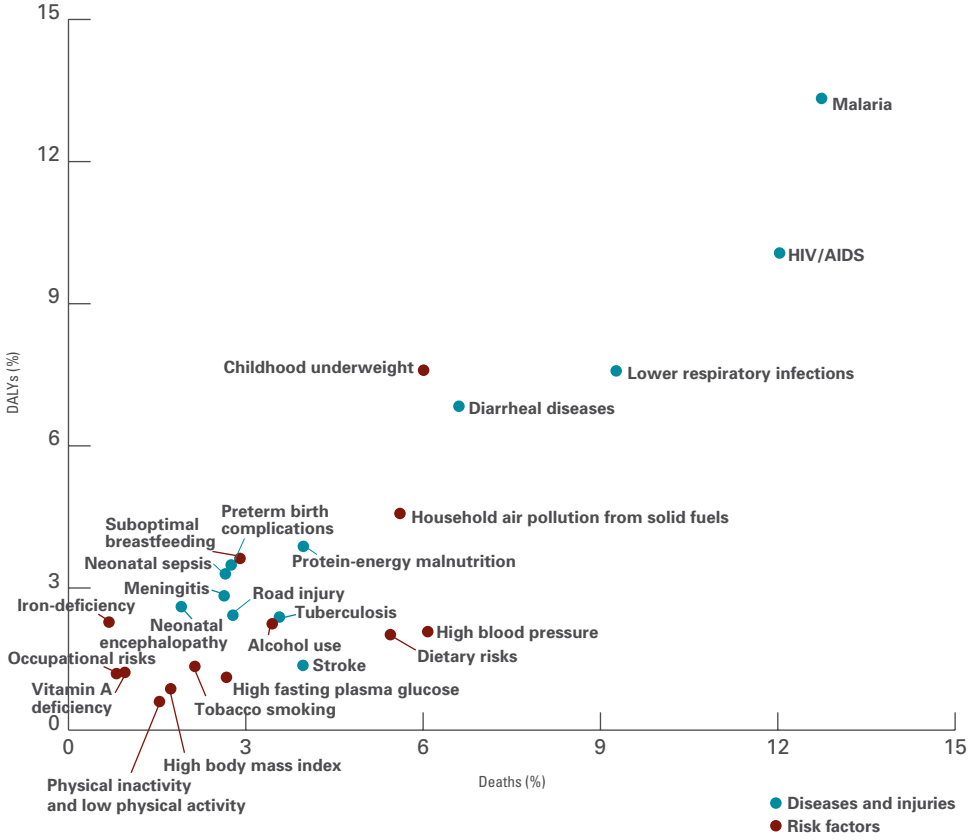
To estimate the number of healthy years lost, or DALYs, attributable to potentially avoidable risk factors, researchers collected detailed data on exposure to different risk factors. The study used data from sources such as satellite data on air pollution, breastfeeding data from population surveys, and blood and bone lead levels from medical examination surveys and epidemiological surveys. Researchers then collected data on the effects of risk factors on disease outcomes through systematic reviews of epidemiological studies.

All risk factors analyzed met common criteria in four areas:

1. The likely importance of a risk factor for policymaking or disease burden.
2. Availability of sufficient data to estimate exposure to a particular risk factor.
3. Rigorous scientific evidence that specific risk factors cause certain diseases and injuries.
4. Scientific findings about the effects of different risk factors that are relevant for the general population.

To calculate the number of DALYs attributable to different risk factors, researchers compared the disease burden in a group exposed to a risk factor to the disease burden in a group that had zero exposure to that risk factor. When subjects with zero exposure were impossible to find, as in the case of high blood pressure, for example, researchers established a level of minimum exposure that leads to the best health outcomes.

Figure A3: The 10 leading diseases and injuries and 10 leading risk factors based on percentage of deaths and DALYs in sub-Saharan Africa, 2010



Note: This figure compares the percent of DALYs and deaths attributable to different diseases and injuries (shown in blue) as well as risk factors (shown in red). Certain causes, such as iron deficiency, cause more DALYs than they do deaths. DALYs are an important tool for decision-makers because they capture years of healthy life lost from both premature death and years lived with disability.

Table A1: Age-standardized death rates, years of life lost, and years lived with disability, and life expectancy at birth and healthy life expectancy at birth for 1990 and 2010 for both sexes combined

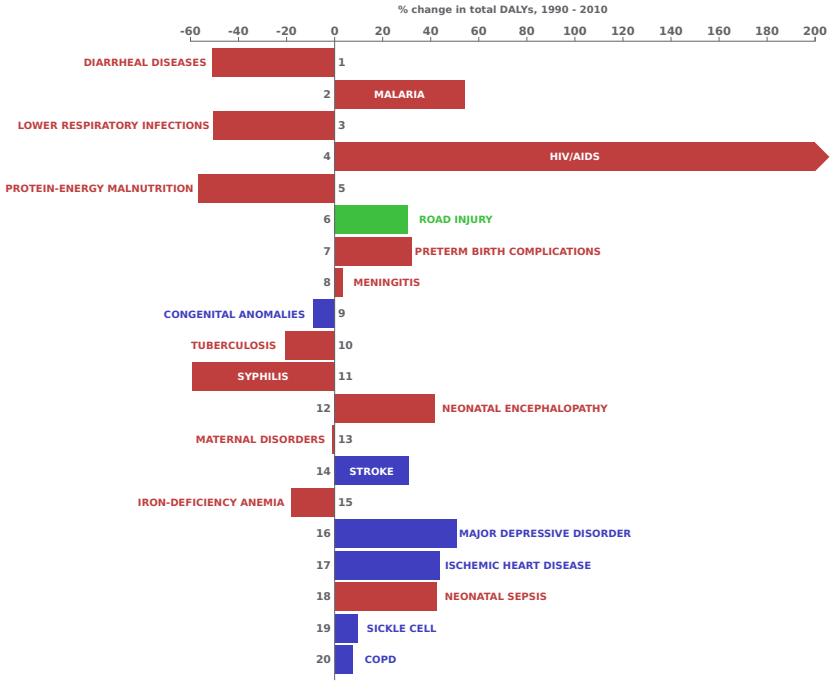
Country	Age-standardized death rate (per 100,000)				Age-standardized YLL rate (per 100,000)			
	1990		2010		1990		2010	
	Rate	*Rank*	*Rate*	*Rank*	*Rate*	*Rank*	*Rate*	*Rank*
Angola	1,995 (1,527-2,733)	43 (29-46)	1,257 (993-1,644)	20 (8-40)	82,686 (66,351-109,548)	42 (30-46)	44,380 (35,634-57,681)	20 (11-36)
Benin	1,312 (1,244-1,388)	19 (13-22)	1,080 (1,014-1,151)	11 (8-14)	58,713 (54,284-63,355)	24 (21-26)	38,726 (35,694-42,020)	13 (11-17)
Botswana	951 (848-1,057)	2 (2-4)	715 (599-821)	2 (2-4)	31,563 (28,522-34,692)	4 (3-5)	26,692 (23,854-29,414)	4 (3-5)
Burkina Faso	1,521 (1,459-1,585)	28 (25-31)	1,396 (1,288-1,503)	33 (26-37)	68,852 (65,046-73,156)	30 (27-34)	59,507 (52,426-67,312)	39 (31-42)
Burundi	1,966 (1,517-2,692)	42 (30-46)	1,759 (1,332-2,427)	40 (31-46)	80,347 (66,981-106,923)	39 (30-46)	62,752 (49,931-85,236)	40 (27-44)
Cameroon	1,296 (1,243-1,345)	16 (13-20)	1,277 (1,178-1,377)	23 (18-30)	51,072 (48,257-53,902)	17 (16-20)	49,262 (44,889-53,932)	26 (21-31)
Cape Verde	785 (746-827)	1 (1-1)	586 (497-685)	1 (1-1)	25,843 (24,238-27,543)	2 (1-2)	16,730 (13,743-20,284)	1 (1-2)
Central African Republic	2,131 (2,010-2,256)	45 (43-46)	2,408 (2,138-2,713)	46 (44-46)	81,026 (76,404-86,270)	44 (39-45)	90,581 (80,204-101,333)	46 (44-46)
Chad	1,508 (1,426-1,596)	27 (24-31)	1,389 (1,284-1,514)	32 (24-37)	67,610 (62,369-73,496)	29 (26-34)	58,839 (52,545-66,878)	37 (31-42)
Comoros	1,439 (1,308-1,590)	24 (19-30)	1,223 (1,092-1,373)	18 (13-29)	52,340 (48,247-57,207)	19 (16-22)	38,959 (34,801-44,336)	14 (9-18)
Congo	1,696 (1,565-1,848)	35 (30-42)	1,401 (1,281-1,540)	34 (26-37)	60,756 (55,481-66,618)	25 (21-29)	49,063 (43,995-54,467)	25 (20-32)
Côte d'Ivoire	1,400 (1,339-1,466)	23 (21-25)	1,457 (1,341-1,576)	36 (31-38)	58,331 (55,059-61,623)	23 (21-26)	56,879 (51,282-62,523)	35 (31-39)
Democratic Republic of the Congo	1,568 (1,467-1,663)	29 (26-33)	1,506 (1,399-1,615)	37 (33-39)	65,799 (61,413-70,116)	27 (26-31)	59,031 (53,984-63,582)	38 (33-40)
Eritrea	1,807 (1,694-1,922)	41 (36-43)	1,353 (1,228-1,466)	30 (20-36)	67,111 (62,090-72,863)	28 (27-33)	44,346 (39,868-48,958)	19 (15-26)
Ethiopia	2,152 (2,044-2,278)	46 (43-46)	1,292 (1,232-1,352)	25 (19-30)	86,420 (80,270-93,661)	45 (42-46)	43,719 (41,409-46,267)	18 (15-22)
Gabon	1,312 (1,218-1,412)	18 (11-23)	1,432 (1,267-1,637)	35 (25-40)	46,033 (42,373-50,001)	15 (12-16)	49,393 (42,613-58,336)	27 (19-37)
Gambia, The	1,315 (1,146-1,518)	17 (9-27)	1,109 (900-1,356)	12 (6-27)	54,039 (48,109-60,649)	20 (16-25)	41,302 (34,115-49,904)	15 (8-26)
Ghana	1,185 (1,115-1,253)	10 (8-12)	1,030 (968-1,086)	8 (6-12)	45,628 (42,476-49,061)	13 (12-15)	35,128 (32,885-37,437)	8 (7-12)
Guinea	1,508 (1,444-1,580)	26 (24-30)	1,233 (1,152-1,324)	19 (15-27)	69,094 (64,734-74,410)	31 (27-34)	48,350 (43,740-53,673)	23 (18-31)
Guinea-Bissau	1,603 (1,407-1,831)	31 (24-41)	1,391 (1,153-1,649)	31 (17-39)	72,398 (64,267-80,951)	33 (27-41)	55,214 (46,304-65,422)	33 (24-40)
Kenya	1,092 (1,041-1,141)	5 (4-8)	1,013 (940-1,081)	7 (6-11)	39,731 (37,585-42,064)	9 (6-11)	36,153 (33,852-38,494)	11 (8-13)
Lesotho	1,316 (1,245-1,394)	20 (13-23)	2,130 (1,930-2,341)	44 (43-46)	43,569 (41,196-46,177)	12 (11-15)	85,888 (78,939-92,875)	45 (44-46)
Liberia	1,585 (1,482-1,728)	30 (26-36)	1,333 (1,244-1,425)	28 (22-34)	75,995 (70,210-82,809)	37 (33-43)	53,808 (49,728-57,821)	32 (28-36)
Madagascar	1,451 (1,391-1,506)	25 (23-27)	1,156 (1,062-1,255)	14 (11-21)	56,586 (53,790-59,954)	22 (20-24)	37,200 (34,362-40,628)	12 (8-15)
Malawi	1,768 (1,685-1,843)	40 (35-43)	1,730 (1,591-1,843)	42 (39-43)	79,007 (74,928-83,200)	43 (36-44)	66,486 (61,969-70,511)	42 (40-43)
Mali	1,726 (1,661-1,800)	38 (33-41)	1,331 (1,241-1,425)	27 (20-34)	78,963 (74,141-84,559)	41 (36-44)	53,703 (48,704-59,440)	31 (27-37)
Mauritania	1,244 (1,194-1,298)	12 (10-17)	1,031 (955-1,110)	9 (6-12)	45,799 (43,134-48,769)	14 (12-15)	36,003 (32,543-39,793)	10 (7-14)
Mauritius	1,014 (1,000-1,024)	3 (2-4)	766 (751-776)	3 (2-5)	24,451 (24,031-24,836)	1 (1-2)	17,273 (16,915-17,579)	2 (1-2)
Mozambique	1,659 (1,585-1,735)	32 (30-37)	1,725 (1,577-1,852)	41 (39-43)	74,370 (69,485-79,516)	35 (32-41)	67,547 (62,839-72,350)	43 (39-43)
Namibia	1,259 (1,215-1,306)	13 (11-18)	1,298 (1,187-1,418)	26 (18-32)	39,681 (38,003-41,586)	8 (6-10)	42,112 (37,956-46,928)	16 (13-21)
Niger	1,765 (1,673-1,866)	39 (34-42)	1,268 (1,184-1,369)	22 (16-31)	88,497 (82,055-95,891)	46 (44-46)	52,955 (47,331-59,543)	30 (23-38)
Nigeria	1,343 (1,267-1,414)	21 (16-23)	1,159 (1,084-1,237)	15 (12-19)	60,604 (56,578-64,799)	26 (23-27)	49,276 (45,962-52,718)	28 (22-30)
Rwanda	2,000 (1,874-2,118)	44 (41-45)	1,062 (994-1,129)	10 (7-13)	76,083 (71,263-80,773)	38 (33-42)	35,591 (33,361-37,861)	9 (7-13)
São Tomé and Principe	1,044 (985-1,099)	4 (3-5)	794 (726-874)	4 (2-5)	39,144 (36,220-42,042)	6 (6-11)	24,592 (22,306-27,110)	3 (3-4)
Senegal	1,278 (1,235-1,331)	14 (12-19)	1,009 (947-1,079)	6 (6-11)	49,632 (47,252-52,338)	16 (15-19)	33,824 (31,796-35,962)	7 (7-10)
Seychelles	1,133 (1,099-1,162)	7 (5-10)	1,187 (1,116-1,238)	16 (12-21)	29,858 (28,919-30,862)	3 (3-4)	31,195 (29,079-32,715)	6 (5-7)
Sierra Leone	1,682 (1,578-1,773)	34 (31-40)	1,347 (1,263-1,423)	29 (23-34)	78,271 (72,119-83,863)	40 (34-44)	49,641 (45,708-53,125)	29 (22-31)
Somalia	1,738 (1,407-2,201)	36 (24-45)	1,606 (1,276-2,027)	39 (24-43)	70,184 (59,274-86,060)	32 (24-44)	57,208 (46,126-70,933)	34 (22-43)
South Africa	1,133 (1,071-1,180)	8 (5-10)	1,266 (1,200-1,334)	21 (17-29)	34,540 (32,586-36,273)	5 (4-5)	48,286 (45,928-51,074)	24 (20-30)
Sudan	1,110 (1,054-1,165)	6 (5-9)	799 (744-860)	5 (3-5)	41,735 (39,218-44,421)	11 (8-12)	28,295 (26,208-30,917)	5 (4-6)
Swaziland	1,239 (1,163-1,316)	11 (10-18)	2,186 (1,950-2,429)	45 (43-46)	39,973 (37,549-42,545)	10 (6-11)	80,065 (72,966-87,908)	44 (43-45)
Tanzania	1,357 (1,305-1,407)	22 (18-23)	1,137 (1,053-1,223)	13 (11-18)	55,603 (52,816-58,575)	21 (19-24)	43,461 (40,811-46,456)	17 (15-21)
Togo	1,282 (1,229-1,337)	15 (12-19)	1,199 (1,106-1,296)	17 (13-23)	51,184 (48,232-54,390)	18 (16-20)	46,594 (42,401-51,158)	22 (17-28)
Uganda	1,658 (1,563-1,760)	33 (30-38)	1,290 (1,196-1,387)	24 (18-31)	75,253 (71,264-79,804)	36 (33-41)	45,587 (42,676-48,830)	21 (17-25)
Zambia	1,722 (1,647-1,792)	37 (33-41)	1,533 (1,414-1,644)	38 (33-40)	73,053 (69,561-76,818)	34 (30-39)	57,620 (53,531-61,944)	36 (31-39)
Zimbabwe	1,144 (1,079-1,201)	9 (5-10)	1,801 (1,601-2,023)	43 (40-43)	39,368 (37,293-41,290)	7 (6-10)	65,919 (59,728-72,926)	41 (38-43)

Age-standardized YLD rate (per 100,000)				Life expectancy at birth				Health-adjusted life expectancy at birth			
1990		2010		1990		2010		1990		2010	
Rate	*Rank*	*Rate*	*Rank*	*LE*	*Rank*	*LE*	*Rank*	*HALE*	*Rank*	*HALE*	*Rank*
15,039 (12,384-18,328)	30 (13-46)	13,712 (11,204-16,796)	12 (4-38)	47.9 (41.8-53.1)	41 (28-46)	61.0 (54.3-67.0)	19 (6-39)	40.5 (35.4-44.8)	40 (28-46)	52.0 (46.5-56.7)	19 (7-38)
15,237 (12,408-18,418)	37 (17-46)	13,830 (11,270-16,742)	17 (6-39)	55.9 (55.1-56.8)	23 (20-26)	63.4 (60.8-65.7)	13 (8-20)	46.6 (44.6-48.4)	24 (21-26)	53.7 (50.9-56.4)	14 (8-21)
13,528 (11,131-16,243)	8 (3-28)	14,557 (12,007-17,522)	34 (10-45)	66.7 (64.2-69.4)	3 (2-5)	71.2 (67.7-75.4)	3 (1-5)	56.6 (53.9-59.4)	4 (3-5)	59.3 (55.9-63.1)	4 (3-6)
14,862 (12,335-17,843)	29 (14-44)	13,409 (10,997-16,422)	11 (4-30)	52.1 (51.2-53.1)	30 (27-34)	55.3 (49.9-59.6)	38 (26-44)	43.8 (42.0-45.5)	30 (27-34)	47.2 (42.3-51.2)	37 (23-43)
14,581 (12,072-17,535)	23 (9-42)	14,412 (11,821-17,419)	32 (11-44)	48.9 (41.7-54.7)	39 (25-46)	54.6 (46.4-62.1)	39 (17-46)	41.6 (36.1-46.4)	37 (26-46)	46.4 (39.8-52.5)	39 (18-46)
14,617 (12,034-17,487)	25 (9-43)	13,891 (11,399-16,769)	19 (7-39)	58.3 (57.6-59.1)	18 (16-20)	59.1 (56.1-61.9)	26 (17-36)	49.1 (47.2-50.8)	18 (16-20)	50.2 (47.2-52.8)	26 (17-35)
13,500 (10,843-18,557)	6 (3-46)	12,947 (10,310-20,228)	6 (2-46)	69.8 (68.8-70.9)	1 (1-2)	75.1 (71.7-78.2)	1 (1-3)	59.1 (55.2-61.4)	2 (1-4)	63.8 (58.3-67.3)	2 (1-4)
15,696 (12,822-18,800)	46 (22-46)	15,022 (12,185-18,088)	40 (23-46)	48.4 (46.9-49.8)	44 (37-44)	46.4 (41.9-50.7)	46 (43-46)	40.8 (38.9-42.6)	44 (36-45)	39.7 (35.7-43.3)	46 (43-46)
15,080 (12,463-18,027)	34 (17-45)	14,364 (11,770-17,273)	30 (14-42)	52.5 (51.6-53.3)	28 (27-33)	55.6 (50.3-59.8)	36 (24-43)	43.9 (42.1-45.6)	29 (27-34)	46.9 (42.3-50.7)	38 (25-44)
13,050 (10,566-15,698)	4 (3-16)	12,879 (10,556-15,420)	5 (3-20)	57.6 (54.5-60.3)	19 (14-26)	62.8 (59.2-66.2)	14 (7-27)	49.6 (46.7-52.1)	17 (12-22)	54.1 (50.6-57.4)	12 (7-23)
15,443 (12,837-18,350)	42 (21-46)	14,357 (11,832-17,146)	31 (14-42)	54.7 (52.8-56.6)	26 (21-29)	58.9 (55.2-61.9)	27 (16-37)	46.0 (43.7-48.2)	26 (22-28)	50.0 (46.6-53.2)	27 (17-37)
14,774 (12,072-17,557)	27 (13-43)	13,910 (11,545-16,710)	21 (8-37)	55.7 (54.7-56.8)	24 (20-26)	56.1 (52.4-59.5)	35 (25-42)	46.9 (45.1-48.6)	23 (20-26)	47.8 (44.2-51.0)	34 (24-42)
15,361 (12,601-18,581)	41 (19-46)	15,099 (12,414-18,230)	41 (23-46)	53.0 (51.4-54.4)	27 (26-33)	55.2 (52.6-57.6)	40 (31-42)	44.3 (42.2-46.3)	27 (26-33)	46.4 (43.8-48.9)	40 (32-42)
15,508 (12,589-18,732)	43 (19-46)	14,614 (11,947-17,617)	37 (14-45)	52.4 (51.1-53.6)	29 (27-34)	60.6 (57.4-63.8)	20 (13-32)	44.0 (42.2-45.9)	28 (27-34)	51.2 (48.0-54.0)	21 (14-32)
13,713 (11,166-16,563)	10 (5-21)	12,723 (10,356-15,313)	3 (3-12)	46.7 (45.5-47.8)	45 (43-46)	60.9 (59.5-62.2)	18 (15-26)	40.2 (38.7-41.7)	45 (40-45)	52.5 (50.4-54.3)	16 (13-22)
14,356 (11,679-17,423)	18 (6-43)	14,462 (11,862-17,640)	33 (8-45)	60.0 (58.6-61.2)	15 (12-17)	58.8 (54.4-62.7)	28 (14-38)	50.8 (48.7-52.8)	14 (11-17)	49.9 (46.1-53.6)	28 (15-38)
14,365 (11,770-17,302)	17 (7-43)	13,291 (10,712-16,349)	9 (3-36)	57.4 (52.1-61.5)	20 (12-30)	62.5 (56.2-68.4)	15 (6-35)	48.5 (44.3-52.1)	20 (12-28)	53.3 (48.2-58.8)	15 (5-32)
14,555 (12,022-17,541)	21 (11-39)	13,298 (10,950-15,894)	7 (4-24)	60.6 (59.2-61.9)	13 (11-16)	64.9 (63.1-66.7)	8 (6-14)	50.9 (48.8-53.0)	13 (11-17)	55.3 (52.8-57.6)	9 (6-14)
14,811 (11,975-17,817)	28 (10-44)	14,194 (11,615-17,119)	28 (10-42)	52.1 (51.3-52.8)	31 (28-34)	59.4 (55.4-62.7)	25 (14-37)	43.7 (41.9-45.4)	31 (27-35)	50.2 (46.6-53.5)	25 (15-37)
14,670 (11,995-17,800)	26 (9-43)	14,148 (11,567-17,461)	25 (8-43)	50.9 (46.3-55.0)	33 (26-45)	56.9 (50.6-63.0)	32 (15-43)	42.9 (39.2-46.3)	33 (26-45)	48.2 (43.2-53.2)	32 (16-43)
13,184 (10,866-15,755)	5 (3-14)	12,884 (10,647-15,396)	4 (3-16)	63.0 (62.2-63.7)	7 (6-10)	64.8 (62.8-66.6)	9 (6-15)	53.8 (52.0-55.5)	6 (6-9)	55.5 (53.2-57.8)	8 (6-14)
13,503 (11,095-16,398)	7 (3-26)	15,483 (12,696-18,367)	44 (31-46)	60.9 (59.7-62.1)	12 (11-15)	47.5 (44.9-50.1)	45 (44-46)	52.0 (50.0-53.9)	11 (8-14)	40.3 (37.7-42.6)	45 (44-46)
15,298 (12,537-18,572)	38 (17-46)	15,200 (12,479-18,353)	42 (27-46)	49.6 (47.6-51.1)	38 (33-43)	57.2 (55.1-59.1)	33 (26-38)	41.4 (39.3-43.4)	39 (34-45)	47.7 (45.2-50.0)	36 (29-39)
14,116 (11,612-16,973)	14 (6-39)	14,145 (11,563-17,065)	26 (8-42)	56.1 (55.2-57.0)	22 (20-25)	63.6 (61.0-65.9)	12 (7-19)	47.6 (45.7-49.2)	22 (19-24)	53.8 (51.0-56.5)	13 (8-20)
15,082 (12,396-18,118)	35 (19-44)	14,549 (12,011-17,620)	36 (17-43)	48.7 (48.0-49.5)	42 (38-44)	52.9 (51.1-54.7)	42 (37-43)	41.0 (39.3-42.4)	42 (37-44)	45.0 (43.0-47.0)	41 (37-43)
14,609 (11,996-17,685)	24 (11-40)	13,991 (11,430-16,879)	24 (9-39)	48.7 (48.1-49.3)	43 (38-44)	57.3 (53.4-60.4)	31 (21-40)	41.1 (39.5-42.6)	41 (37-44)	48.6 (45.0-51.8)	31 (21-40)
15,248 (12,506-18,559)	36 (18-46)	14,307 (11,651-17,295)	29 (12-46)	60.2 (59.2-61.2)	14 (12-16)	64.5 (60.7-67.6)	11 (6-21)	50.3 (48.1-52.1)	15 (12-18)	54.3 (50.4-57.5)	11 (6-24)
11,333 (9,373-13,820)	1 (1-2)	10,953 (9,055-13,131)	1 (1-2)	68.9 (68.7-69.1)	2 (1-3)	73.2 (72.9-73.5)	2 (1-3)	60.3 (58.5-61.8)	1 (1-2)	63.9 (62.1-65.6)	1 (1-2)
15,342 (12,595-18,469)	39 (18-46)	14,841 (12,229-18,090)	39 (18-46)	50.0 (49.2-50.8)	36 (33-40)	52.6 (50.1-55.0)	43 (37-44)	41.8 (40.1-43.3)	38 (34-42)	44.5 (42.0-47.0)	43 (38-44)
13,774 (11,339-16,490)	11 (4-28)	13,809 (11,363-16,481)	14 (6-37)	62.4 (61.6-63.2)	9 (7-11)	61.6 (59.2-63.9)	17 (12-26)	53.2 (51.3-54.9)	8 (6-11)	52.5 (50.0-55.1)	17 (12-25)
14,526 (11,819-17,512)	19 (8-42)	13,915 (11,287-16,885)	22 (7-39)	46.2 (45.4-46.9)	46 (43-46)	57.8 (52.9-61.8)	30 (17-40)	38.9 (37.4-40.4)	46 (44-46)	48.9 (44.8-52.9)	30 (18-41)
14,273 (11,679-17,286)	15 (10-30)	13,842 (11,322-16,609)	16 (10-32)	55.1 (53.9-56.2)	25 (22-27)	59.6 (57.8-61.3)	24 (18-31)	46.4 (44.4-48.3)	25 (22-27)	50.5 (48.2-52.5)	24 (19-31)
15,064 (12,345-18,050)	32 (15-45)	13,895 (11,380-16,696)	20 (7-40)	49.7 (48.4-50.9)	37 (33-42)	64.6 (63.2-65.9)	10 (7-14)	42.2 (40.4-43.9)	35 (32-40)	54.7 (52.7-56.7)	10 (8-15)
13,532 (11,028-16,399)	9 (3-28)	13,252 (10,889-15,942)	8 (3-33)	63.5 (62.0-64.8)	6 (5-10)	70.2 (67.6-72.7)	4 (3-5)	53.8 (51.5-56.0)	7 (5-10)	59.6 (56.7-62.5)	3 (2-5)
13,914 (11,500-16,946)	13 (5-30)	13,379 (10,885-16,061)	10 (4-32)	58.8 (57.9-59.7)	16 (15-19)	65.3 (63.7-67.0)	7 (6-13)	49.9 (48.0-51.7)	16 (14-19)	55.7 (53.3-57.8)	7 (6-13)
11,681 (9,463-14,149)	2 (1-4)	11,259 (9,160-13,515)	2 (1-3)	66.7 (66.1-67.3)	4 (3-4)	66.1 (65.3-66.9)	6 (6-9)	58.3 (56.5-60.0)	3 (2-4)	58.1 (56.2-59.7)	5 (3-6)
15,322 (12,518-18,441)	40 (20-46)	15,221 (12,420-18,389)	43 (26-46)	48.9 (47.6-50.1)	40 (35-44)	58.7 (56.5-60.6)	29 (20-35)	40.9 (39.1-42.8)	43 (36-45)	49.1 (46.5-51.5)	29 (23-36)
14,350 (11,688-17,404)	16 (6-43)	14,546 (11,973-17,647)	35 (13-44)	51.6 (45.1-56.8)	32 (21-46)	56.2 (48.1-62.2)	34 (15-44)	43.9 (38.5-48.3)	32 (21-45)	47.6 (41.4-52.4)	33 (18-44)
12,905 (10,595-15,408)	3 (2-11)	13,826 (11,406-16,608)	15 (8-34)	64.6 (63.5-65.8)	5 (4-6)	59.9 (57.5-61.8)	23 (16-31)	55.5 (53.5-57.3)	5 (4-6)	51.1 (48.8-53.2)	22 (16-30)
15,584 (12,830-18,747)	44 (25-46)	14,781 (12,215-17,870)	38 (21-45)	62.1 (61.2-63.1)	11 (7-12)	68.8 (67.0-70.6)	5 (3-6)	51.4 (49.0-53.4)	12 (10-16)	57.1 (54.4-59.5)	6 (4-9)
13,819 (11,344-16,614)	12 (5-29)	15,781 (12,925-18,907)	46 (36-46)	62.3 (60.9-63.7)	10 (6-12)	49.5 (46.7-52.5)	44 (42-46)	53.0 (51.0-55.0)	9 (6-11)	41.9 (39.3-44.5)	44 (42-46)
14,553 (11,922-17,667)	20 (9-42)	14,177 (11,555-17,240)	27 (9-42)	56.7 (55.8-57.4)	21 (19-23)	61.7 (59.9-63.8)	16 (12-24)	47.7 (45.8-49.5)	21 (19-24)	52.2 (49.7-54.5)	18 (13-25)
14,577 (11,954-17,755)	22 (10-42)	13,973 (11,447-16,887)	23 (6-40)	58.3 (57.3-59.2)	17 (16-20)	60.2 (57.2-62.9)	22 (14-32)	49.0 (46.9-50.9)	19 (16-21)	51.0 (47.9-53.7)	23 (14-32)
15,596 (12,780-18,763)	45 (26-46)	13,882 (11,434-16,785)	18 (7-39)	50.4 (49.0-51.9)	35 (32-40)	60.4 (58.2-62.5)	21 (15-30)	42.2 (40.4-44.0)	36 (32-41)	51.4 (49.0-53.8)	20 (15-28)
15,030 (12,440-17,875)	31 (14-46)	13,732 (11,383-16,403)	13 (6-36)	50.6 (49.5-51.7)	34 (32-38)	55.9 (53.3-58.2)	37 (29-41)	42.7 (41.0-44.3)	34 (31-38)	47.8 (45.1-50.3)	35 (28-40)
15,058 (12,485-17,828)	33 (18-44)	15,659 (12,887-18,558)	45 (36-46)	63.0 (61.8-64.1)	8 (6-11)	53.2 (50.0-56.3)	41 (34-44)	52.7 (50.6-54.6)	10 (7-12)	44.8 (41.9-47.5)	42 (36-44)

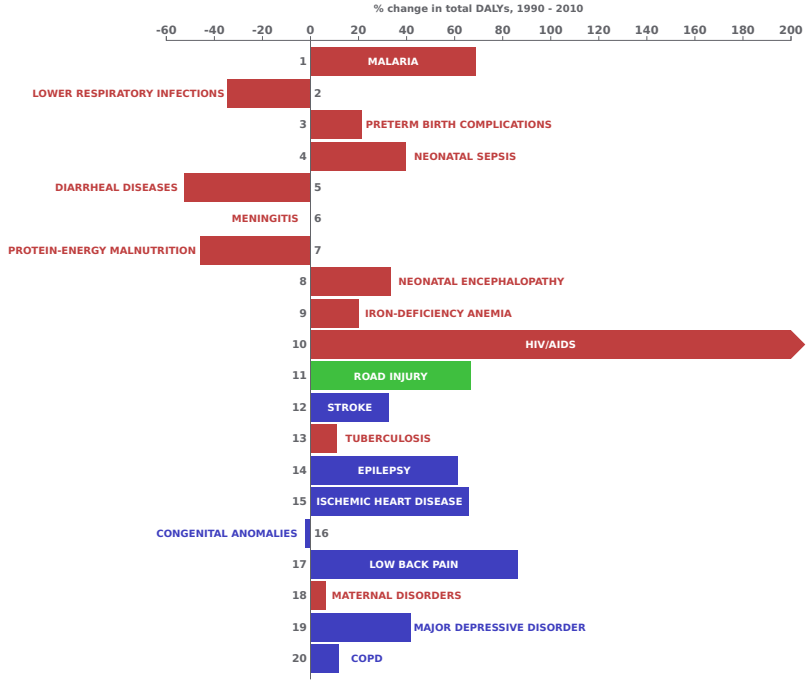
CHANGES IN LEADING CAUSES OF DALYS BETWEEN 1990 AND 2010 FOR COUNTRIES IN SUB-SAHARAN AFRICA

In the following figures, pointed arrows indicate causes that have increased by a greater amount than shown on the x-axis. For more country data, explore IHME's data visualization tools online: www.ihmeuw.org/GBDcountryviz.

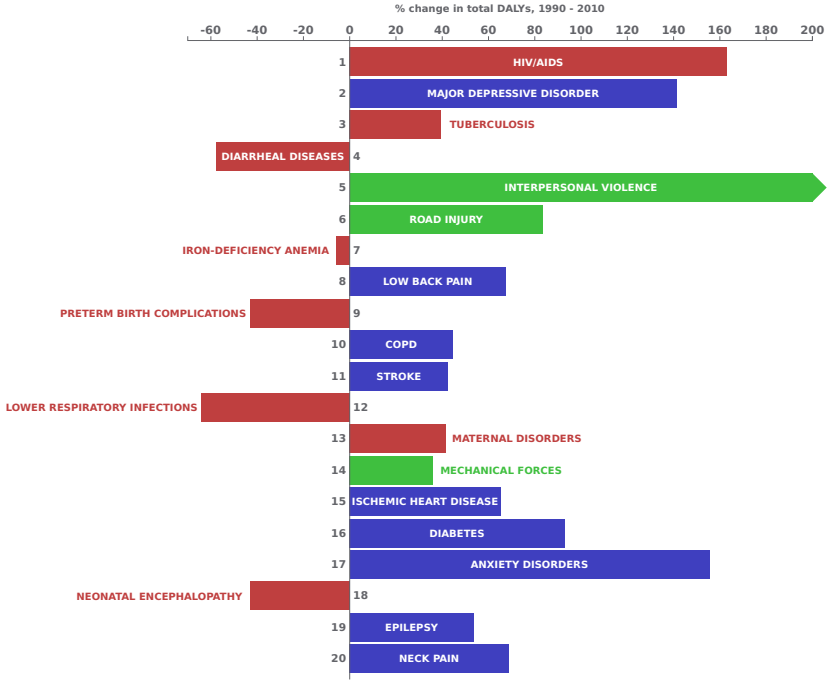
Shifts in leading causes of DALYs in Angola, 1990-2010



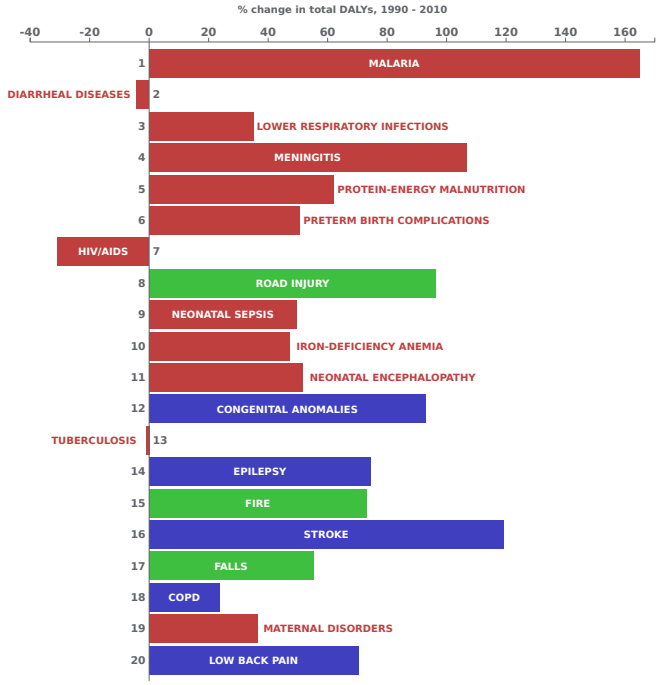
Shifts in leading causes of DALYs in Benin, 1990-2010



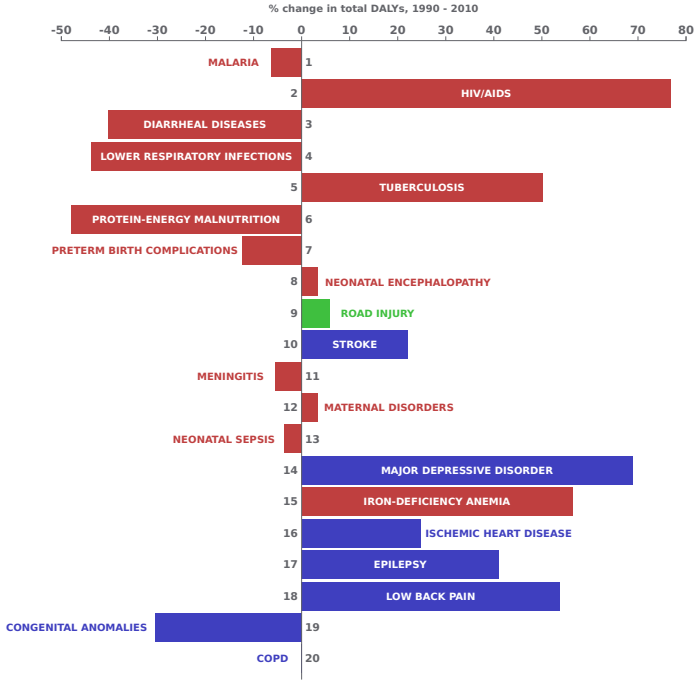
Shifts in leading causes of DALYs in Botswana, 1990-2010



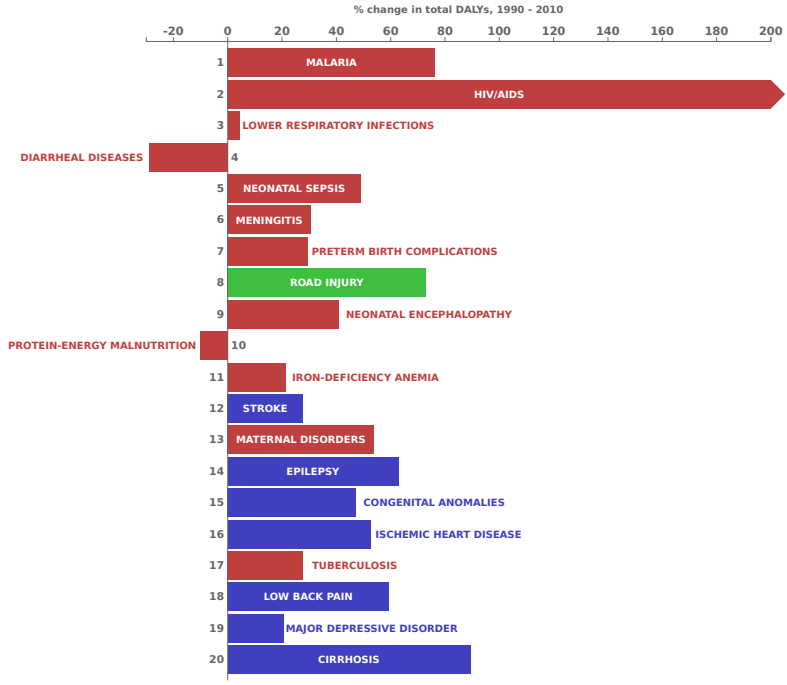
Shifts in leading causes of DALYs in Burkina Faso, 1990-2010



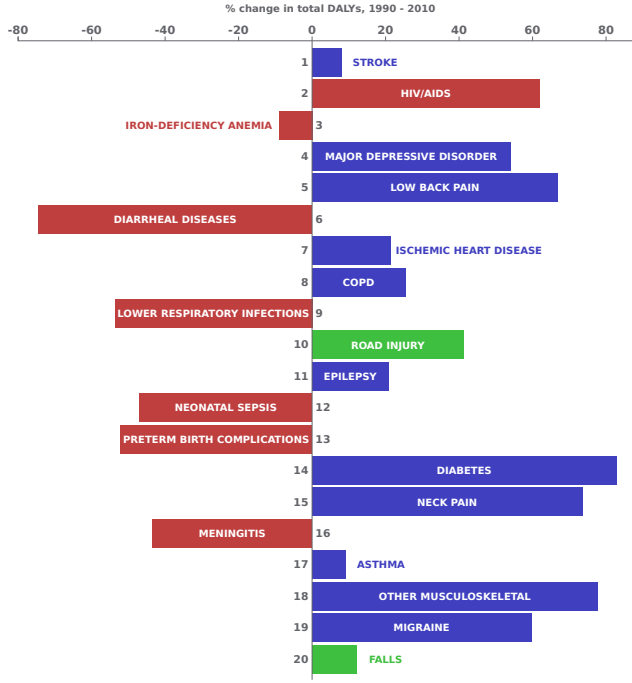
Shifts in leading causes of DALYs in Burundi, 1990-2010



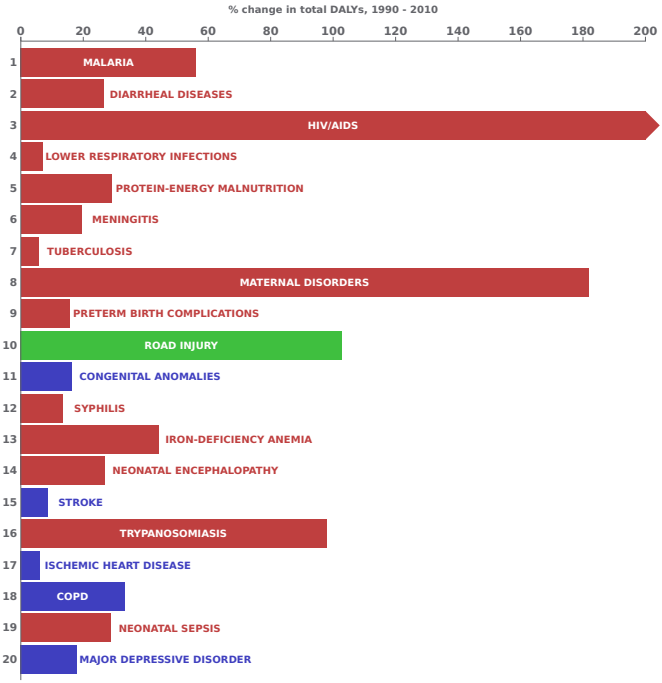
Shifts in leading causes of DALYs in Cameroon, 1990-2010



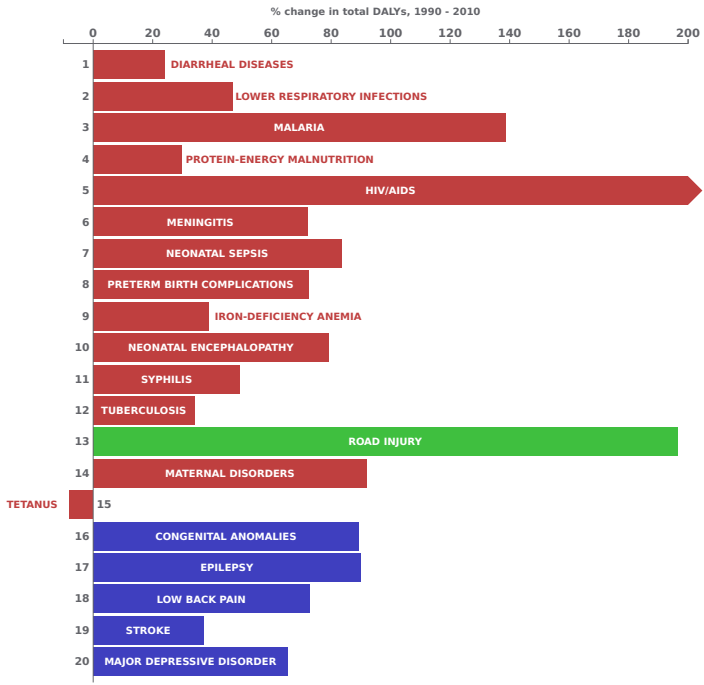
Shifts in leading causes of DALYs in Cape Verde, 1990-2010



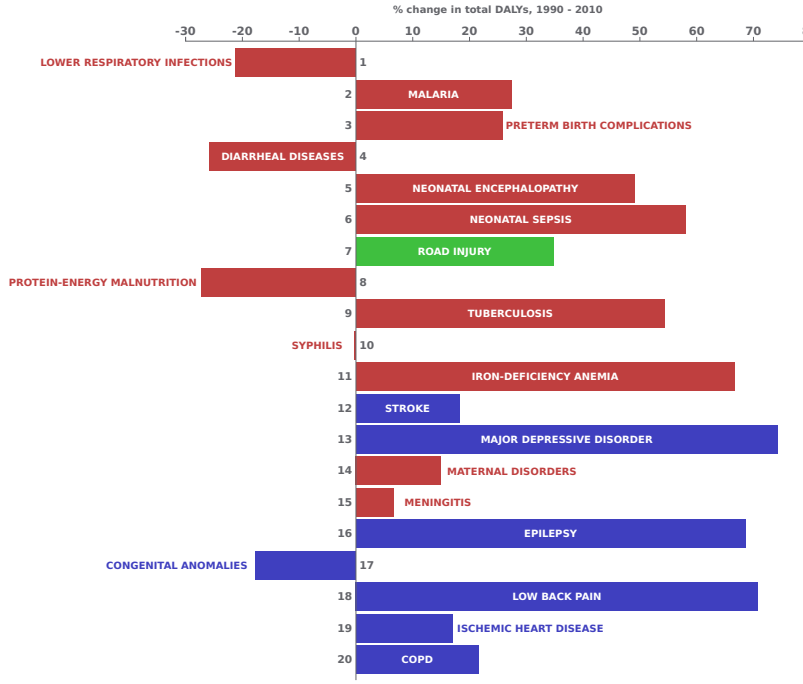
Shifts in leading causes of DALYs in the Central African Republic, 1990-2010



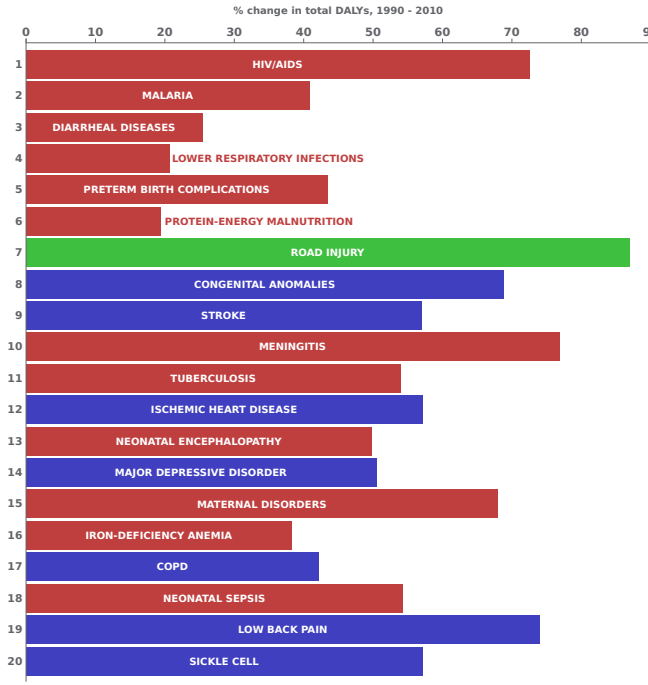
Shifts in leading causes of DALYs in Chad, 1990-2010



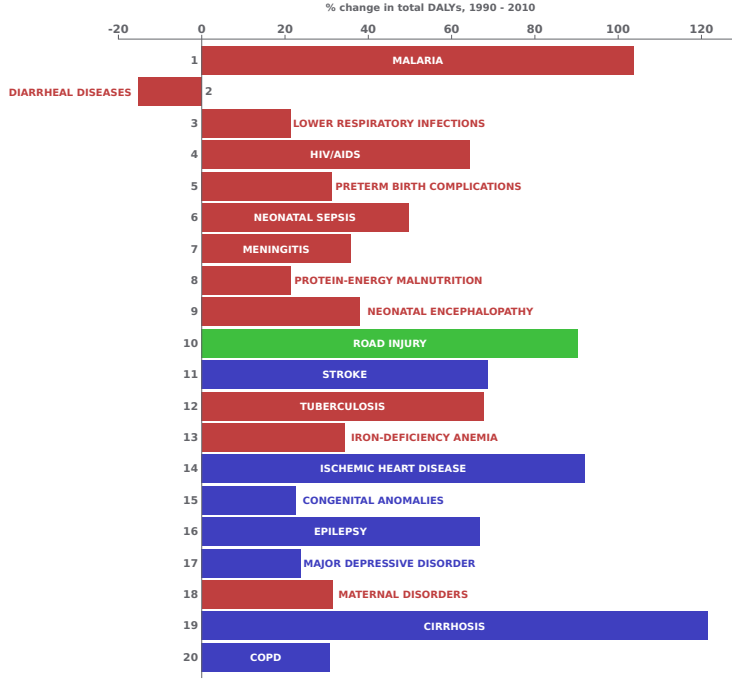
Shifts in leading causes of DALYs in Comoros, 1990-2010



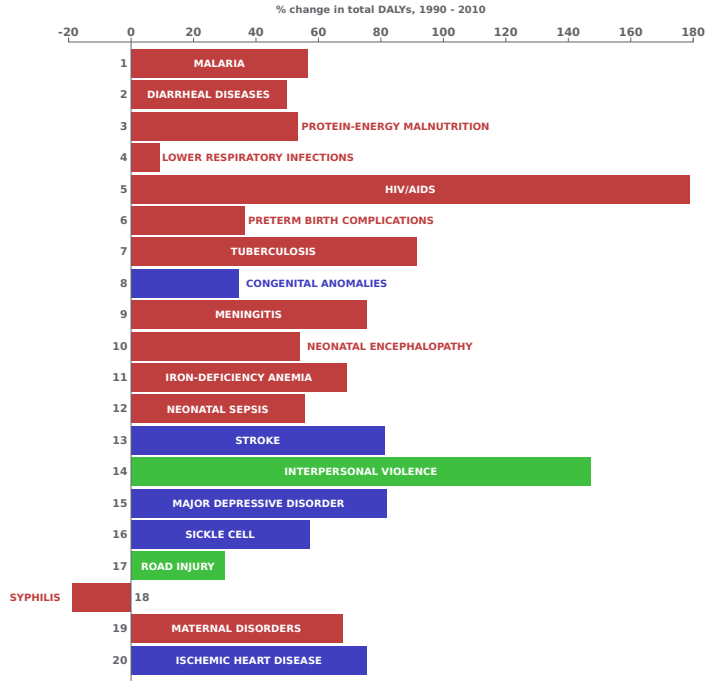
Shifts in leading causes of DALYs in Congo, 1990-2010



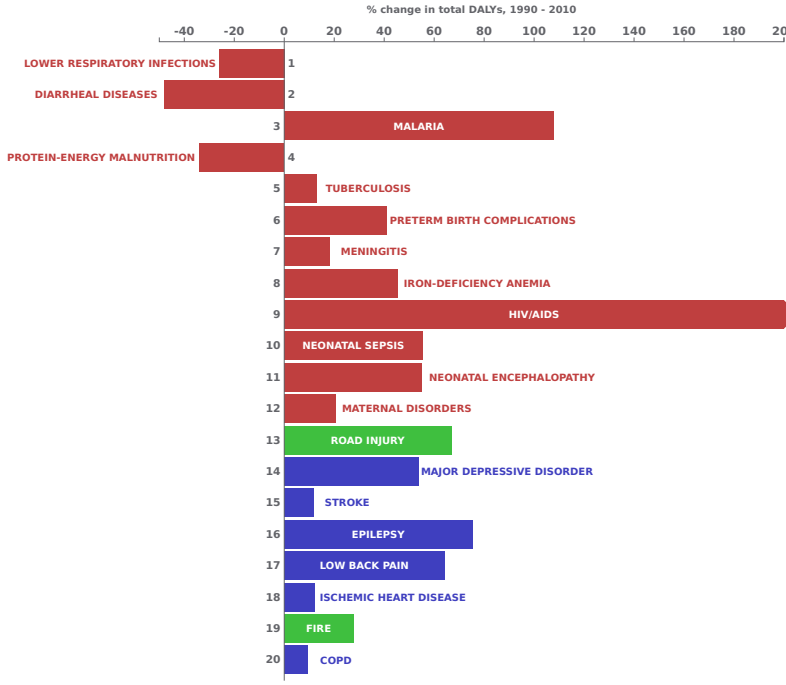
Shifts in leading causes of DALYs in Côte d'Ivoire, 1990-2010



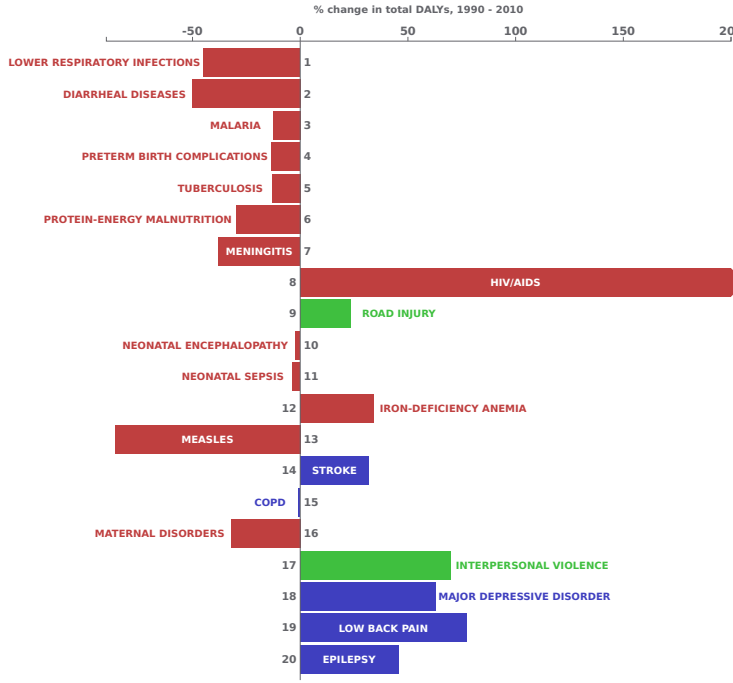
Shifts in leading causes of DALYs in Democratic Republic of the Congo, 1990-2010



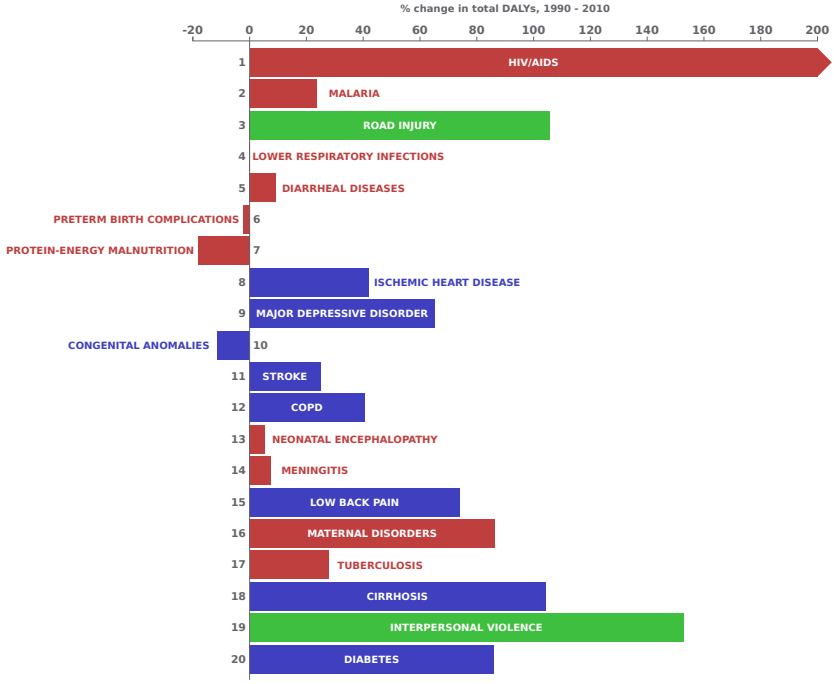
Shifts in leading causes of DALYs in Eritrea, 1990-2010



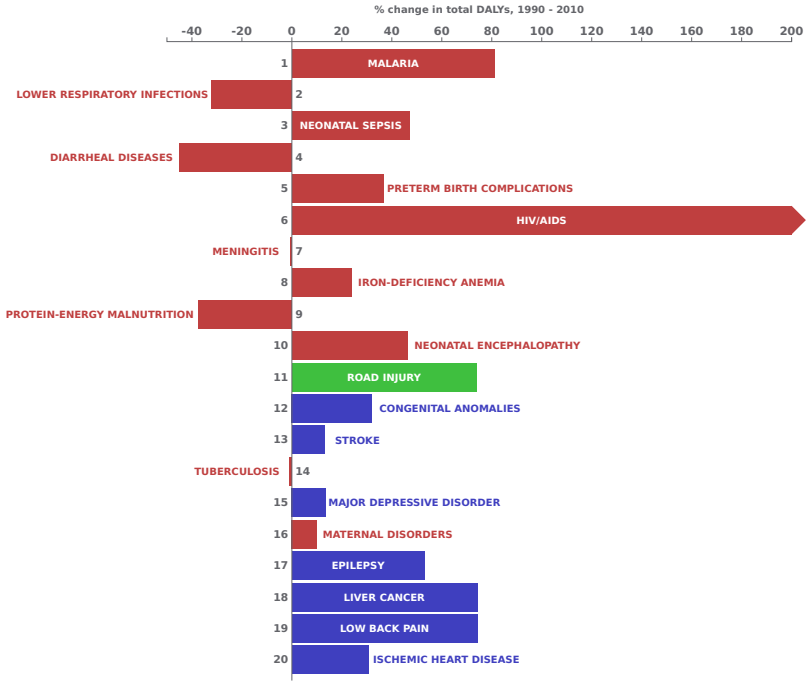
Shifts in leading causes of DALYs in Ethiopia, 1990-2010



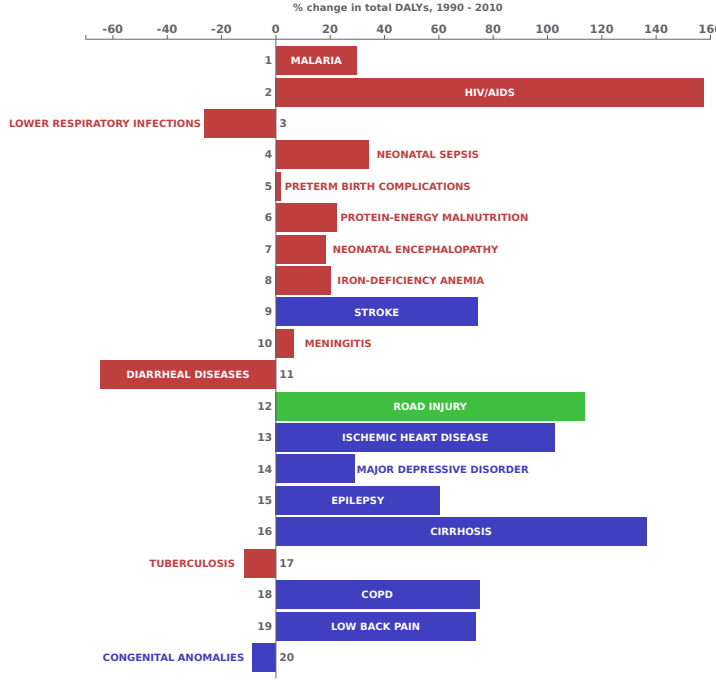
Shifts in leading causes of DALYs in Gabon, 1990-2010



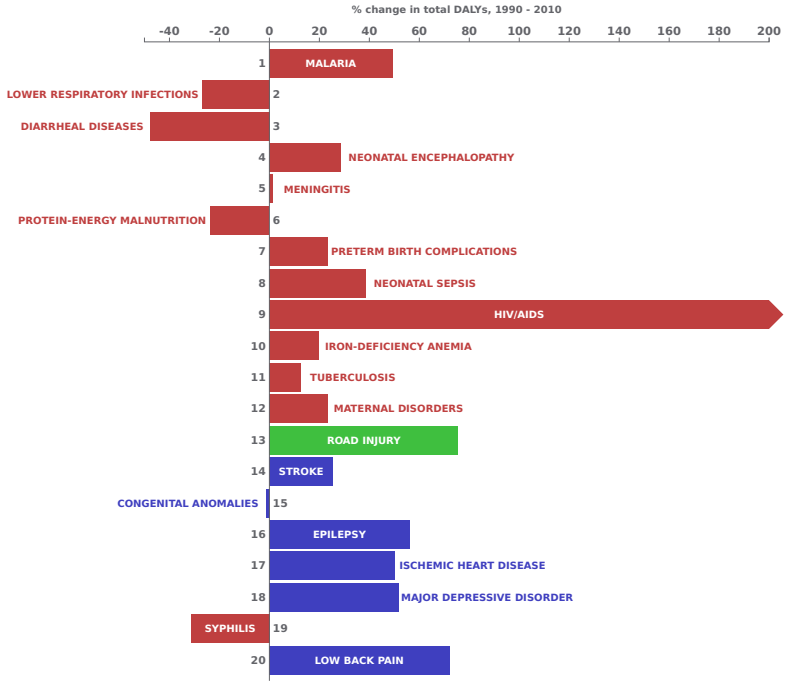
Shifts in leading causes of DALYs in The Gambia, 1990-2010



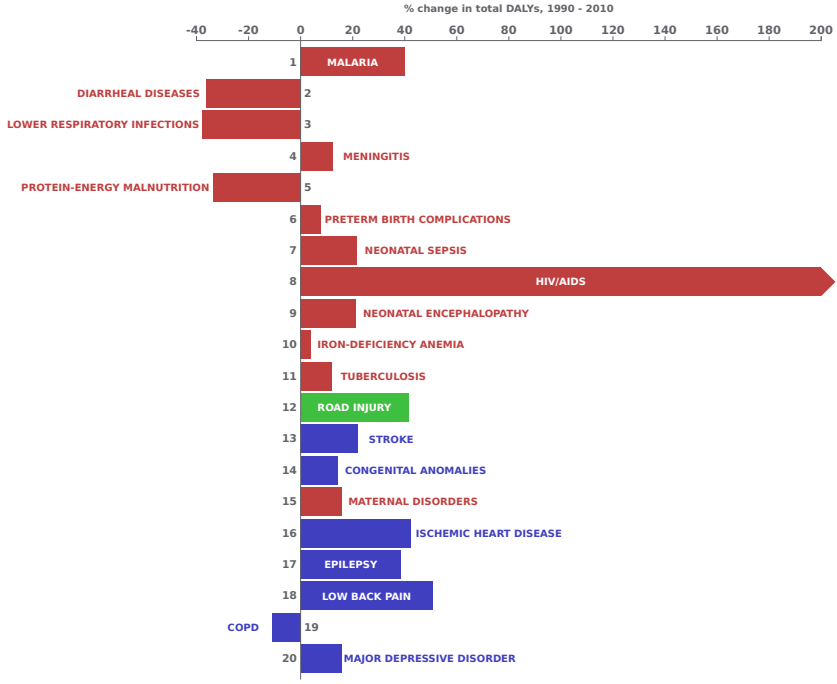
Shifts in leading causes of DALYs in Ghana, 1990-2010



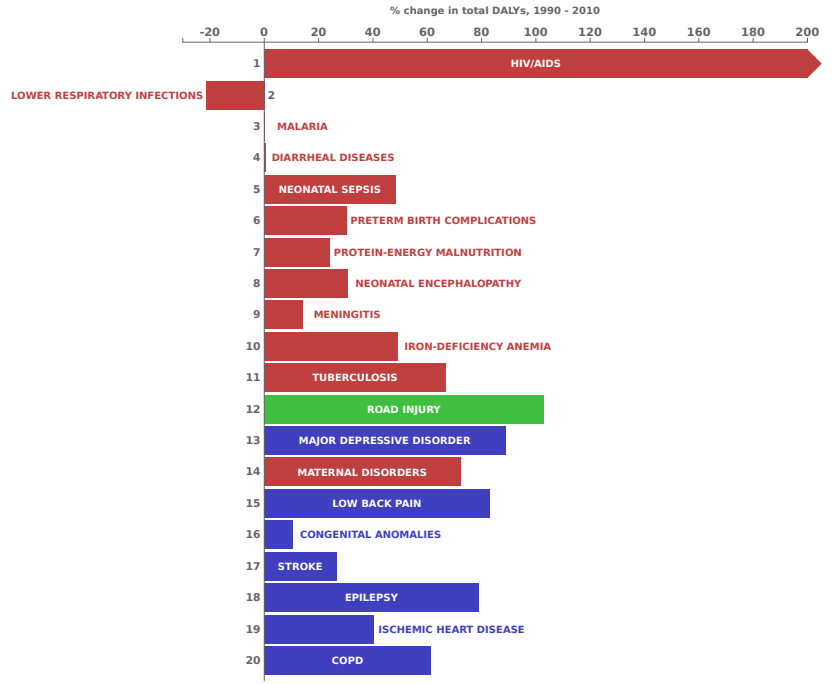
Shifts in leading causes of DALYs in Guinea, 1990-2010



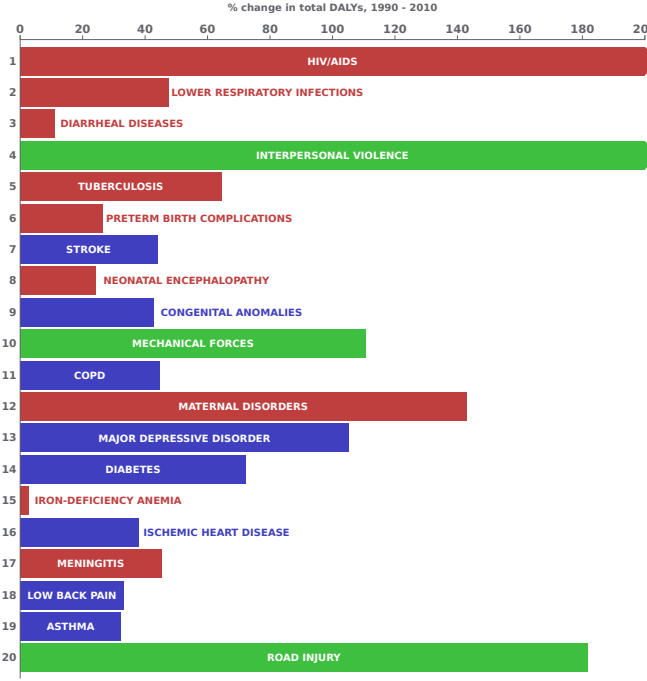
Shifts in leading causes of DALYs in Guinea-Bissau, 1990-2010



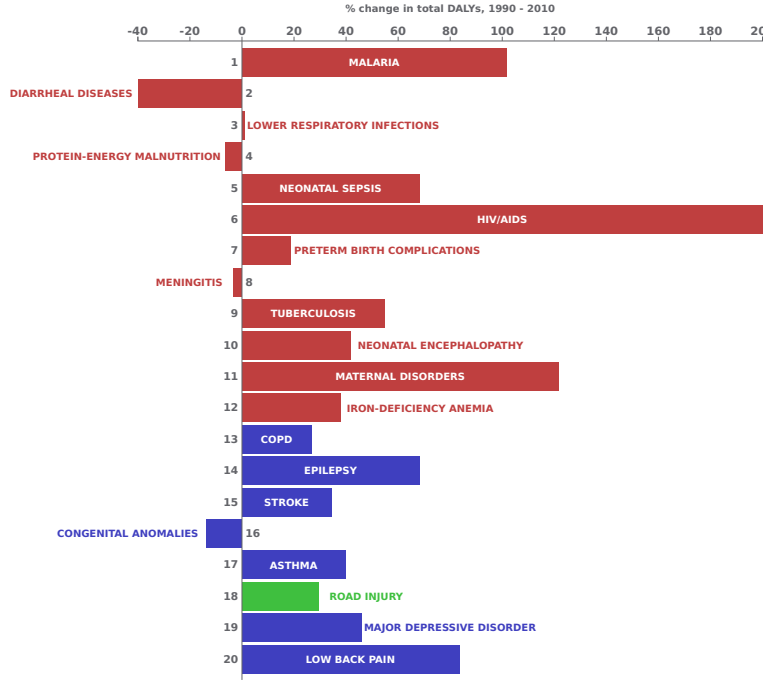
Shifts in leading causes of DALYs in Kenya, 1990-2010



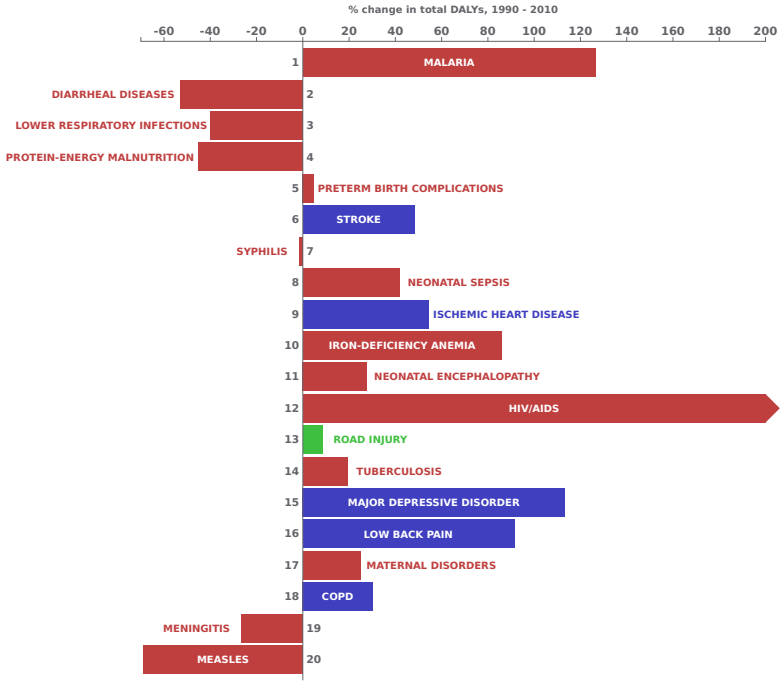
Shifts in leading causes of DALYs in Lesotho, 1990-2010



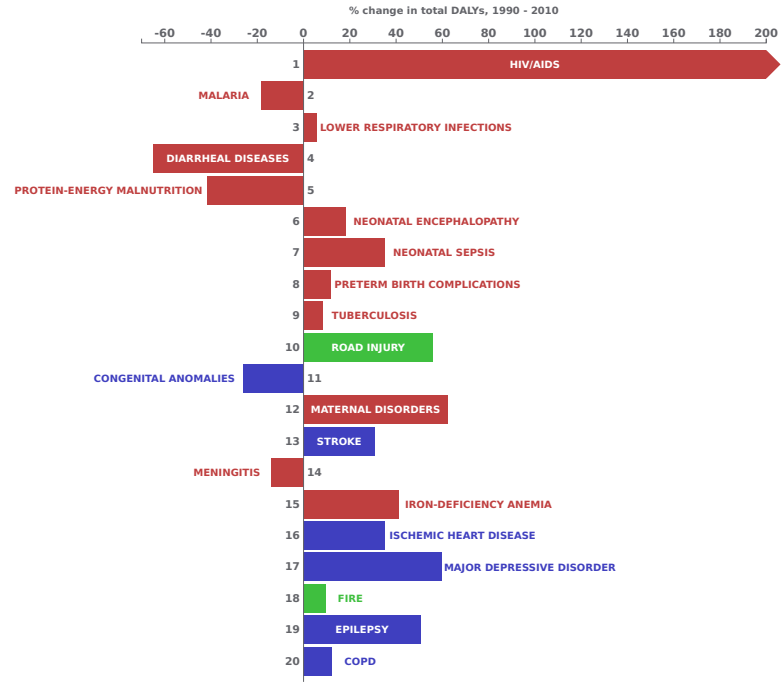
Shifts in leading causes of DALYs in Liberia, 1990-2010



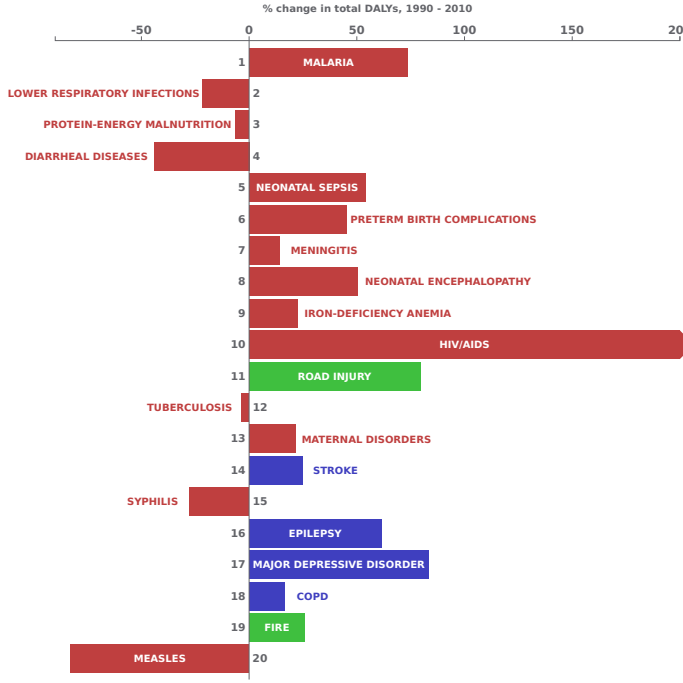
Shifts in leading causes of DALYs in Madagascar, 1990-2010



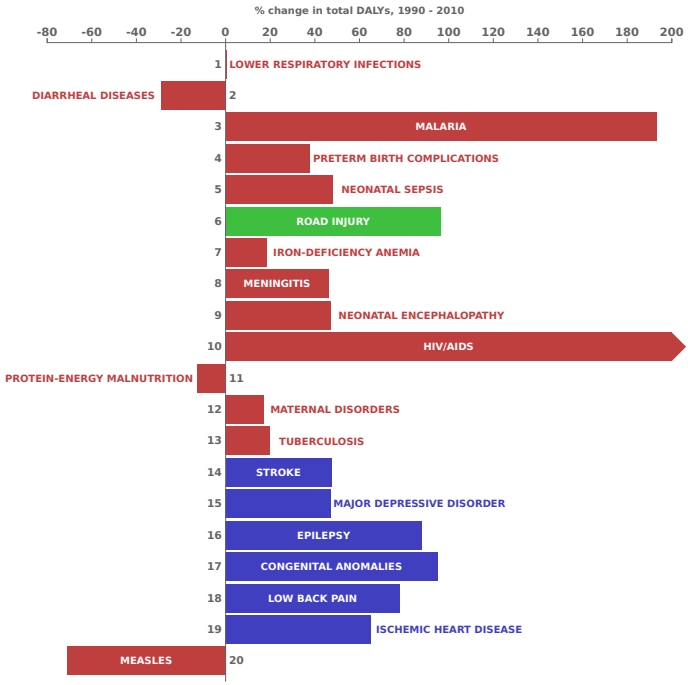
Shifts in leading causes of DALYs in Malawi, 1990-2010



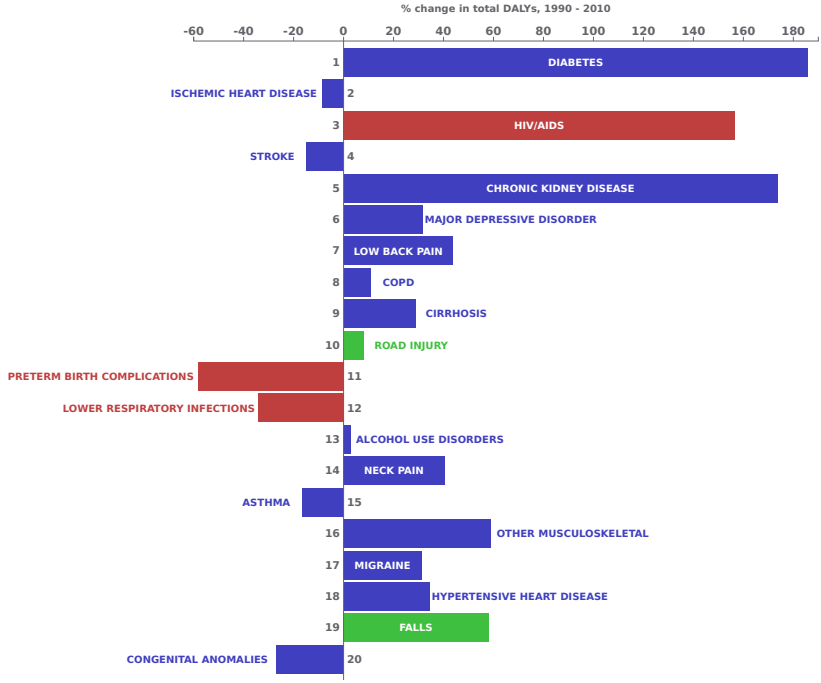
Shifts in leading causes of DALYs in Mali, 1990-2010



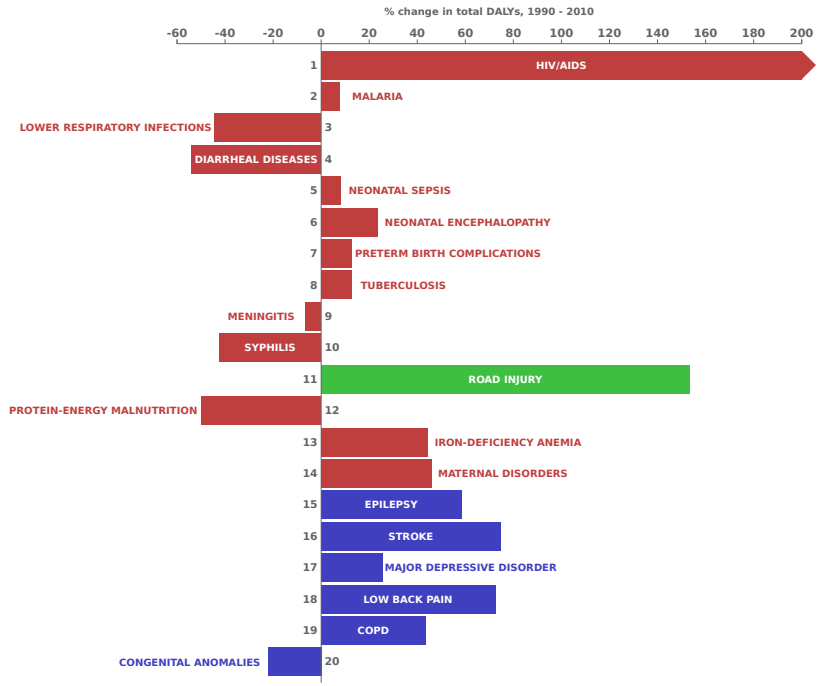
Shifts in leading causes of DALYs in Mauritania, 1990-2010



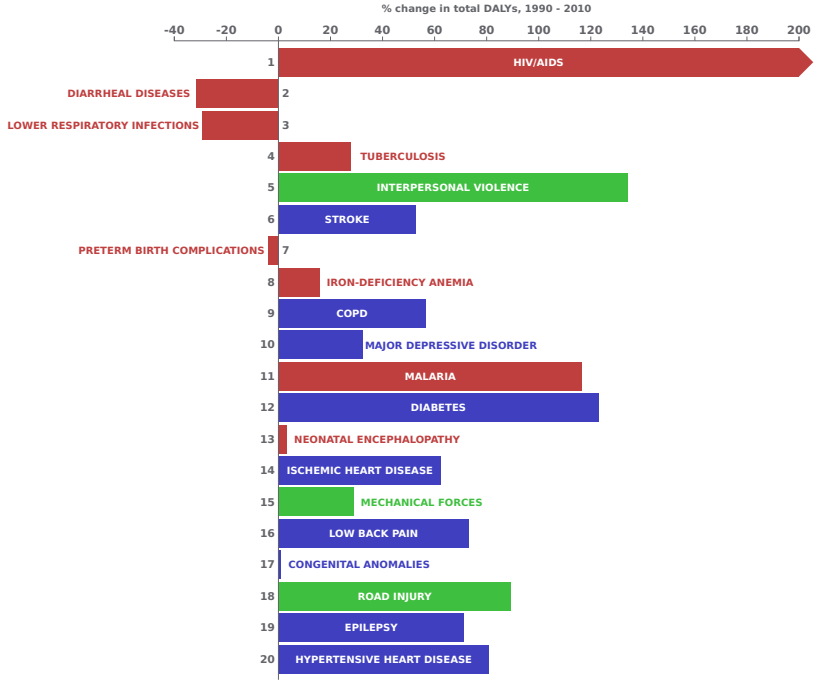
Shifts in leading causes of DALYs in Mauritius, 1990-2010



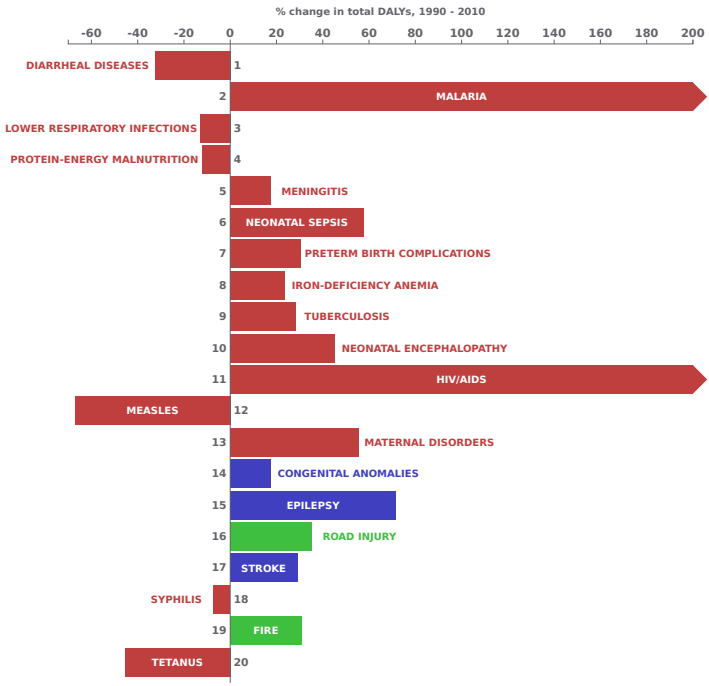
Shifts in leading causes of DALYs in Mozambique, 1990-2010



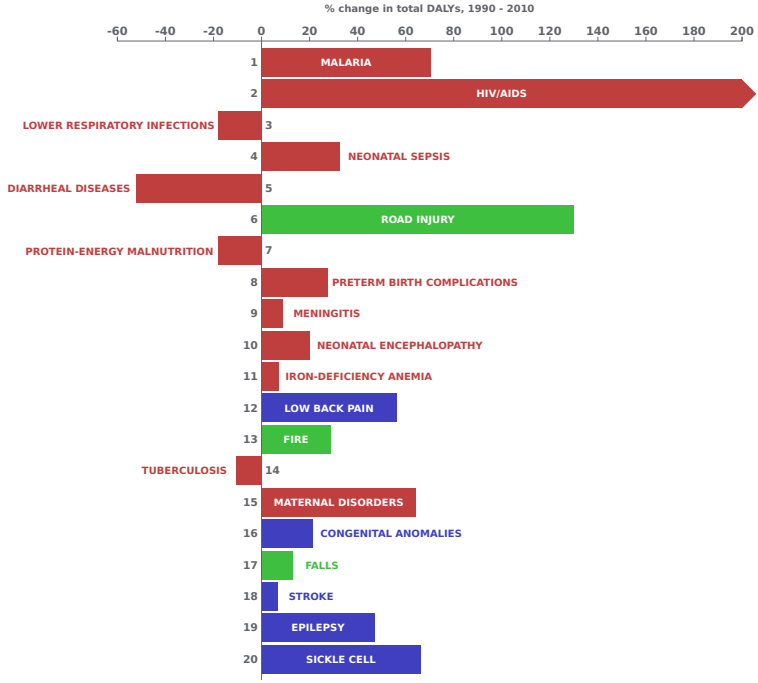
Shifts in leading causes of DALYs in Namibia, 1990-2010



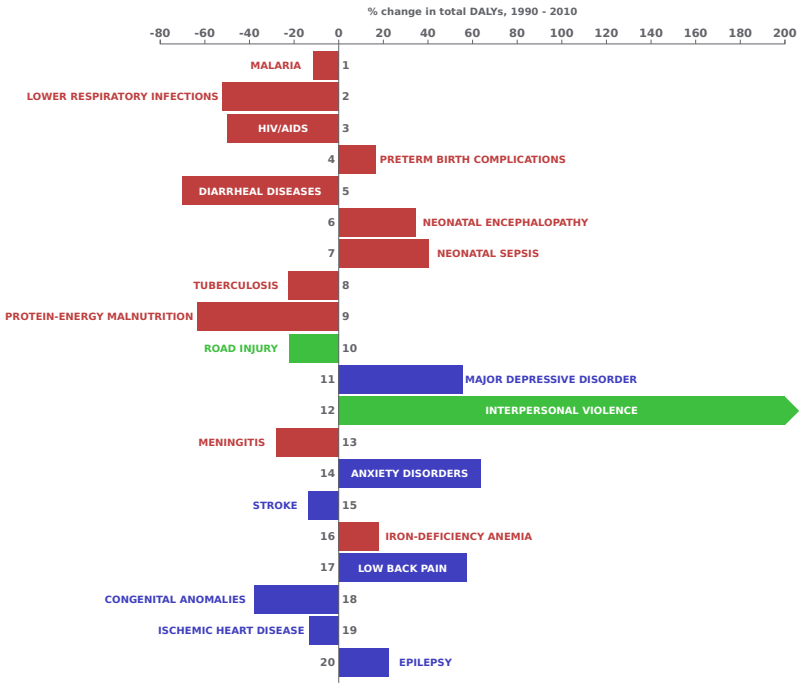
Shifts in leading causes of DALYs in Niger, 1990-2010



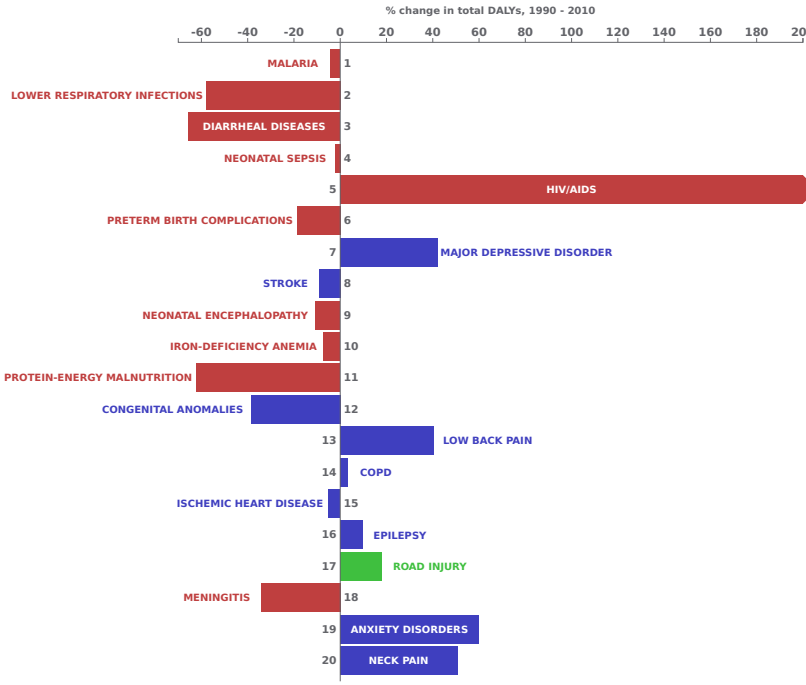
Shifts in leading causes of DALYs in Nigeria, 1990-2010



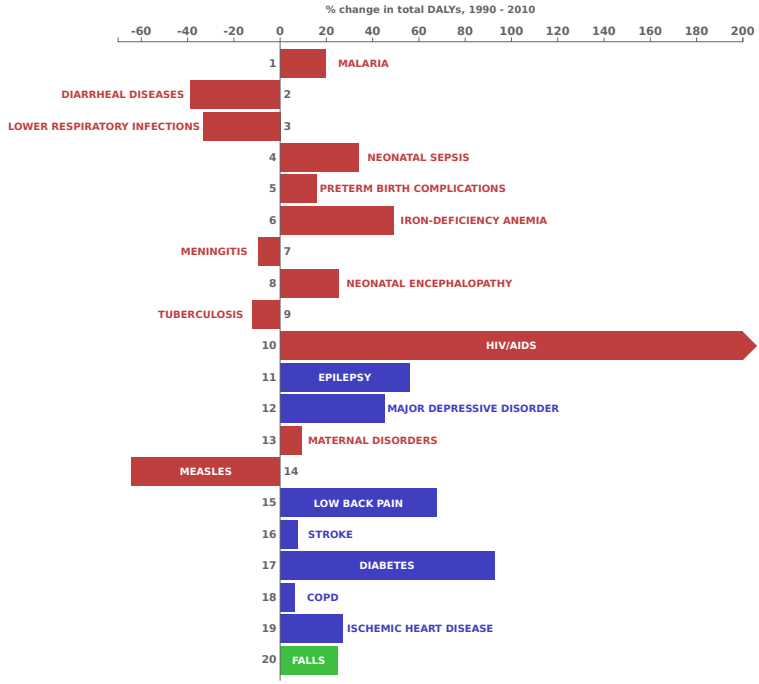
Shifts in leading causes of DALYs in Rwanda, 1990-2010



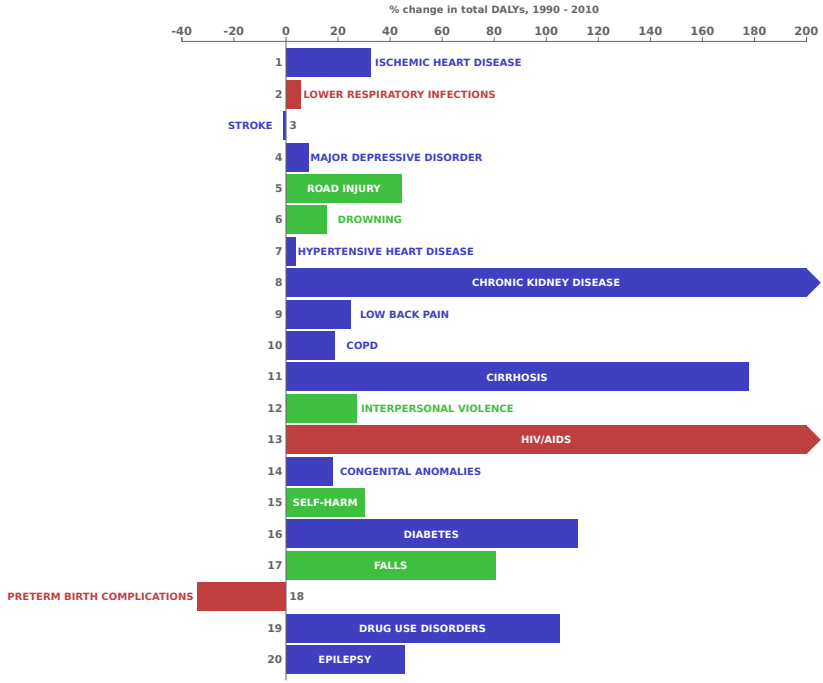
Shifts in leading causes of DALYs in São Tomé and Príncipe, 1990-2010



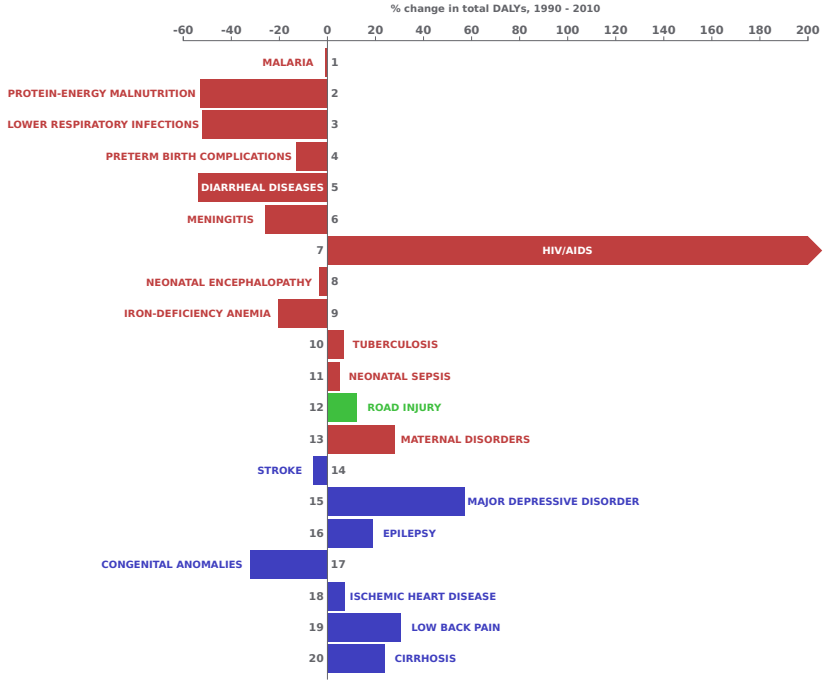
Shifts in leading causes of DALYs in Senegal, 1990-2010



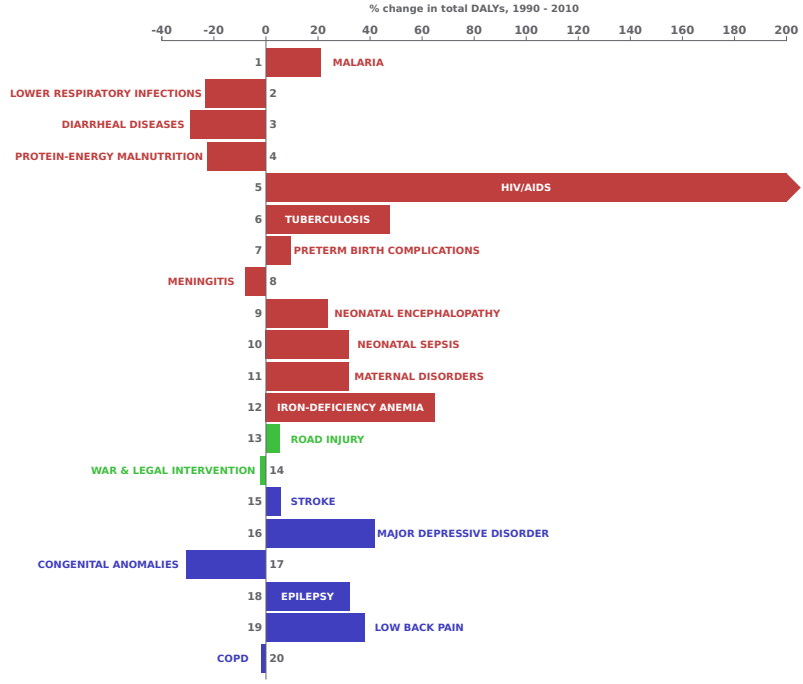
Shifts in leading causes of DALYs in Seychelles, 1990-2010



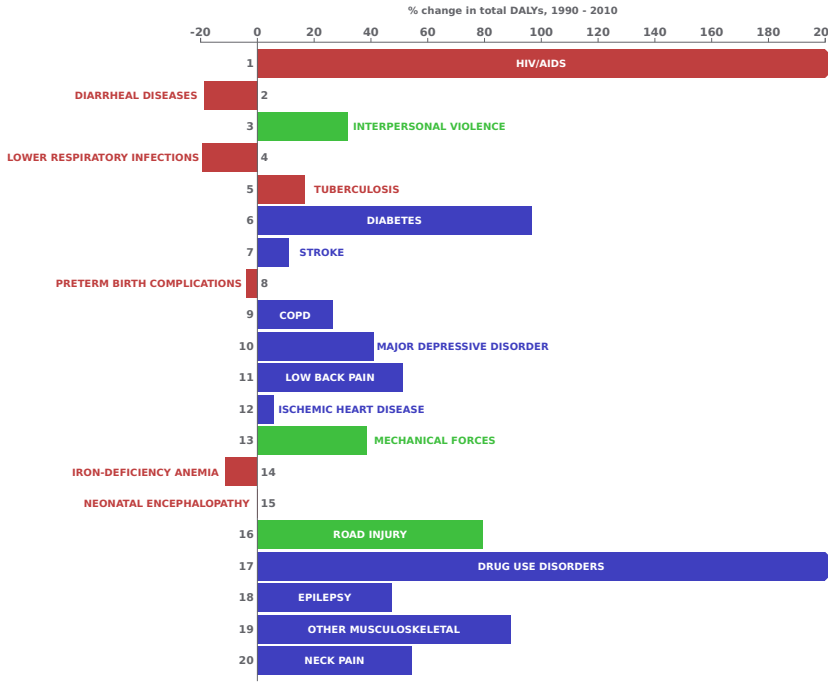
Shifts in leading causes of DALYs in Sierra Leone, 1990-2010



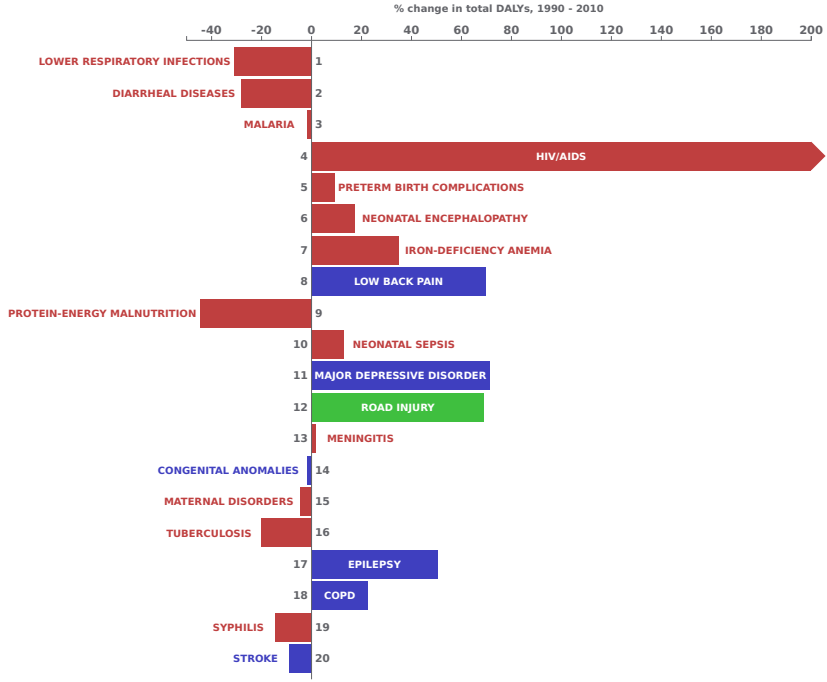
Shifts in leading causes of DALYs in Somalia, 1990-2010



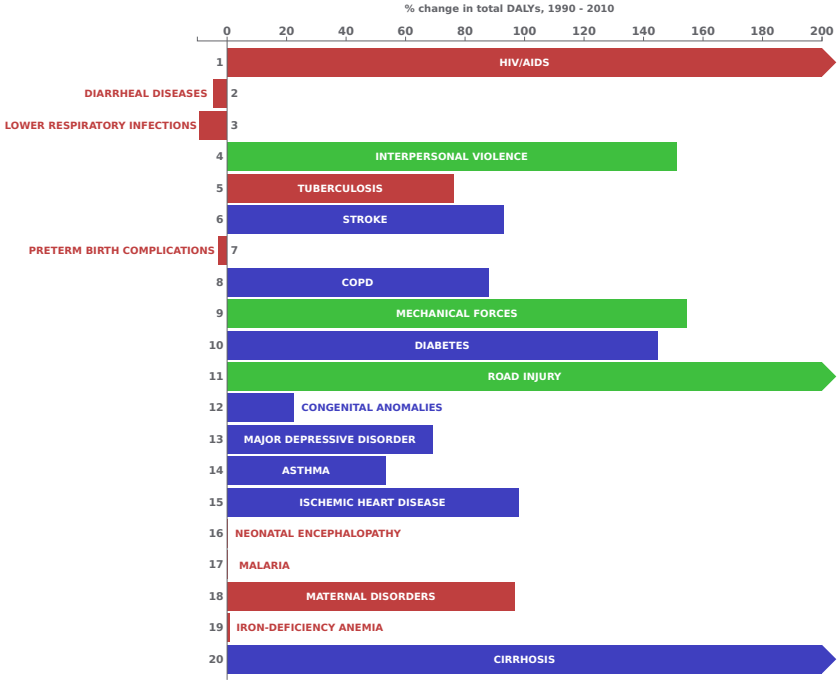
Shifts in leading causes of DALYs in South Africa, 1990-2010



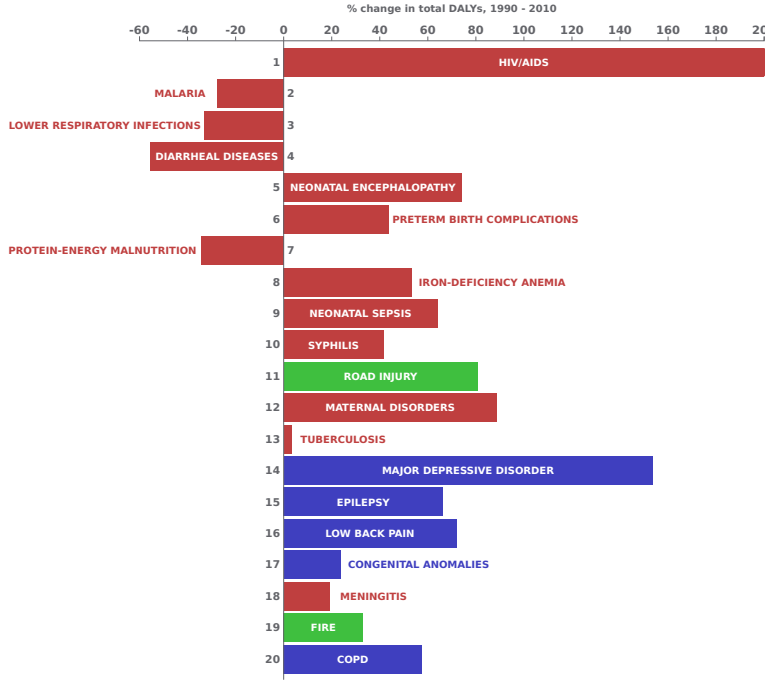
Shifts in leading causes of DALYs in Sudan, 1990-2010



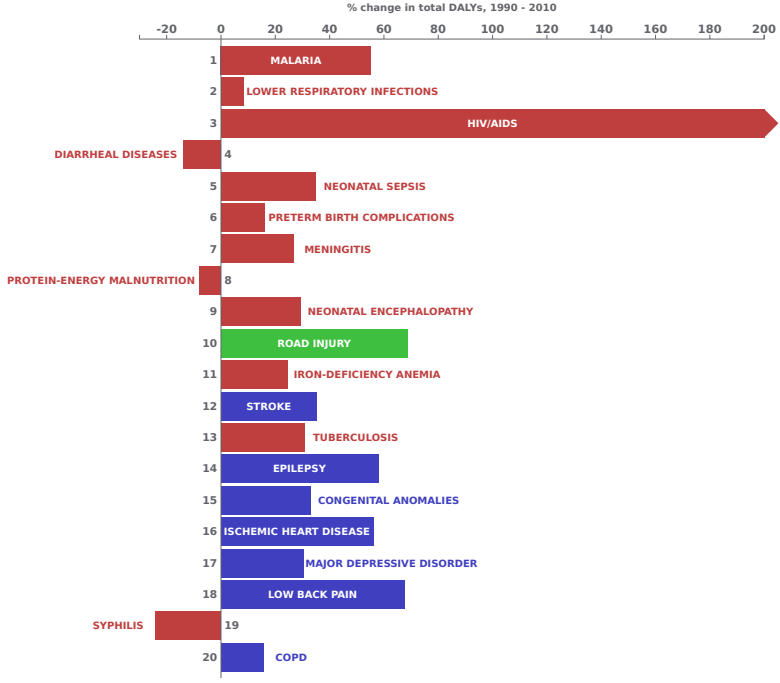
Shifts in leading causes of DALYs in Swaziland, 1990-2010



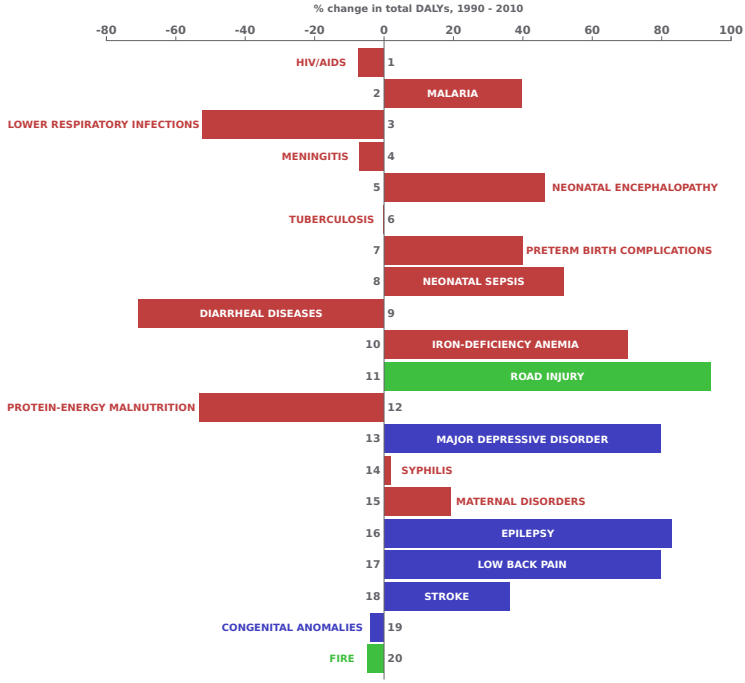
Shifts in leading causes of DALYs in Tanzania, 1990-2010



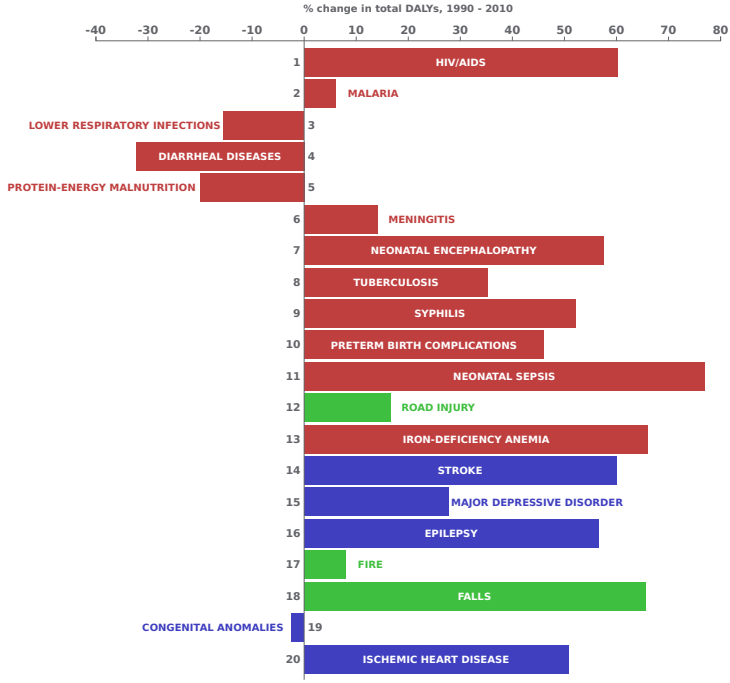
Shifts in leading causes of DALYs in Togo, 1990-2010



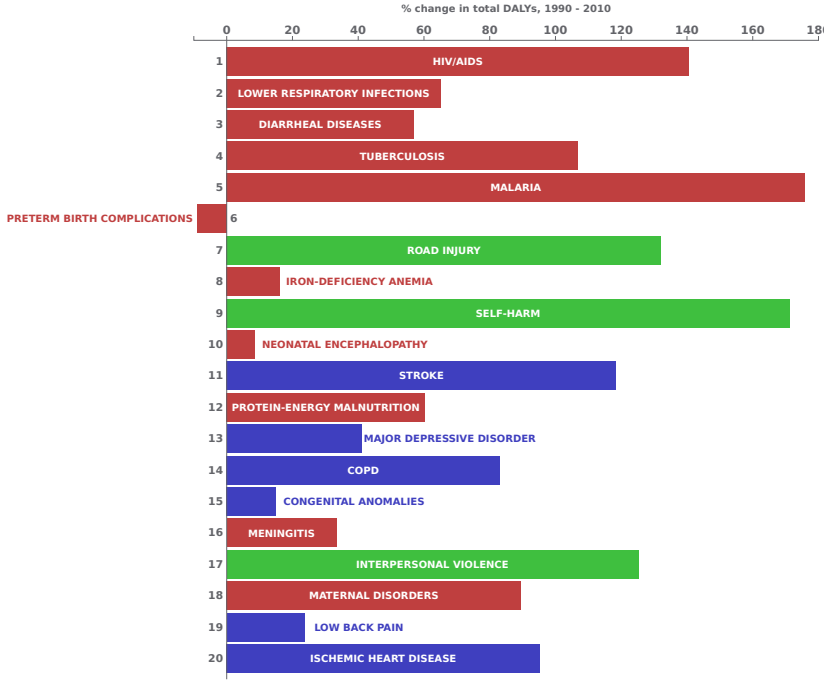
Shifts in leading causes of DALYs in Uganda, 1990-2010



Shifts in leading causes of DALYs in Zambia, 1990-2010



Shifts in leading causes of DALYs in Zimbabwe, 1990-2010



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