ANNEX

METHODS

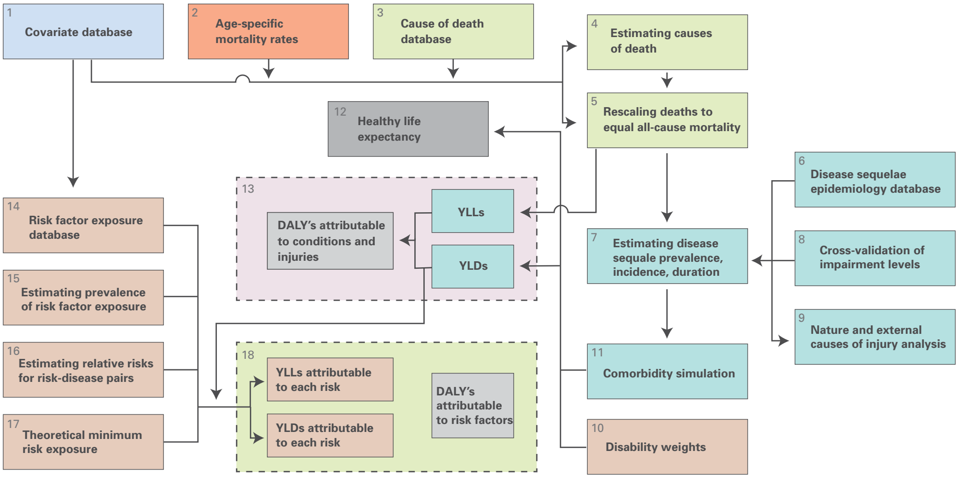
The analytical strategy of GBD

The Global Burden of Disease (GBD) approach contains 18 distinct components, as outlined in Figure A1. The components of GBD are interconnected. For example, when new data are 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 (HALE) (component 12), years of life lost (YLLs) and years lived with disability (YLDs) (component 13), and estimation of YLLs and YLDs attributable to each risk factor (component 18). The inner workings of key components are briefly described in this annex, 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 those 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.

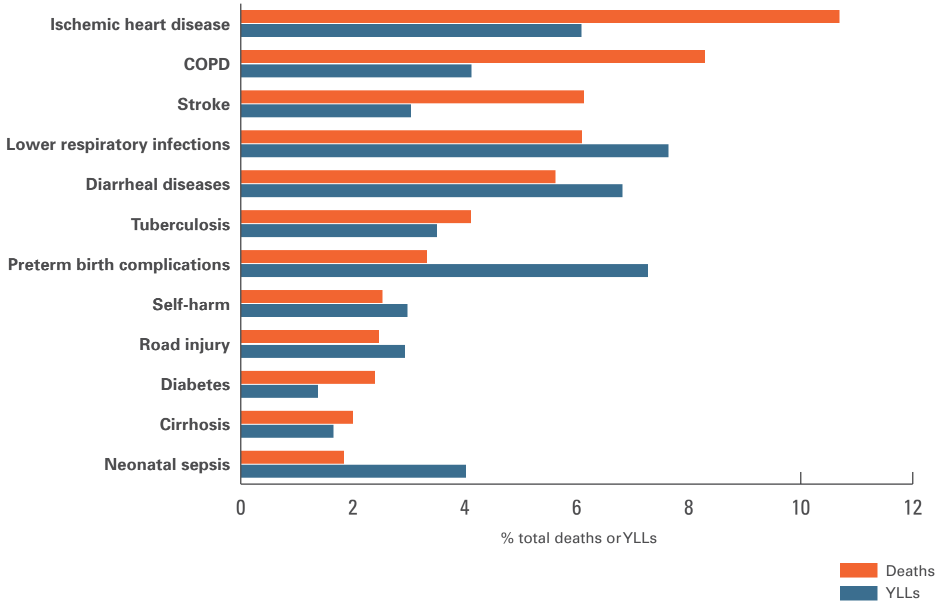
After addressing data-quality issues, researchers used a variety of statistical models to determine the number of deaths from each cause. This approach, named CODEm (for Cause of Death Ensemble modeling), was designed based on statistical techniques called "ensemble modeling." Ensemble modeling was made 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 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 YLLs. For every death from a particular cause, researchers estimated the YLLs 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 Pakistan in 2010, he has 66 YLLs, which 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, lower respiratory infections represent a greater percentage of total YLLs than total deaths since they are leading killers 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.

Figure A2: Leading causes of death and premature death in South Asia, 2010



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 from surveys and other sources.

Confronted with the challenge of data gaps in many regions and for numerous types of sequelae, researchers 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, YLDs were calculated as prevalence of a sequela multiplied by the disability weight for that sequela. The number of YLDs for a specific disease or injury was 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 South Asia region. It illustrates how a decision-maker looking only at the top 10 causes of death would fail to see the importance of iron-deficiency anemia, for example, which was a leading cause of DALYs in 2010. 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 preterm birth complications. In contrast, stroke causes a larger percentage of total deaths than DALYs, as it primarily impacts older people.

Estimating DALYs attributable to risk factors

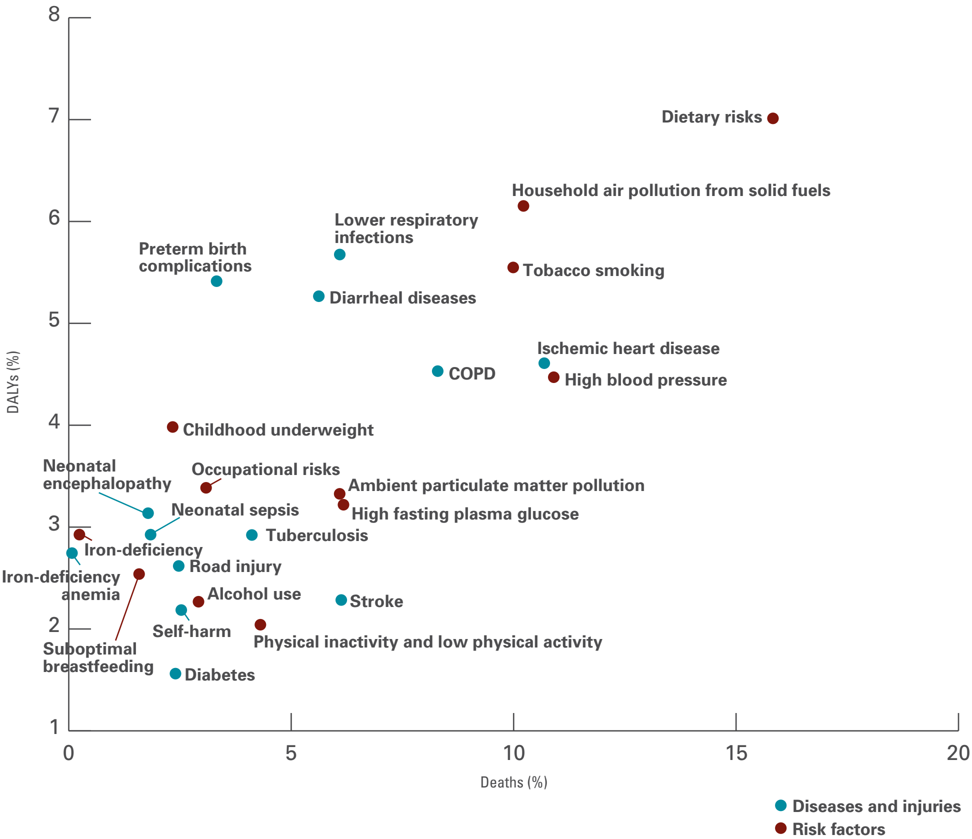
To estimate the number of healthy years lost, or DALYs, attributable to potentially avoidable risk factors, researchers collected detailed data on exposure to different risk factors. The study used data from sources such as satellite data on air pollution, breastfeeding data from population surveys, 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 South Asia, 2010



Note: This figure compares the percentage 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 a substantial numbers of DALYs but few 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

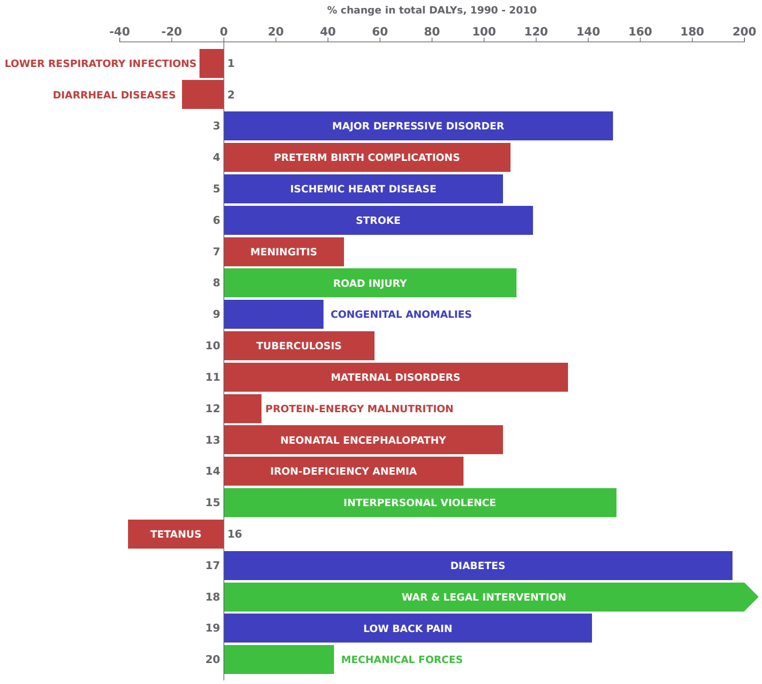
Country	**Age-standardized death rate** (per 100,000)				**Age-standardized YLL rate** (per 100,000)			
	1990		2010		1990		2010	
	Rate	*Rank*	*Rate*	*Rank*	*Rate*	*Rank*	*Rate*	*Rank*
Afghanistan	1,931 (1,752-2,232)	8 (8-8)	1,668 (1,497-1,897)	8 (8-8)	68,958 (62,444-79,302)	8 (8-8)	52,078 (46,284-58,742)	8 (8-8)
Bangladesh	1,295 (1,206-1,373)	6 (4-6)	864 (802-912)	5 (3-5)	49,258 (45,947-52,446)	4 (4-7)	26,361 (24,424-27,828)	5 (3-5)
Bhutan	1,284 (1,105-1,497)	4 (3-7)	822 (649-990)	3 (3-5)	49,438 (43,249-56,520)	5 (4-7)	26,020 (21,479-30,644)	3 (3-5)
India	1,447 (1,389-1,530)	7 (6-7)	1,097 (1,011-1,166)	7 (7-7)	50,084 (47,613-53,409)	7 (4-7)	33,366 (30,670-35,506)	6 (6-7)
Maldives	997 (949-1,042)	2 (2-2)	440 (419-454)	1 (1-1)	34,466 (32,069-36,731)	2 (2-2)	11,060 (10,413-11,637)	1 (1-1)
Nepal	1,285 (1,210-1,385)	5 (4-6)	832 (777-885)	4 (3-5)	49,745 (46,653-53,434)	6 (4-7)	26,361 (24,803-28,050)	4 (3-5)
Pakistan	1,120 (1,057-1,185)	3 (3-4)	982 (866-1,073)	6 (6-6)	41,231 (39,066-43,805)	3 (3-3)	33,518 (29,921-36,510)	7 (6-7)
Sri Lanka	712 (688-736)	1 (1-1)	620 (595-642)	2 (2-2)	20,846 (19,888-21,801)	1 (1-1)	14,898 (14,239-15,608)	2 (2-2)

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*
17,727 (14,746-21,160)	8 (8-8)	17,252 (14,177-20,566)	8 (8-8)	52.0 (49.0-54.4)	8 (8-8)	57.8 (54.3-61.1)	8 (8-8)	42.6 (39.8-45.0)	8 (8-8)	47.5 (44.3-50.5)	8 (8-8)
14,743 (12,132-17,743)	7 (6-7)	13,206 (10,774-15,936)	7 (5-7)	58.9 (57.6-60.3)	5 (4-7)	69.0 (67.8-70.1)	5 (3-5)	49.5 (47.4-51.5)	7 (4-7)	58.6 (56.1-60.7)	5 (3-6)
13,781 (11,147-16,513)	5 (2-7)	12,113 (9,779-14,641)	3 (1-7)	59.0 (53.9-63.7)	4 (3-7)	69.5 (65.2-73.6)	3 (3-7)	50.1 (45.9-53.8)	5 (3-7)	59.8 (55.9-63.6)	3 (3-6)
13,727 (11,265-16,542)	6 (3-6)	12,494 (10,287-14,967)	5 (3-7)	58.3 (56.9-59.7)	7 (4-7)	65.2 (63.5-66.9)	7 (6-7)	49.8 (47.8-51.7)	6 (4-7)	56.2 (53.8-58.3)	7 (6-7)
13,138 (10,779-15,911)	3 (1-6)	11,281 (9,200-13,584)	1 (1-4)	65.1 (64.5-65.7)	2 (2-2)	78.8 (78.2-79.4)	1 (1-1)	55.6 (53.5-57.3)	2 (2-2)	68.0 (65.7-70.1)	1 (1-1)
13,660 (11,255-16,417)	4 (2-7)	12,959 (10,598-15,442)	6 (4-7)	58.8 (57.3-60.4)	6 (4-7)	69.2 (67.7-70.9)	4 (3-5)	50.0 (48.1-51.9)	4 (4-7)	58.9 (56.7-61.1)	4 (3-5)
12,877 (10,612-15,370)	2 (1-5)	12,323 (10,153-14,644)	4 (2-7)	62.4 (60.9-63.8)	3 (3-4)	65.8 (63.3-68.1)	6 (5-7)	53.4 (51.4-55.3)	3 (3-4)	56.6 (54.0-58.9)	6 (5-7)
12,231 (10,031-15,133)	1 (1-4)	11,452 (9,269-14,503)	2 (1-7)	72.3 (71.5-72.9)	1 (1-1)	75.5 (74.6-76.3)	2 (2-2)	62.0 (59.6-63.9)	1 (1-1)	65.2 (62.4-67.3)	2 (2-2)

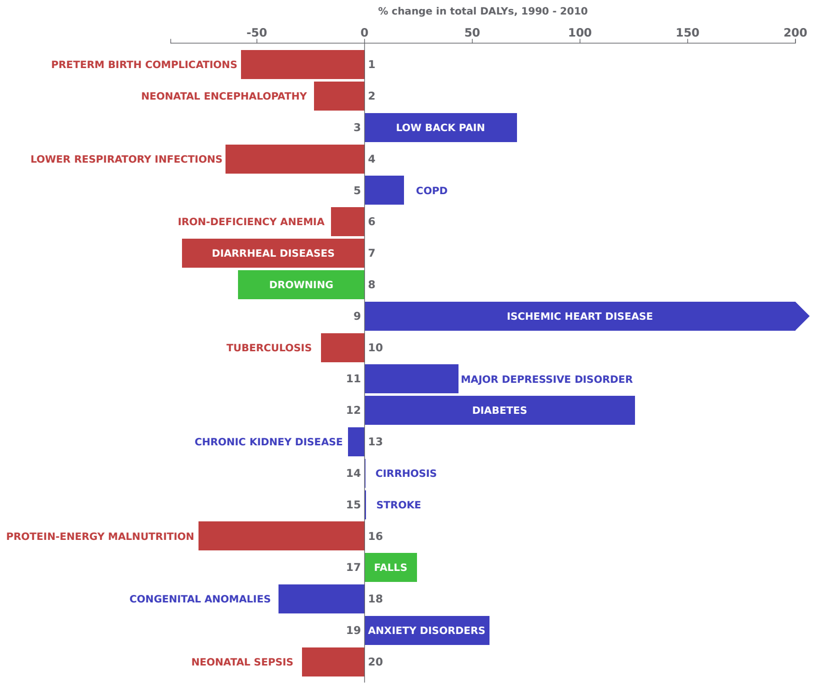
CHANGES IN LEADING CAUSES OF DALYS BETWEEN 1990 AND 2010 FOR COUNTRIES IN SOUTH ASIA

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.

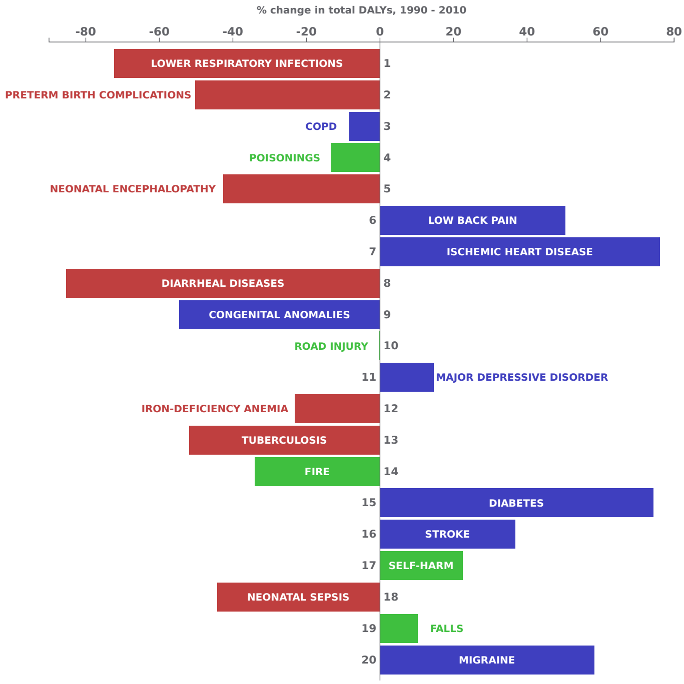
Shifts in leading causes of DALYs in Afghanistan, 1990-2010



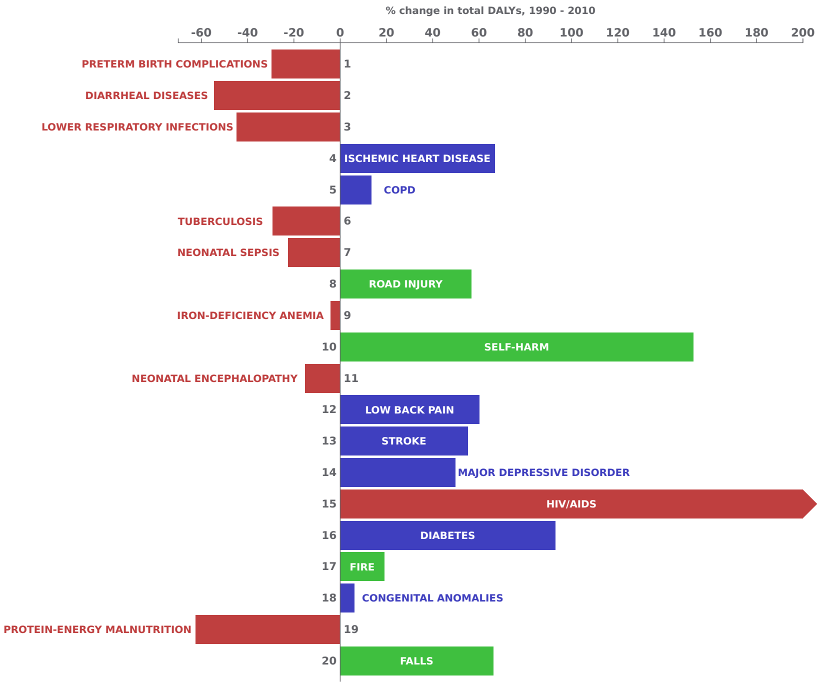
Shifts in leading causes of DALYs in Bangladesh, 1990-2010



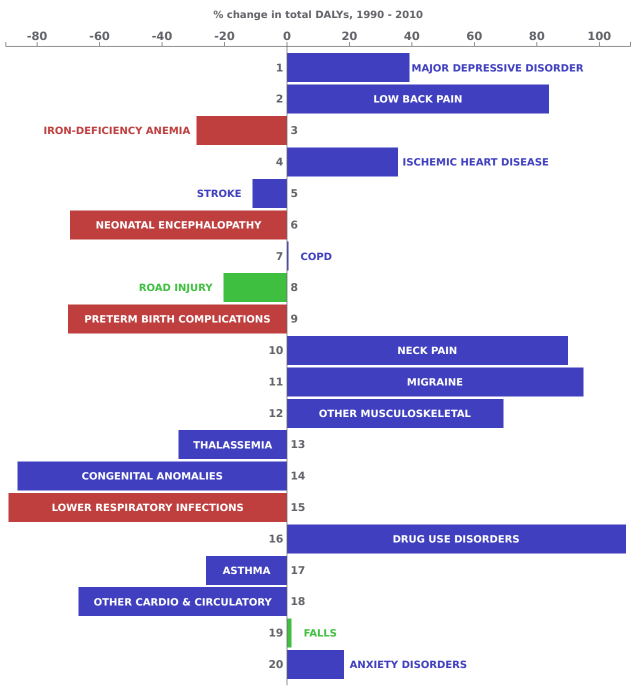
Shifts in leading causes of DALYs in Bhutan, 1990-2010



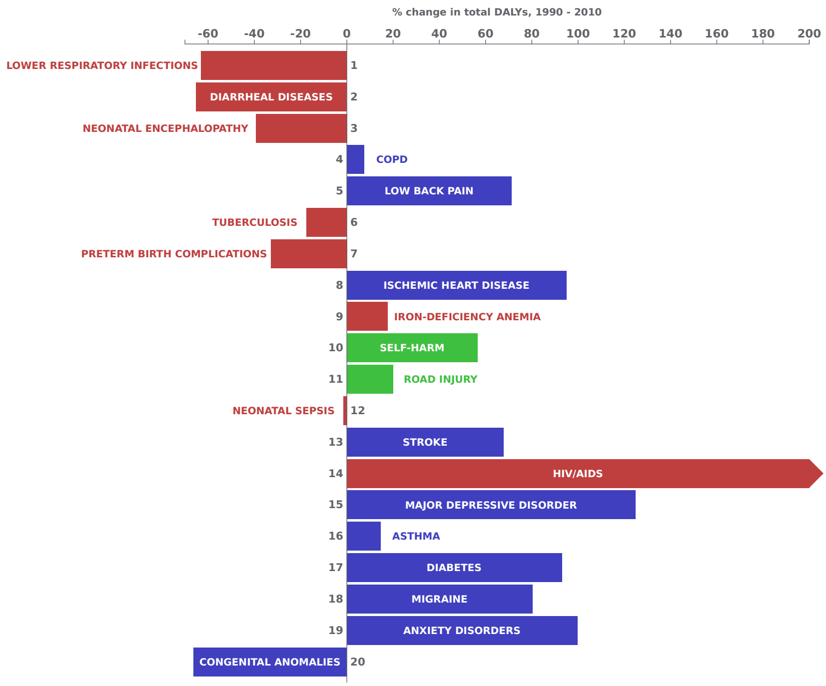
Shifts in leading causes of DALYs in India, 1990-2010



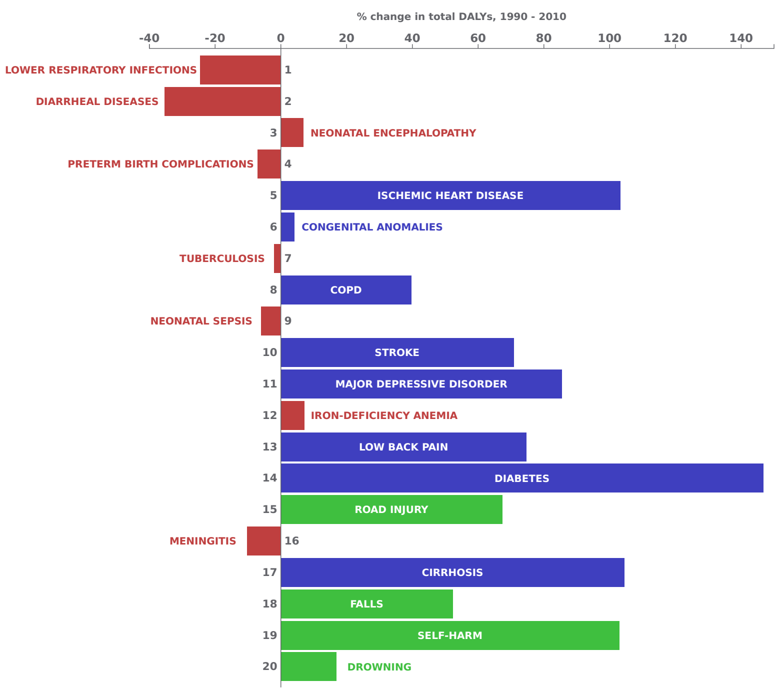
Shifts in leading causes of DALYs in the Maldives, 1990-2010



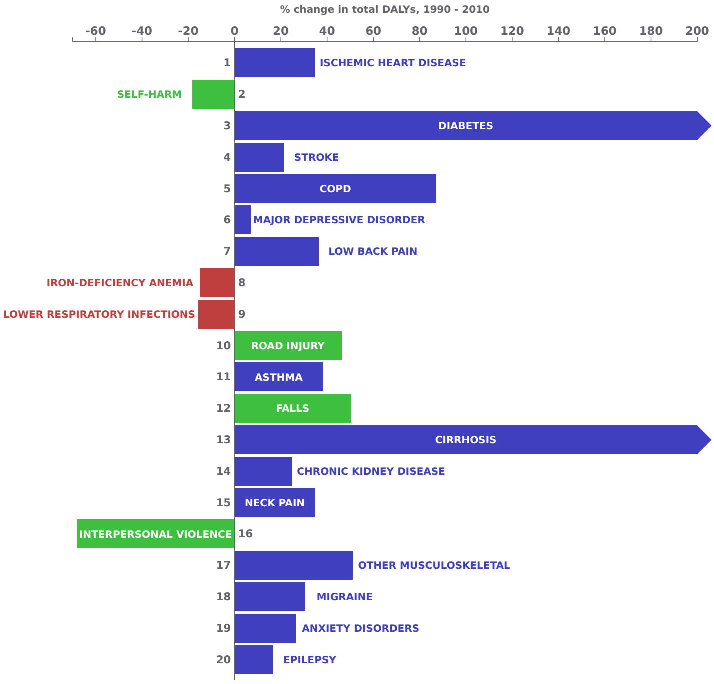
Shifts in leading causes of DALYs in Nepal, 1990-2010



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



Shifts in leading causes of DALYs in Sri Lanka, 1990-2010



THE WORLD BANK

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