Global mortality, disability, and the contribution of risk factors: Global Burden of Disease Study

Christopher J L Murray, Alan D Lopez

Summary

Background Prevention and control of disease and injury require information about the leading medical causes of illness and exposures or risk factors. The assessment of the public-health importance of these has been hampered by the lack of common methods to investigate the overall, worldwide burden. The Global Burden of Disease Study (GBD) provides a standardised approach to epidemiological assessment and uses a standard unit, the disability-adjusted life year (DALY), to aid comparisons.

Methods DALYs for each age-sex group in each GBD region for 107 disorders were calculated, based on the estimates of mortality by cause, incidence, average age of onset, duration, and disability severity. Estimates of the burden and prevalence of exposure in different regions of disorders attributable to malnutrition, poor water supply, sanitation and personal and domestic hygiene, unsafe sex, tobacco use, alcohol, occupation, hypertension, physical inactivity, use of illicit drugs, and air pollution were developed.

Findings Developed regions account for 11·6% of the worldwide burden from all causes of death and disability, and account for 90·2% of health expenditure worldwide. Communicable, maternal, perinatal, and nutritional disorders explain 43·9%; non-communicable causes 40·9%; injuries 15·1%; malignant neoplasms 5·1%; neuropsychiatric conditions 10·5%; and cardiovascular conditions 9·7% of DALYs worldwide. The ten leading specific causes of global DALYs are, in descending order, lower respiratory infections, diarrhoeal diseases, perinatal disorders, unipolar major depression, ischaemic heart disease, cerebrovascular disease, tuberculosis, measles, road-traffic accidents, and congenital anomalies. 15·9% of DALYs worldwide are attributable to childhood malnutrition and 6·8% to poor water, and sanitation and personal and domestic hygiene.

Interpretation The three leading contributors to the burden of disease are communicable and perinatal disorders affecting children. The substantial burdens of neuropsychiatric disorders and injuries are under-recognised. The epidemiological transition in terms of DALYs has progressed substantially in China, Latin America and the Caribbean, other Asia and islands, and the middle eastern crescent. If the burdens of disability and death are

Harvard School of Public Health, Boston, Massachusetts, USA
(C J L Murray MD), **and World Health Organization, Geneva, Switzerland** (A D Lopez PhD)

Correspondence to: Dr Christopher J L Murray, Harvard Center for Population and Developmental Studies, 9 Bow Street, Cambridge, MA 02138, USA

taken into account, our list differs substantially from other lists of the leading causes of death. DALYs provide a common metric to aid meaningful comparison of the burden of risk factors, diseases, and injuries.

Introduction

In this, the third of a four-article series on the Global Burden of Disease Study (GBD) (see *Lancet* 1997; **349:** 1269–76 and 1347–52, and the next issue) the primary indicator used to summarise the burden of premature mortality and disability (including temporary disability) is the disability-adjusted life year (DALY). The burden of 107 disorders is compared with the burden attributable to ten major risk factors and to selected diseases as risk factors for other conditions. More extensive detail on the estimation of causes of death and development of epidemiological profiles of each disabling sequela have been published.[1]

DALYs are the sum of life years lost due to premature mortality and years lived with disability adjusted for severity. The value choices incorporated into DALYs and the basis of their selection have been extensively debated and discussed.[2-4] In this article we give more details on the methods used to estimate attributable burden.

Methods

Estimation of attributable burden

For the GBD, assessments of the burden attributable to each of the ten major risk factors were made by specialists on each topic: tobacco,[5] alcohol,[6] illicit drugs,[7] occupation,[8] air pollution,[9] poor water supply, sanitation, and personal and domestic hygiene,[10] hypertension,[11] physical inactivity,[12] malnutrition,[13] and unsafe sex.[14] Attributable burden in this study has been defined (for a specific risk factor, population, and time) as "the difference between currently observed burden and the burden that would be observed if past levels of exposure had been equal to a specified reference distribution of exposure". Definition of the reference distribution of exposure varies by risk factor (table 1).

Malnutrition—Mason and colleagues[13] estimated the burden of disease attributable to malnutrition with data from 55 studies on the relative risk of mortality as a function of the SD of nutritional status. The proportion of the population aged 0–4 years with a weight-for-age lighter than 2 SDs below the National Center for Health statistics' reference population mean (based on extensive survey data in almost every country in the world) was used to estimate the attributable fraction of child mortality in each region.

Poor water supply, sanitation, and personal and domestic hygiene—Huttly[10] estimated attributable fractions for diarrhoea, ascariasis, trichuriasis, and dracunculiasis, based largely on the theoretical effects of interruption of the faecal-oral route of transmission.

Unsafe sex—Berkley and colleagues[14] estimated the burden attributable to unsafe sex based on 100% of the burden of

Risk factors	Measure of exposure	Reference distribution of exposure	Time lag from exposure to burden
Malnutrition	Population with weight-for-age less than 2 SDs below average based on extensive national surveys	Population weight-for-age more than minus 2 SDs	Intermediate
Poor water, sanitation, and hygiene	Based on the theoretical faecal-oral route of transmission	..	Short
Unsafe sex	Based on the theoretical model of transmission of STDs and on contraceptive-demand surveys for maternal disorders	..	Short to long
Alcohol*			
Disease	Indexed on alcohol consumption, non-hepatitis B cirrhosis, and alcohol-dependence syndrome	..	Long
Injury	Indexed on estimate of consumption patterns based on small-scale studies	..	Short
Occupation*			
Disease	Registration data for developed regions† and constant rates for all other regions	..	Long
Injury	Registration data for established market economies and constant rates for all other regions	..	Short
Tobacco	Indexed on lung cancer	..	Long
Hypertension	Population surveys of blood pressure	Systolic blood pressure of 110 mm Hg	Long
Physical inactivity	Population surveys of activity patterns	Regular physical activity	Long
Illicit drugs	Small-scale studies	..	Short to intermediate
Air pollution	Monitoring systems in urban areas for most regions	WHO guidelines	Short to long

*Different methods and characteristics apply depending on whether burden arises from a disease or injury. †Established market and formerly socialist economies of Europe, and Latin America and the Caribbean.

Table 1: **Summary of procedures used to estimate attributable burden from ten major risk factors**

sexually transmitted diseases and fractions for HIV, hepatitis B, and cervical cancer (caused by human papillomavirus). In addition, the burden of maternal disorders based on the proportion of "unwanted births" was estimated from the data of various contraceptive-demand surveys.

Tobacco—To estimate the burden attributable to tobacco, the method proposed by Peto and Lopez[15] was used. Relative risks of death from lung cancer, upper aerodigestive cancers, other cancers, chronic obstructive pulmonary disease, cardiovascular diseases, and other medical causes were taken from the American Cancer Society Cancer Prevention Study, second round, a prospective study with follow-up in 1984–88. To correct for potential confounding of the estimated relative risks for smokers, the excess risk due to tobacco for all diseases other than lung cancer was halved.[15] A smoking impact ratio defined as:

$$\text{Smoking impact ratio} = \frac{C-N}{S-N}$$

where C is the observed lung-cancer rate in a given age-group of a population; N is the non-smoker lung-cancer rate observed in the Cancer Prevention Study population; and S is the smoker lung-cancer rate in the Cancer Prevention Study. The smoking impact ratio can be used as a surrogate for the prevalence of cumulative exposure in the attributable fraction formula. Because non-smoker lung-cancer rates are higher in China and other Asia and islands than in the USA,[16] alternative non-smoker lung-cancer rates were used for these two regions. Preliminary results from a large case-control study in China were used to estimate the attributable fractions for China and other Asia and islands (Peto and Liu Boqu, personal communication). Deaths from tobacco-chewing among women in India were also estimated with attributable fractions reported by Notani and colleagues.[17]

Alcohol—The attributable burden of alcohol includes alcohol-related injuries and alcohol-related disease, and the protective effect of alcohol on ischaemic heart disease. The reference distribution for the burden of alcohol from all three components was no consumption. Attributable fractions for injuries in the established market economies were based on review of published data of the effects of alcohol on diseases and injuries,[18] and for disease, attributable fractions were based on a meta-analysis.[18] For other regions, attributable fractions were scaled to reflect different regional rates of consumption and estimated differences in drinking patterns for injuries, and consumption per person by country, cirrhosis death rates (excluding those attributed to hepatitis B), and deaths coded to alcohol dependence for disease. Large-scale prospective studies consistently show that, after correction for smoking, alcohol consumption exerts a protective

effect on cardiovascular death at all levels of consumption.[22–25] The protective effect of alcohol was estimated for each region from the relative risk of death from ischaemic heart disease and scaled estimates of the proportion of the population that abstains from drinking.

Occupation—Leigh and colleagues[8] used direct reports on occupation-related injuries in Scandinavia to arrive at minimum occupational injury rates for each region. The incidence rates were scaled, based on small-scale, published studies and other registration sources. For occupational diseases, data from reporting systems were available for the USA, Canada, Australia, Sweden, Denmark, the UK, Switzerland, Luxembourg, Hungary, Mexico, and China (selected causes only). For most of the working population in countries without registration systems, the reported rates from Canada and Australia were used to estimate occupational-disease death rates.

Hypertension—Nichols and Elliott[11] reviewed more than 50 population-based studies (including multicentre studies) to estimate the distributions of systolic and diastolic blood pressure by region, age, and sex. Relative risks of death for different blood pressures were estimated by logistic regression analysis of data from 18 studies. The reference distribution used was a systolic blood pressure of 110 mm Hg. Estimates of attributable burden due to hypertension are based on their attributable fractions for cerebrovascular and ischaemic heart disease. Burden from other causes due to hypertension was not estimated.

Physical inactivity—Pratt and Koplan[12] estimated relative risks specific for age and sex for ischaemic heart disease, colon cancer, and diabetes, based on a review of published studies. To control for confounding, the excess risk from inactivity was halved in developing regions. The prevalence of inactivity was estimated from a review of population-based surveys of physical activity for each region. The reference of exposure was a population in which 100% of individuals are regularly physically active.

Illicit drugs—Donoghoe and colleagues[7] developed attributable fractions for HIV, hepatitis B, perinatal disorders, protein-energy malnutrition, drug use, road-traffic accidents, poisonings, self-inflicted injuries, and violence, based on a review of published data about illicit drug use[18] and, in the absence of local prevalence studies, on the estimated number of illicit drug users in each region.

Air pollution—Hong and colleagues[9] analysed the burden attributable to total suspended particulates and sulphur dioxide. Exposure levels in urban areas were available for all regions except the middle eastern crescent and sub-Saharan Africa. The reference distribution used was the WHO air quality guidelines.

Results

We calculated the regional distribution of the burden of disease and health expenditure worldwide (figure 1). In 1990, nearly 90% of the worldwide burden of disease occurred in devloping regions, where only 10% of health-care funds were spent.[23] In terms of overall worldwide burden of disease, sub-Saharan Africa and India had the largest proportions (21·4% and 20·9%, respectively) but very small proportions (0·7% and 1·0%) of health expenditure. Established market economies accounted for 7·2% of burden but 87·3% of health expenditure, whereas formerly socialist economies of Europe accounted for only 4·5% of burden and 2·9% of health expenditure.

The contribution of the three major groups of causes (group 1=communicable, maternal, perinatal, and nutritional disorders; group 2=non-communicable diseases; group 3=injuries) to overall disease and injury burden differed dramatically across regions. As expected, group 1 disorders were dominant in sub-Saharan Africa (65·9% of burden), but were much less important in established market economies (7·1%). Even in China, where mortality rates were close to those of the developed regions, group 1 conditions still accounted for 25% of burden. In Latin America and the Caribbean, other Asia and islands, and the middle eastern crescent, burden from group 1 covered 35–48% of total regional burden. The pattern for group 2 disorders contrasted sharply to group 1. More than 80% DALYs in established market economies, but under 20% in sub-Saharan Africa were attributed to group 2 disorders. Group 3 disorders remained an important source of burden in all regions, accounting for 12–19% of the total burden in each region.

Table 2 shows a breakdown of DALYs by region and level 2 categories within each of the cause groups in 1990. Worldwide, 22·9% of DALYs were caused by infectious and parasitic diseases, but this proportion ranged from 2·7% in formerly socialist economies of Europe to 42·5% in sub-Saharan Africa. Respiratory infections contributed about 1·4% of DALYs in established market economies, compared with 10·7% in the middle eastern crescent, whereas DALYs from maternal disorders varied from 0·3% in established market economies to 3·2% in sub-Saharan Africa. Among group 2 disorders, cancers accounted for 5·1% of worldwide burden; however, this figure was 13·7% in developed regions. Worldwide, neuropsychiatric disorders accounted for 10·5% of DALYs; their contribution was much greater in developed regions, where they accounted for 22·0% of total DALYs, than in developing regions. Other major categories of burden included cardiovascular diseases (10% of DALYs) and respiratory and digestive diseases (more than 3% of burden each worldwide). In the developed regions, musculoskeletal diseases were also major causes of burden, causing just under 5% of DALYs. Unintentional injuries caused more than 10% of DALYs in all regions except the middle eastern crescent, established market economies and sub-Saharan Africa. Intentional injuries had a wider range from 1·5% of DALYs in India to more than 6% in sub-Saharan Africa and the middle eastern crescent.

The 30 leading causes of DALYs worldwide in 1990 are shown in table 3. The top three causes of DALYs in 1990 were lower respiratory infections, diarrhoeal diseases, and perinatal disorders (low birthweight and birth asphyxia or birth trauma). The ten leading causes of

DALYs by region*
(% total DALYs worldwide, 1990)
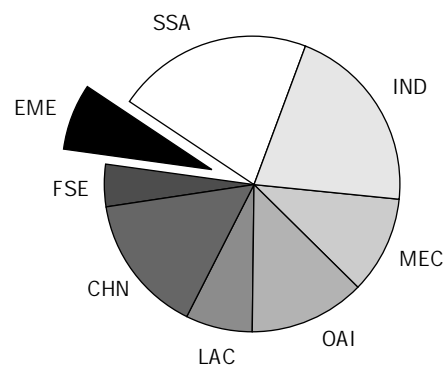
Health expenditure by region*
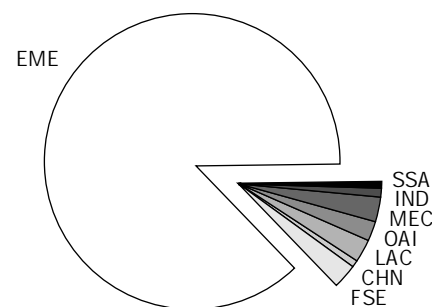**(% health expenditure worldwide, 1990)**

Figure 1: **Comparison of total DALYs by region and total health expenditure by region**
*EME=established market economies; FSE=formerly socialist economies of Europe; CHN= China; LAC=Latin America and the Caribbean; OAI=other Asia and islands; MEC=middle eastern crescent; IND=India; SSA=sub-Saharan Africa.

DALYs for the two sexes differ only slightly. If all maternal causes were combined, maternal disorders would be the fourth highest cause of DALYs. The rankings for developed regions were quite different from the worldwide rankings: alcohol use, osteoarthritis, lung cancer, dementia, suicide, and chronic obstructive pulmonary disease were all among the leading causes of DALYs in established market and formerly socialist economies of Europe, and the top three causes of burden were ischaemic heart disease, unipolar major depression, and cerebrovascular diseases. The leading causes of DALYs in developing regions were similar to the leading causes worldwide, except that malaria was the seventh most important cause of burden.

Table 4 shows estimates of the total burden attributable to eight diseases, including their directly attributable burden and their roles as risk factors for death and disability for other diseases. The largest difference between burden directly attributed to a disease and total burden from a disease was found for hepatitis B. The estimates in primary tabulations were actually for hepatitis B and hepatitis C combined. The vast majority of this burden, as estimated, was from hepatitis B. The attributable burden for liver cancer and cirrhosis was estimated for hepatitis B alone. Hepatitis B was ranked at 69 out of the 107 disorders in the study; if attributable burden is included, hepatitis B rose to 25th place in the worldwide list. In 1990, hepatitis B was estimated to have

Disorder group	% of DALYs by region*										
	EME	FSE	IND	CHN	OAI	SSA	LAC	MEC	Developed	Developing	World
Group 1											
Total group 1	7·1	8·8	56·4	24·2	44·7	65·9	35·3	47·7	7·8	48·7	43·9
Infectious and parasitic diseases	2·8	2·7	28·9	7·5	22·3	42·5	17·6	20·2	2·7	25·6	22·9
Respiratory infections	1·4	2·0	11·9	5·9	8·7	10·5	4·9	10·7	1·6	9·4	8·5
Maternal disorders	0·3	0·9	2·6	1·3	2·3	3·2	1·7	2·4	0·6	2·4	2·2
Perinatal disorders	1·8	2·2	8·8	4·9	6·9	6·5	7·4	9·7	1·9	7·3	6·7
Nutritional deficiencies	0·9	1·0	4·2	4·6	4·5	3·2	3·7	4·7	0·9	4·1	3·7
Group 2											
Total group 2	81·0	72·6	29·0	58·2	40·9	18·8	48·2	39·3	77·7	36·1	40·9
Malignant neoplasms	15·0	11·7	2·5	8·7	5·1	2·1	4·5	2·4	13·7	4·0	5·1
Other neoplasms	0·9	0·6	0·1	0·4	0·3	0·2	0·5	0·2	0·8	0·2	0·3
Diabetes mellitus	2·4	1·1	0·8	0·5	0·7	0·2	1·5	1·0	1·9	0·7	0·8
Endocrine disorders	1·3	0·4	0	0·3	0·3	0·4	1·4	0·7	0·9	0·4	0·4
Neuropsychiatric disorders	25·1	17·2	7·0	14·2	10·8	4·0	15·9	8·7	22·0	9·0	10·5
Sense organ disorders	0·1	0·1	1·1	1·0	1·0	0·7	0·6	0·6	0·1	0·8	0·8
Cardiovascular disorders	18·6	23·2	8·2	11·0	10·1	3·9	8·0	11·1	20·4	8·3	9·7
Respiratory disorders	4·8	4·8	2·7	10·7	2·7	2·6	4·0	4·2	4·8	4·3	4·4
Digestive disorders	4·4	4·4	2·2	4·9	4·7	1·8	3·8	4·2	4·4	3·3	3·4
Genitourinary disorders	1·1	1·6	0·7	1·2	1·1	0·9	1·2	2·0	1·3	1·1	1·1
Skin disorders	0·1	0·2	0	0·2	0·1	0·2	0·1	0·1	0·1	0·1	0·1
Musculoskeletal disorders	4·2	4·4	0·5	1·7	1·2	0·4	3·1	0·6	4·3	1·0	1·4
Congenital anomalies	2·2	2·2	2·9	3·0	2·3	1·3	2·7	2·7	2·2	2·4	2·4
Oral disorders	0·9	0·8	0·4	0·5	0·7	0·1	1·0	0·9	0·8	0·5	0·5
Group 3											
Total group 3	11·9	18·7	14·6	17·6	14·4	15·4	16·4	13·0	14·5	15·2	15·1
Unintentional injuries	8·7	12·9	13·0	12·9	12·1	9·3	11·9	6·8	10·3	11·1	11·0
Intentional injuries	3·2	5·8	1·5	4·7	2·3	6·0	4·5	6·2	4·2	4·1	4·1

*Abbreviations for regions as in figure 1. Developed regions=EME and FSE. Developing regions=all other regions.

Table 2: **Distribution % of DALYs for specific causes (level 2 categories), 1990**

caused 819 000 deaths, most of which occurred in people older than 40 years. When the higher risks of cardiovascular disease and death among diabetic people had been taken into account, diabetes rose from the 29th to the 14th most important cause of worldwide burden. Diabetes accounted for 571 000 deaths in the primary GBD tabulations, whereas the total number of deaths attributed to diabetes was 2·8 million. Incorporation of

attributable burden into our DALY estimates for diabetes in developed countries raised it from the 14th to the second rank, beaten only by ischaemic heart disease. Only about 42% of the burden of diabetes was captured in primary tabulations of directly attributable burden.

Risk-factor results

Table 5 shows an overview of the estimated contribution of the ten major risk factors to the burden of disease in

Rank	Disorder	Number of DALYs × 10⁶
1	Lower respiratory infections	112·9
2	Diarrhoeal diseases	99·6
3	Perinatal disorders	92·3
4	Unipolar major depression	50·8
5	Ischaemic heart disease	46·7
6	Cerebrovascular disease	38·5
7	Tuberculosis	38·4
8	Measles	36·5
9	Road-traffic accidents	34·3
10	Congenital anomalies	32·9
11	Malaria	31·7
12	Chronic obstructive pulmonary disease	29·1
13	Falls	26·7
14	Iron-deficiency anaemia	24·6
15	Protein-energy malnutrition	21·0
16	War injuries	20·0
17	Self-inflicted injuries	19·0
18	Tetanus	17·5
19	Violence	17·5
20	Alcohol use*	16·7
21	Drownings	15·7
22	Bipolar disorder	14·3
23	Pertussis	13·4
24	Osteoarthritis	13·3
25	Cirrhosis of the liver	13·2
26	Schizophrenia	12·8
27	Burns	11·9
28	HIV	11·2
29	Diabetes mellitus	11·1
30	Asthma	10·8

*Consequences directly coded to alcohol use only.

Table 3: **Thirty leading causes of worldwide DALYs for both sexes in 1990**
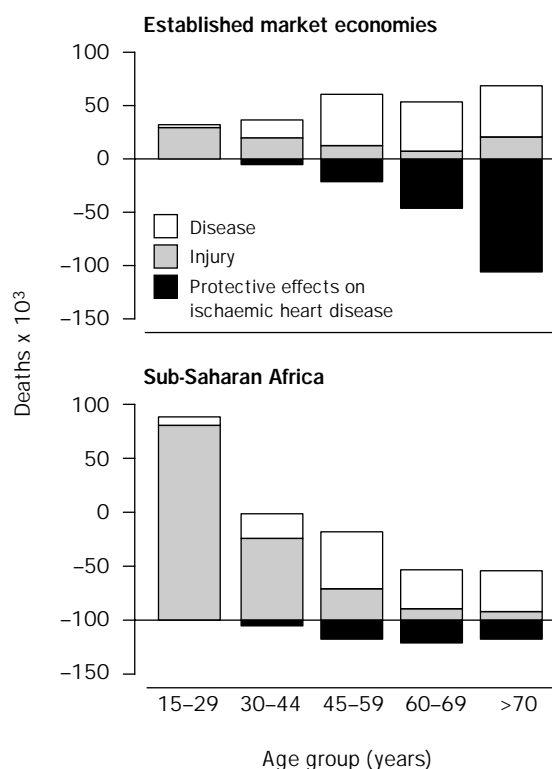

Figure 2: **Estimated deaths attributable to and averted by alcohol use in males in two regions, 1990**

Disorder	Number of deaths × 10³	% total	Number of DALYs × 10⁶	% total
Chagas' disease	49	0·1	1·6	0·1
Hepatitis B and hepatitis C	819	1·6	13·3	1·0
Tuberculosis	1960	4·0	39·8	2·9
Diabetes mellitus	2759	5·5	26·3	1·9
Cataracts	1104	2·2	17·9	1·3
Glaucoma	331	0·7	5·8	0·4
Onchocerciasis	19	0·0	1·2	0·1
Trachoma	103	0·2	2·0	0·1
Unipolar major depression	786	1·6	69·8	5·1
Sexually transmitted diseases	413	0·8	25·3	1·8

Table 4: **Estimated total attributable burden for selected conditions as risk factors for death and disability from other diseases and injuries**

Figure 3: **Relation of rank order of worldwide burden calculated for deaths and DALYs, 1990, from lowest rank to highest rank**

1990. Malnutrition was, not surprisingly, the risk factor responsible for the greatest loss of DALYs (15·9%) worldwide, followed by the combination of poor water supply, sanitation, and personal hygiene (combined, 6·8%). Unsafe sex and alcohol use each caused 3·5% of DALYs, and occupational hazards and tobacco were each estimated to cause 2·0–3·0% of DALYs worldwide, roughly equivalent to the burden of measles or tuberculosis. Of the ten risk factors examined, air pollution and illicit drug use seemed to be the least important, each causing about 0·5% of DALYs worldwide. Nevertheless, these exposures caused as much burden as stomach cancer, liver cancer, or syphilis.

Unsafe sex was estimated to account for more than 6·0% of total regional burden in sub-Saharan Africa, and 4·0–5·0% of regional DALYs in India and other Asia and islands. Given the strong age-dependence of sexual activity, the impact of this exposure was particularly evident among women of childbearing age. Therefore, in women aged 15–44 years, unsafe sex was estimated to account for 1·0% of DALYs in China and 6·0% and 30·0% in established market economies and sub-Saharan Africa respectively.

For tobacco use, DALYs largely reflected the health consequences of smoking before 1990. Tobacco was already a major cause of DALYs in established market and formerly socialist economies of Europe, where tobacco smoking has been widespread for many years. Tobacco was estimated to have caused about 1·8 million deaths in 1990 in these two regions combined. This represented about 15% of all deaths in established market and formerly socialist economies of Europe, and about 12% of DALYs. Therefore, tobacco was the most important cause of DALYs in these two regions. The effect on mortality of the massive increase in tobacco consumption in developing countries, particularly during the 1970s and 1980s, may well cause tobacco-related
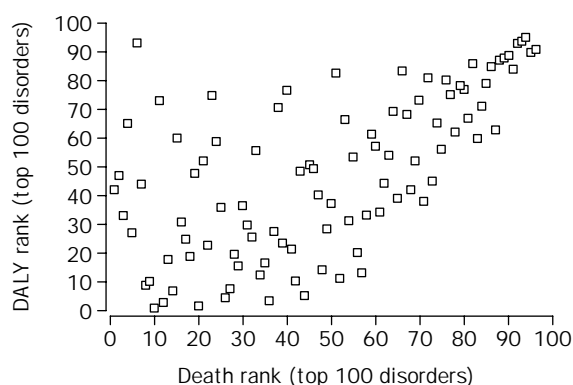
mortality to increase from 3 million deaths in 1990 to more than 8 million by 2020. Worldwide DALYs attributed to tobacco are predicted to rise from just under 40 million (1990, 2·6% of all DALYs) to 120 million (2020, just under 9% of all DALYs).

Attributable burden for alcohol in 1990 illustrated how the impact of the same risk factor can vary between regions (figure 2). In established market economies, the protective effects of alcohol probably averted as many deaths as its harmful effects caused. However, most of the averted deaths would have been in older ages, since ischaemic heart disease, the disorder against which alcohol protects, is rare in those younger than 50. As a result, the number of DALYs averted was substantially smaller than the number of DALYs caused by alcohol, particularly from injuries, in the 15–29 years age-group. Although the estimated net proportion of deaths due to alcohol use was relatively small in established market economies (about 1%), the proportion of DALYs due to alcohol was large (8%) because of the young ages at death and the large number of years lived with severity-adjusted disability attributable to alcohol. A very different pattern was seen in sub-Saharan Africa, where ischaemic heart disease was still rare and the protective effect of alcohol was, therefore, only of marginal public health importance. Alcohol was, however, a major cause of death and disability from injury.[24] As a result, proportionate mortality from alcohol was higher in sub-Saharan Africa than in established market economies (2 vs 1%).

The impact of alcohol was even greater in Latin America and the Caribbean, where almost 5% of deaths and 8% of DALYs were estimated to be attributable to alcohol. Alcohol was estimated to have caused about 750 000 more deaths worldwide than it averted, with more than 80% of these deaths in developing countries.

Risk factor	% of total DALYs by region*										
	EME	FSE	IND	CHN	OAI	SSA	LAC	MEC	Developed	Developing	World
Malnutrition	0	0	22·4	5·3	14·5	32·7	5·1	11·0	0	18·0	15·9
Poor water, sanitation, and hygiene	0·1	0·2	9·5	2·0	7·4	10·1	5·3	8·8	0·1	7·6	6·8
Unsafe sex	2·0	2·2	4·0	0·4	4·4	6·5	3·7	1·5	2·1	3·7	3·5
Tobacco	11·7	12·5	0·6	3·9	1·5	0·4	1·4	1·2	12·1	1·4	2·6
Alcohol	10·3	8·3	1·6	2·3	2·8	2·6	9·7	0·4	9·6	2·7	3·5
Occupation	5·0	3·8	2·0	3·9	2·8	1·3	3·7	2·6	4·6	2·5	2·7
Hypertension	3·9	5·9	0·9	1·0	0·3	0·6	1·8	1·7	4·7	0·9	1·4
Physical inactivity	4·8	2·8	1·0	0·8	0·3	0	1·0	0·8	4·0	0·6	1·0
Illicit drugs	2·3	1·3	0·1	0·3	0·7	0·2	1·6	0·7	1·9	0·4	0·6
Air pollution	0·5	3·1	0·5	0·4	0·4	0·2	0·5	0·5	1·5	0·4	0·5

*Abbreviations for regions as in figure 1.

Table 5: **Percentage worldwide DALYs attributable to each of ten risk factors, by region, 1990**

Figure 3 shows all disorders in the GBD in terms of deaths compared with DALYs. The Spearman's rank order correlation coefficient was only 0·63.

Discussion

Three findings from the GBD should be emphasised. First, despite dramatic improvements in child health conditions in the developing world, the three leading contributors to the burden of disease are lower respiratory infections, diarrhoeal diseases, and perinatal disorders. Together with measles, the eighth largest cause of burden, these childhood diseases account for 25% of the whole burden of premature mortality and disability in developing regions. Two important risk factors that contribute to a large share of this burden are paediatric malnutrition (16% of worldwide burden), and poor water, sanitation, and hygiene (7%). Programmes such as the Expanded Programme of Immunization are to be commended for their efforts to address these disorders. However, these will need to be intensified if continued progress is to be achieved.

Our taking into account temporary and permanent disability, has made apparent the burden of neuropsychiatric disorders. This cluster caused 0·3% of deaths, and 10·5% of the burden of disease and injury worldwide in 1990. Even in developing regions, neuropsychiatric disorders accounted for 9·0% of burden; in developed regions, the contribution was as high as 22·0%. Perhaps even more surprisingly, the fourth largest disorder was unipolar major depression. In accordance with ICD-9 conventions, suicides, many of which were due to major depression, were not included in the primary tabulations of unipolar major depression. With the addition of suicide, the burden of unipolar major depression increased by nearly 40%. Other neuropsychiatric conditions in the 30 leading causes of burden included alcohol use, schizophrenia, and bipolar disorder.

Unintentional and intentional injuries caused 10% of mortality worldwide but accounted for 15% of DALYs. Across regions, the fraction of burden due to injuries was relatively uniform but the specific injuries that contributed to the total were highly variable. Intentional injuries had a much greater role in formerly socialist economies of Europe, China, sub-Saharan Africa, Latin America and the Caribbean, and the middle eastern crescent. Seven group 3 causes (injuries) were listed in the 30 leading causes of DALYs worldwide in 1990 (table 3)—road-traffic accidents, falls, war injuries, self-inflicted injuries, violence, drownings, and burns. Compared with the research and policy attention devoted to other top 30 contributors to burden, injuries are remarkably neglected. Although the nature of successful prevention, treatment, and rehabilitation for injuries may differ from that for other disorders they are still legitimate foci for reasarch and action.

The results of this study suggest that the epidemiological transition has progressed substantially in several developing regions. The ratio of burden from group 2 to group 1 disorders can be used as a convenient index of the epidemiological transition.[25,26] Group 2 disorders—which occur primarily in older populations—already cause more burden than group 1 disorders in China and Latin America and the Caribbean, whereas other Asia and islands and the middle eastern crescent are not yet at this point. Established market economies and formerly socialist economies of Europe have essentially completed the epidemiological transition, but sub-Saharan Africa remains in an early phase. The top ten causes of DALYs in all developing regions combined already include ischaemic heart disease and cerebrovascular disease. Clearly, the focus of research and debate about health policy in developing regions should address the current challenges presented by the epidemiological transition now, rather than several decades hence.

In the low-mortality regions, the health situation is much worse for men than for women. The life expectancy at birth is substantially longer for women than for men, as is disability-adjusted life expectancy at birth, and the percentage of the lifespan lived with disability is higher for men than women. Rates of years lost due to mortality and years lived with disability are higher in men than in women. These differences seem to be much greater than those expected purely on the basis of biological differences in maximum lifespan and health potential. Much of the difference can, however, be explained by the combined effects of tobacco, alcohol, and other addictions or exposures that lead to injuries. Narrowing of this gap will be a major challenge for health policy.

Do these extensive efforts to quantify non-fatal health outcomes change our perception of the relative importance of different health problems? Would the priority attached to different health problems be the same if we examined only deaths or only deaths in children by cause? There are 14 conditions that are in the top half of the rank-order list of causes of DALYs but are in the bottom half of rank-order list of causes of death and the correlation between death rank and DALY rank was only 0·63 (figure 3). Not surprisingly, the relation between the rank order of child deaths and the rank order of DALYs by cause was even weaker; the Spearman's rank order correlation coefficient was 0·45.

The overall rankings of various disorders in terms of their contribution to worldwide burden are largely insensitive to alternative assumptions about the discount rate and age-weighting.[1] The major effect of discounting and age-weighting is to enhance the importance of neuropsychiatric disorders and sexually transmitted diseases. Although disease ranks are largely unaffected, the share of burden due to disability, the age-distribution of burden, and the distribution by cause are sensitive to the discount rate but are largely unaffected by age-weighting. The uncertainty of underlying epidemiological assessments is vastly more important than social preferences for the results of burden-of-disease analysis.

In this study, we aimed to construct a comprehensive and comparable view of health questions from all available sources of information. The estimates that emerge from this approach to estimation of death and disability from different disorders are superior to estimates that emerge from examination of specific disorders in isolation. The approach of the GBD allows many more types of information to be incorporated into the analysis. It also avoids the tendency to assume that if there are no data, or if the available data are weak, that there is no problem.

The heavy emphasis on internal consistency in this study also provides a very clear idea of what aspects of the descriptive epidemiology of each disorder are well understood and in which regions. Many sources of

information, for example routinely collected service data, may not be useful for estimation of the burden of disease. Such insights can help to identify priorities as to which health information to gather. In various national applications, these methods have helped identify gaps in the health information system and areas where currently collected information is not being used.[27]

Social values have a prominent role in any dialogue about health problems and health priorities. DALYs make the social preferences incorporated into the analysis explicit. The effects of changes in health-state preferences can be easily explored and understood. Given the inevitable ethical dimension to any health policy dialogue, the information base for our understanding of the descriptive epidemiology of various health problems and the social values that influence our perception of these problems should be laid bare for the public to debate and deliberate. If the assumptions and methods used in the study are made explicit, they can become topics for insightful debate, which will lead ultimately, to their improvement. Future reproductions of this study, if undertaken, will benefit from such an informed dialogue.

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