CHAPTER FOUR

Quantifying Selected Major Risks to Health

In attempting to reduce risks to health and, in particular, to redress the imbalance that leaves the poor and the disadvantaged with the greatest burden of disease, the first steps are to quantify health risks and to assess the distribution of risk factors by poverty levels. The analysis in this report covers selected risk factors, grouped as follows: childhood and maternal undernutrition; other diet-related risk factors and physical inactivity; sexual and reproductive health; addictive substances; environmental risks; occupational risks; and other risks to health (including unsafe health care practices, and abuse and violence). These risk factors are responsible for a substantial proportion of the leading causes of death and disability. This chapter ranks them globally and within major world regions and goes on to estimate how much of the burden each of them causes is avoidable between now and the year 2020. The potential benefits are huge, but they will depend on effective and cost-effective interventions if they are to be realized.

4

Quantifying Selected Major Risks to Health

Risks to health and socioeconomic status

The greatest burden of health risks is very often borne by the disadvantaged in our societies. The vast majority of threats to health are more commonly found among poor people, in people with little formal education, and those with lowly occupations. These risks cluster and they accumulate over time. In attempting to reduce risks to health, the focus of WHO and many other international organizations and governments is on trying to redress this imbalance – by directly tackling poverty, by concentrating on the risks to health amongst the impoverished, or by improving population health and hence overall economic growth *(1)*. An important component of the strategy is first to assess how much more prevalent risks are among the disadvantaged. While this provides information relevant to the targeting of interventions, it should be borne in mind that poverty and socioeconomic status are also of themselves key determinants of health status. This report seeks to shed further light on the mechanisms through which poverty acts, by assessing the distribution of risk factors by poverty levels.

Unfortunately, data are particularly scanty where they are required most – in the poorest countries of the world. Nonetheless, this report attempts to stratify global levels of selected risks by levels of absolute income poverty (<US$ 1, US$ 1–2 and >US$ 2 per day), as well as by age, sex and region. These analyses were conducted using individual-level data, not just comparisons of regional characteristics. The mapping of risk factors by poverty was conducted for:

- childhood protein–energy malnutrition;
- water and sanitation;
- lack of breastfeeding;
- unsafe sex;
- alcohol;
- tobacco;
- overweight;
- indoor air pollution;
- urban air pollution.

In addition, available research findings are summarized on the links between poverty and high blood pressure, cholesterol, physical inactivity, exposure to lead, and use of illicit drugs.

Rates of poverty across the world

Approximately one-fifth of the world's population live on less than US$ 1 per day and nearly a half live on less than US$ 2 per day. Of the 14 world subregions (derived by dividing the six WHO regions into mortality strata – see the List of Member States by WHO Region and mortality stratum) three (EUR-A, AMR-A and WPR-A) had negligible levels of absolute poverty and were excluded from analyses. In the EMR-B subregion, 9% of people live on less than $2 per day (2% less than $1 per day), but the estimates for this subregion were based on sparse data. There were, however, more data supporting estimates for the remaining 10 subregions, where the corresponding percentages ranged from 18% (3%) for EUR-B to 85% (42%) for SEAR-D and 78% (56%) for AFR-D.

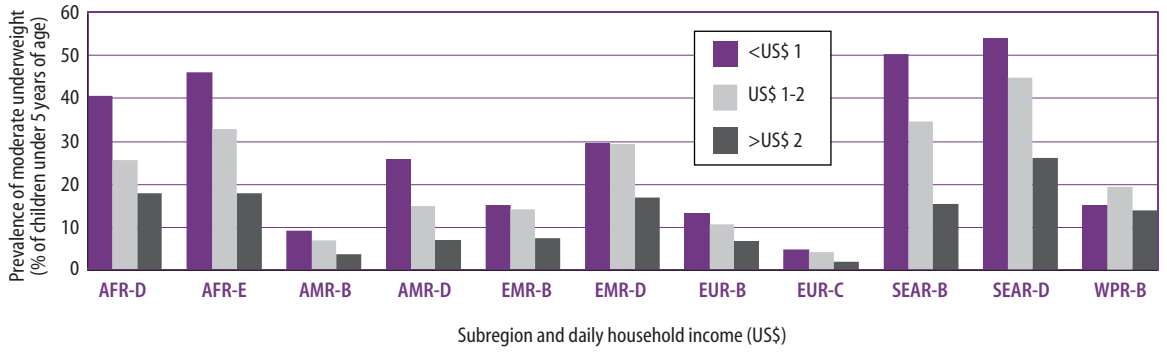
Relationships between risk factor levels and poverty

For all subregions, there was a strong gradient of increasing child underweight with increasing absolute poverty (see Figure 4.1). The strength of the association varies little across regions, people living on less than $1 per day generally being at two- to three-fold higher relative risk compared with people living on more than $2 per day.

Unsafe water and sanitation, and indoor air pollution are also strongly associated with absolute poverty. For unsafe water and sanitation, the relative risks for those in households with an income of less than $1 per day, as compared to households with an income greater than $2 per day ranged from 1.7 (WPR-B) to 15.1 (EMR-D), with considerable variation between regions. For the association between indoor air pollution and poverty, there is considerable variation between subregions in the average level and in the relative differences within subregions. In the subregions of Africa, there is both a high prevalence of exposure to indoor air pollution and little relative difference between the impoverished and non-impoverished.

The associations of poverty with tobacco and alcohol consumption, lack of breastfeeding, and unsafe sex (unprotected sex with non-marital partner) are weaker and more variable between subregions. There is considerable variation between subregions in tobacco consumption, and a relatively weak association, within subregions, of tobacco consumption with individual-level poverty. Similarly, there is a more marked variation in alcohol consumption between WHO regions than within WHO regions by individual-level absolute poverty. In none of the subregions analysed was there a suggestion of increased alcohol

Figure 4.1 Prevalence of moderate underweight in children by average daily household income (<US$ 1, US$ 1-2 and >US$ 2 per day), by subregion[a]



[a]See the List of Member States by WHO Region and mortality stratum for an explanation of subregions.

consumption among the more impoverished. But in two subregions, AFR-E (South Africa data only) and AMR-B (Panama data only), impoverished people had approximately half the alcohol consumption of non-impoverished people. However, these results were based on household survey data recording expenditure on alcohol (not consumption) that may not have fully captured individual consumption and consumption of non-manufactured sources, such as alcohol distilled locally. Findings were also consistent with the higher socioeconomic groups in the developing world having more adverse lipid profiles, high blood pressure and overweight than the poor. However, if the trends seen in the industrialized world are repeated, these patterns will reverse with increasing economic development. These cross-sectional analyses were consistent with differing stages of progression of tobacco, obesity and other key noncommunicable disease determinants in poorer regions of the world as they undergo economic development. For example, obesity and tobacco consumption are initially found among the non-impoverished within regions, and later these risks are given up by the non-impoverished but taken up among the impoverished. These findings were consistent with regions being at different stages of such a transition. In the absence of major public health initiatives, these risk factors are likely to become increasingly concentrated among poor people in the poorer regions of the world. Public health action is required now to prevent this progression.

Potential impact on risk factor levels of shifting poverty distributions

In addition to estimating the associations of risk factor prevalence with poverty, population impact fractions of poverty on the risk factors were estimated. If people living on less than $2 per day had the same risk factor prevalence as people living on more than $2 per day, then protein–energy malnutrition, indoor air pollution and unimproved water and sanitation would be reduced by approximately 37%, 50% and 51%, respectively (see Table 4.1). These total population impact fractions would be reduced to 23%, 21% and 36% if the impoverished had the same risk factor prevalence as people living on exactly $2 per day.

Other risks present a more variable pattern, although data gaps particularly limit certainty of conclusions. Nonetheless, these analyses suggest that the prevalence of alcohol consumption and being overweight would increase by approximately 20% to 60% in Africa

Table 4.1 Population impact fractions by subregion for counterfactual scenario of population moving from living on <US$ 2 per day to >US$ 2 per day

Subregion	Protein–energy malnutrition (%)	Unsafe water, sanitation and hygeine (%)	Unsafe sex men (%)	Unsafe sex women (%)	Indoor air pollution (%)	Tobacco (%)	Alcohol (%)	Body weight (%)
AFR-D	44	84	-17	-34	10	5	-19	-58
AFR-E	42	65	19	-9	38	-15	-38	-39
AMR-B	24	68	3	-5	58	4	-13	-3
AMR-D	43	69	3	-0.4	77	-16	-6	-5
EMR-B	8	17	...	...	...	...	...	0
EMR-D	32	85	...	...	60	24	...	-17
EUR-B	10	24	...	...	4	-4	-5	-3
EUR-C	24	68	...	-18	9	1	-5	0
SEAR-B	40	26	...	...	...	...	...	0
SEAR-D	43	75	...	...	65	...	...	-65
WPR-B	13	19	...	...	...	0.4	-8	0.7
Total	37	51	5	-13	50	0.5	-9	-9

Note: The 'total' population impact fractions apply only to subregions with population impact fraction estimates.
See the List of Member States by WHO Region and mortality stratum for an explanation of subregions.

overall if prevalence among the poor matched those amongst the better-off. The population impact fractions for breastfeeding, unsafe sex and tobacco were more moderate, and even varied in direction across subregions.

Burden of disease and injury attributable to selected risk factors

The next sections of the chapter describe selected major health risk factors, grouped as follows: childhood and maternal undernutrition; other diet-related risk factors and physical inactivity; sexual and reproductive health; addictive substances; environmental risks; occupational risks; and other risks to health (including unsafe health care practices, and abuse and violence). Each risk is briefly described, along with its main causes, its extent in the world and what health problems it causes. The main results in terms of attributable mortality, years of life lost and DALYs as well as attributable fractions are summarized in Annex Tables 6–13. All these results should be considered in the context of likely uncertainty levels, indicated in the Statistical Annex Explanatory Notes.

Childhood and maternal undernutrition

Many people in the developing world, particularly women and children, continue to suffer from undernutrition. The poor especially often suffer from a basic lack of protein and energy, the adverse health effects of which are frequently compounded by deficiencies in micronutrients, particularly iodine, iron, vitamin A and zinc. Another important risk factor is lack of breastfeeding.

The theoretical minimum exposure and measured adverse outcomes for this group of risk factors are shown in Table 4.2. Each of these factors is discussed separately below and some summary results are shown graphically in Figure 4.2.

Underweight

Undernutrition, defined in public health by poor anthropometric status, is mainly a consequence of inadequate diet and frequent infection, leading to deficiencies in calories, protein, vitamins and minerals. Underweight remains a pervasive problem in developing

Table 4.2 Selected major risks to health: childhood and maternal undernutrition

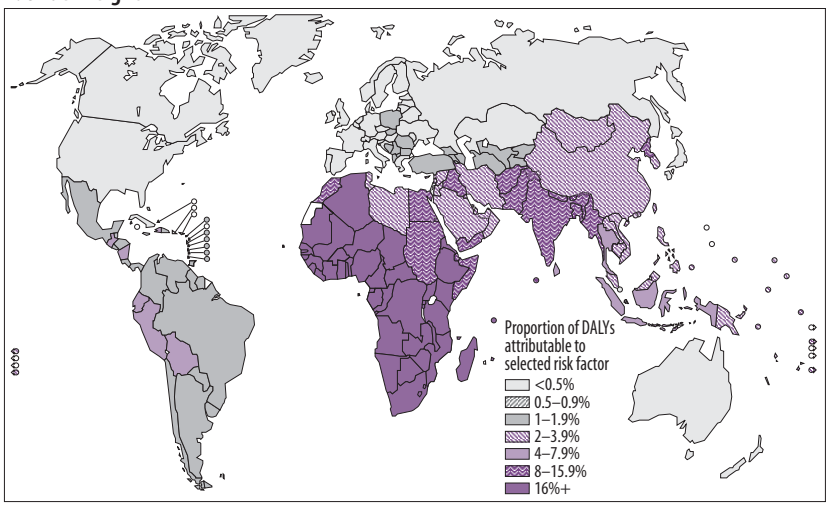
Risk factor	Theoretical minimum exposure	Measured adverse outcomes of exposure
Underweight	Same percentage of children under 5 years of age with <1 standard deviation weight-for-age as the international reference group; all women of childbearing age with BMI >20 kg/m^2	Mortality and acute morbidity from diarrhoea, malaria, measles, pneumonia, selected other Group 1 (infectious) diseases. Perinatal conditions from maternal underweight.
Iron deficiency	Haemoglobin distributions which halve anaemia prevalence, estimated to occur if all iron deficiency were eliminated (g/dl)	Anaemia, maternal and perinatal causes of death
Vitamin A deficiency	Children and women of childbearing age consuming sufficient vitamin A to meet physiological needs	Diarrhoea, malaria, maternal mortality, vitamin A deficiency disease
Zinc deficiency	The entire population consuming sufficient dietary zinc to meet physiological needs, taking into account routine and illness-related losses and bioavailability	Diarrhoea, pneumonia, malaria

countries, where poverty is a strong underlying determinant, contributing to household food insecurity, poor child care, maternal undernutrition, unhealthy environments, and poor health care. All ages are at risk, but underweight is most prevalent among children under five years of age, especially in the weaning and post-weaning period of 6–24 months. WHO has estimated that approximately 27% (168 million) of children under five years of age are underweight *(2)*. Underweight is also common among women of reproductive age, especially in Africa and South Asia, where some prevalence estimates of undernutrition are as high as 27–51% *(3)*.

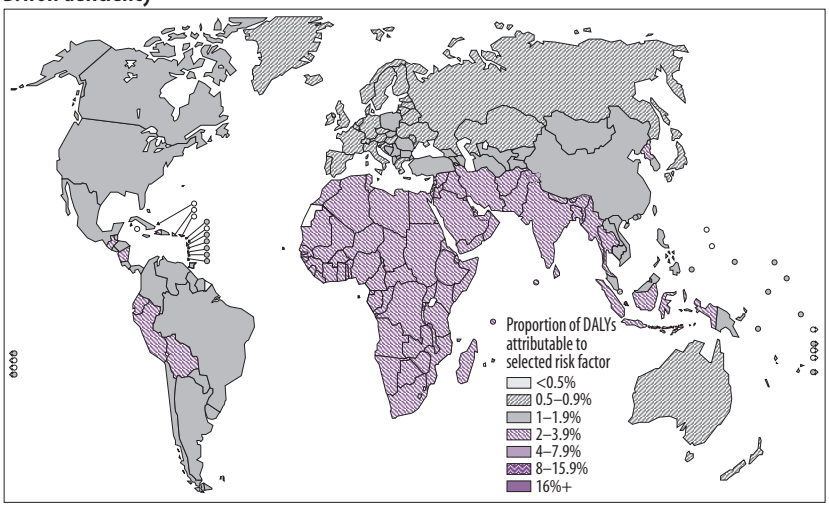
Underweight children are at increased risk of mortality from infectious illnesses such as diarrhoea and pneumonia *(4)*. The effects of undernutrition on the immune system are wide-ranging, and infectious illnesses also tend to be more frequent and severe in underweight children. A child's risk of dying from undernutrition is not limited to those children with the most severe undernutrition. There is a continuum of risk such that even mild undernutrition places a child at increased risk. Since mild and moderate undernutrition are more prevalent than severe undernutrition, much of the burden of deaths resulting from undernutrition is associated with less severe undernutrition. These analyses indicate that 50–70% of the burden of diarrhoeal diseases, measles, malaria and lower respiratory infections in childhood is attributable to undernutrition. Chronic undernutrition in the first two to three years of life can also lead to long-term developmental deficits *(5)*. Among adolescents and adults, undernutrition is also associated with adverse pregnancy outcomes and reduced work capacity.

Figure 4.2 Burden of disease attributable to childhood and maternal undernutrition (% DALYs in each subregion)

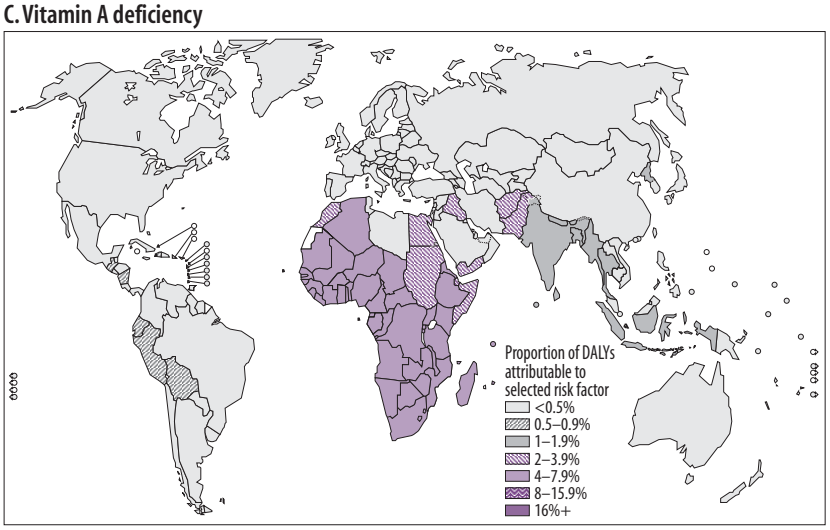
A. Underweight



B. Iron deficiency



C. Vitamin A deficiency



The values presented here are averages by subregion; variations occur within these subregions but are not shown here. For an explanation of subregions see the List of Member States by WHO Region and mortality stratum.

Underweight was estimated to cause 3.7 million deaths in 2000. This accounted for about 1 in 15 deaths globally. About 1.8 million deaths occurred in Africa, 1.2 million in SEAR-D and 0.5 million in EMR-D, accounting for 10–20% of deaths in these regions. The disease burden occurred about equally among males and females. Since deaths from undernutrition almost all occur among young children, the loss of healthy life years is even more substantial: about 138 million DALYs, 9.5% of the global total, were attributed to underweight. These estimates of burden resulting from underweight, together with those given below for micronutrient deficiences, are consistent with previous estimates of over half of childhood deaths in developing countries being caused by undernutrition *(6)*.

Iodine deficiency

Iodine deficiency is likely to be the single most common preventable cause of mental retardation and brain damage. "Endemic cretinism", the form of profound mental retardation most closely identified with iodine deficiency, represents the severe end of a broad spectrum of abnormalities collectively referred to as iodine deficiency disorders. Iodine deficiency has also been associated with lower mean birth weight and increased infant mortality, hearing impairment, impaired motor skills, and neurological dysfunction. Iodine deficiency is controlled through direct supplementation with oral or intramuscular iodized oil, addition of iodine to a vehicle such as irrigation water, or most commonly iodization of salt. Over 2.2 billion people in the world may be at risk for iodine deficiency, and recent estimates suggest over one billion experience some degree of goitre *(7–9)*. Globally, iodine deficiency disorders were estimated to result in 2.5 million DALYs (0.2% of total). Approximately 25% of this burden occurred in AFR-E, 17% in SEAR-D and 16% in EMR-D.

Iron deficiency

Iron is required in all tissues of the body for basic cellular functions, and is critically important in muscle, brain and red blood cells. Anaemia is simple to measure and has been used as the hallmark of iron deficiency severe enough to affect tissue functions. However, iron deficiency is not the sole cause of anaemia in most populations. Even in an individual, anaemia may be caused by multiple factors.

Iron deficiency is one of the most prevalent nutrient deficiencies in the world, affecting an estimated two billion people *(10)*. Young children and pregnant and postpartum women are the most commonly and severely affected because of the high iron demands of infant growth and pregnancy. Iron deficiency may, however, occur throughout the life span where diets are based mostly on staple foods with little meat intake or people are exposed to infections that cause blood loss (primarily hookworm disease and urinary schistosomiasis).

About one-fifth of perinatal mortality and one-tenth of maternal mortality in developing countries is attributable to iron deficiency. There is also a growing body of evidence indicating that iron deficiency anaemia in early childhood reduces intelligence in mid-childhood. In its most severe form, this will cause mild mental retardation. There is also evidence that iron deficiency decreases fitness and aerobic work capacity through mechanisms that include oxygen transport and respiratory efficiency within the muscle.

In total, 0.8 million (1.5%) of deaths worldwide are attributable to iron deficiency, 1.3% of all male deaths and 1.8% of all female deaths. Attributable DALYs are even greater, amounting to the loss of about 35 million healthy life years (2.4% of global DALYs). Of these DALYs, 12.5 million (36%) occurred in SEAR-D, 4.3 million (12.4%) in WPR-B, and 10.1 million (29%) in Africa.

Vitamin A deficiency

Vitamin A is an essential nutrient required for maintaining eye health and vision, growth, immune function, and survival *(11)*. Several factors, often acting together, can cause Vitamin A deficiency: low dietary intake, malabsorption, and increased excretion associated with common illnesses. Severe vitamin A deficiency can be identified by the classic eye signs of xerophthalmia, such as corneal lesions. Milder vitamin A deficiency is far more common. While its assessment is more problematic, it can be gauged by serum retinol levels and reports of night blindness.

Vitamin A deficiency causes visual impairment in many parts of the developing world and is the leading cause of acquired blindness in children. Children under five years of age and women of reproductive age are at highest risk of this nutritional deficiency and its adverse health consequences. Globally, approximately 21% of all children suffer from vitamin A deficiency (defined as low serum retinol concentrations), with the highest prevalence of deficiency, and the largest number affected, in parts of Asia (30% in SEAR-D and 48% in SEAR-B) and in Africa (28% in AFR-D and 35% in AFR-E). There is a similar pattern for women affected by night blindness during pregnancy, with a global prevalence of approximately 5% and the highest prevalence among women living in Asia and Africa where maternal mortality rates are also high.

This analysis estimated that Vitamin A deficiency also caused about 16% of worldwide burden resulting from malaria and 18% resulting from diarrhoeal diseases. Attributable fractions for both diseases were 16–20% in Africa. In South-East Asia, about 11% of malaria was attributed to vitamin A deficiency. About 10% of maternal DALYs worldwide were attributed to vitamin A deficiency, again with the proportion highest in South-East Asia and Africa. Other outcomes potentially associated with vitamin A deficiency are fetal loss, low birth weight, preterm birth and infant mortality.

In total, about 0.8 million (1.4%) of deaths worldwide result from vitamin A deficiency, 1.1% in males and 1.7% in females. Attributable DALYs are higher: 1.8% of global disease burden. Over 4–6% of all disease burden in Africa was estimated to result from vitamin A deficiency.

Zinc deficiency

Zinc deficiency is largely related to inadequate intake or absorption of zinc from the diet, although excess losses of zinc during diarrhoea may also contribute. The distinction between intake and absorption is important: high levels of inhibitors (such as fibre and phytates) in the diet may result in low absorption of zinc, even though intake of zinc may be acceptable. For this reason, zinc requirements for dietary intake are adjusted upward for populations in which animal products – the best sources of zinc – are limited, and in which plant sources of zinc are high in phytates.

Severe zinc deficiency was defined in the early 1900s as a condition characterized by short stature, hypogonadism, impaired immune function, skin disorders, cognitive dysfunction, and anorexia *(12)*. Using food availability data, it is estimated that zinc deficiency affects about one-third of the world's population, with estimates ranging from 4% to 73% across subregions. Although severe zinc deficiency is rare, mild-to-moderate zinc deficiency is quite common throughout the world *(13)*.

Worldwide, zinc deficiency is responsible for approximately 16% of lower respiratory tract infections, 18% of malaria and 10% of diarrhoeal disease. The highest attributable fractions for lower respiratory tract infection occurred in AFR-E, AMR-D, EMR-D and

SEAR-D (18–22%); likewise, the attributable fractions for diarrhoeal diseases were high in these four subregions (11–13%). Attributable fractions for malaria were highest in AFR-D, AFR-E and EMR-D (10–22%).

In total, 1.4% (0.8 million) of deaths worldwide were attributable to zinc deficiency: 1.4% in males and 1.5% in females. Attributable DALYs were higher, with zinc deficiency accounting for about 2.9% of worldwide loss of healthy life years. Of this disease burden, amounting to 28 million DALYs worldwide, 34.2% occurred in SEAR-D, 31.1% in AFR-E and 18.0% in AFR-D.

Lack of breastfeeding

Breast milk provides optimal nutrition for a growing infant, with compositional changes that are adapted to the changing needs of the infant. Human milk contains adequate minerals and nutrients for the first six months of life. Breast milk also contains immune components, cellular elements and other host-defence factors that provide various antibacterial, antiviral and antiparasitic protection. Breast-milk components stimulate the appropriate development of the infant's own immune system. On the basis of the current evidence, WHO's public health recommendation is that infants should be exclusively breastfed during the first six months of life and that they should continue to receive breast milk throughout the remainder of the first year and during the second year of life *(14)*. "Exclusive breastfeeding" means that no water or other fluids (or foods) should be administered. In almost all situations, breastfeeding remains the simplest, healthiest and least expensive method of infant feeding, which is also adapted to the nutritional needs of the infant.

In general, exclusive breastfeeding rates are low. The proportion of infants less than 6 months of age that are exclusively breastfed ranges from about 9% in EUR-C and AFR-D, respectively, to 55% in WPR-B (excluding EUR-A and WPR-A for which sufficient information was not available). On the other hand, the proportion of infants less than six months old that are not breastfed at all ranges from 35% in EUR-C to 2% in SEAR-D (again, excluding all A subregions). In Africa, however, where breastfeeding is nearly universal, exclusive breastfeeding remains rare. For infants aged 6–11 months, the proportion not breastfed ranges from 5% in SEAR-D to 69% in EUR-C. In all the subregions in Africa and South-East Asia, over 90% of infants aged 6–11 months are still breastfed.

Lack of breastfeeding – and especially lack of exclusive breastfeeding during the first months of life – are important risk factors for infant and childhood morbidity and mortality, especially resulting from diarrhoeal disease and acute respiratory infections in developing countries. For example, in a study in Brazil *(15)*, infants less than 12 months of age who received only powdered milk or cow's milk had approximately 14 times the risk of death from diarrhoeal disease and about 4 times the risk of death from acute respiratory infection compared with those who were exclusively breastfed. Furthermore, those who received powdered milk or cow's milk in addition to breast milk were found to be at 4.2 times the risk of diarrhoeal death and 1.6 times the risk of death from acute respiratory infection, compared with infants exclusively breastfed. Breastfeeding has also been demonstrated to be important for neurodevelopment, especially in premature, low-birth-weight infants and infants born small for gestational age.

Other diet-related risk factors and physical inactivity

As well as undernutrition, substantial disease burden is also attributable to risks that are related to overconsumption of certain foods or food components. This section includes estimates of burden of disease attributable to suboptimal blood pressure, cholesterol and overweight, as well as low fruit and vegetable intake and physical inactivity (see Table 4.3). Some summary results are shown graphically in Figure 4.3.

High blood pressure

Blood pressure is a measure of the force that the circulating blood exerts on the walls of the main arteries. The pressure wave transmitted along the arteries with each heartbeat is easily felt as the pulse – the highest (systolic) pressure is created by the heart contracting and the lowest (diastolic) pressure is measured as the heart fills. Raised blood pressure is almost always without symptoms. However, elevated blood pressure levels produce a variety of structural changes in the arteries that supply blood to the brain, heart, kidneys and elsewhere. In recent decades it has become increasingly clear that the risks of stroke, ischaemic heart disease, renal failure and other disease are not confined to a subset of the population with particularly high levels (hypertension), but rather continue among those with average and even below-average blood pressure *(16–18)* (see Figure 4.4).

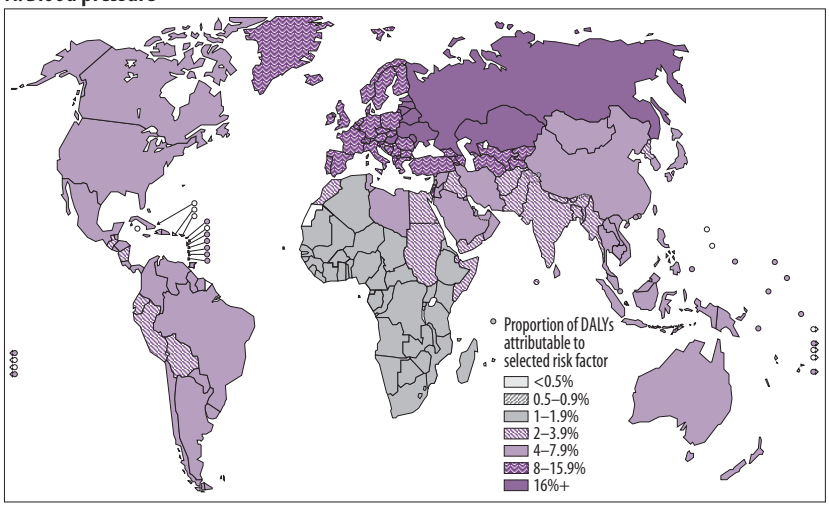
The main modifiable causes of high blood pressure are diet, especially salt intake, levels of exercise, obesity, and excessive alcohol intake. As a result of the cumulative effects of these factors blood pressure usually rises steadily with age, except in societies in which salt intake is comparatively low, physical activity high and obesity largely absent. Most adults have blood pressure levels that are suboptimal for health. This is true for both economically developing and developed countries, but in the European subregions blood pressure levels are particularly high. Across WHO regions, the range between the highest and lowest age-specific mean systolic blood pressure levels is estimated at about 20 mmHg. Globally, these analyses indicate that about 62% of cerebrovascular disease and 49% of ischaemic heart disease are attributable to suboptimal blood pressure (systolic >115 mmHg), with little variation by sex.

Table 4.3 Selected major risks to health: other diet-related factors and inactivity

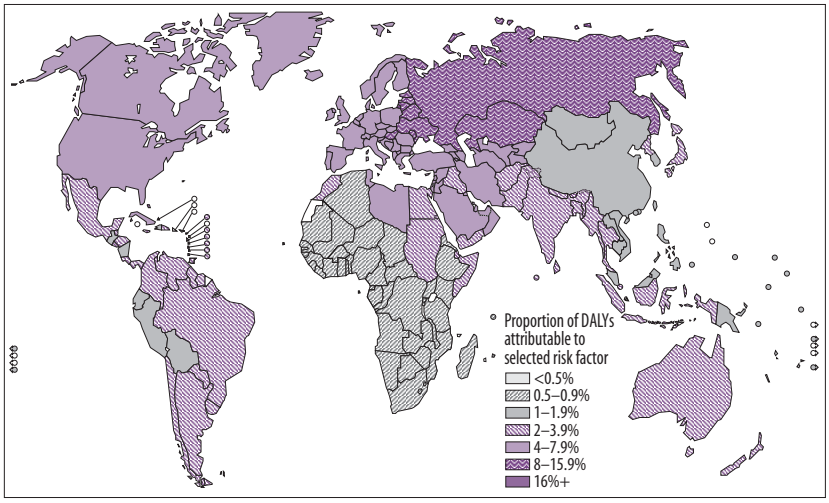
Risk factor	Theoretical minimum exposure	Measured adverse outcomes of exposure
Blood pressure	115; SD 11 mmHg	Stroke, ischaemic heart disease, hypertensive disease, other cardiac disease
Cholesterol	3.8; SD 1 mmol/l (147 SD 39 mg/dl)	Stroke, ischaemic heart disease
Overweight	21; SD 1 kg/m^2	Stroke, ischaemic heart disease, diabetes, osteoarthritis, endometrial cancer, postmenopausal breast cancer.
Low fruit and vegetable intake	600; SD 50 g intake per day for adults	Stroke, ischaemic heart disease, colorectal cancer, gastric cancer, lung cancer, oesophageal cancer
Physical inactivity	All taking at least 2.5 hours per week of moderate exercise or 1 hour per week of vigorous exercise	Stroke, ischaemic heart disease, breast cancer, colon cancer, diabetes

Figure 4.3 Burden of disease attributable to diet-related risk factors and physical inactivity (% DALYs in each subregion)

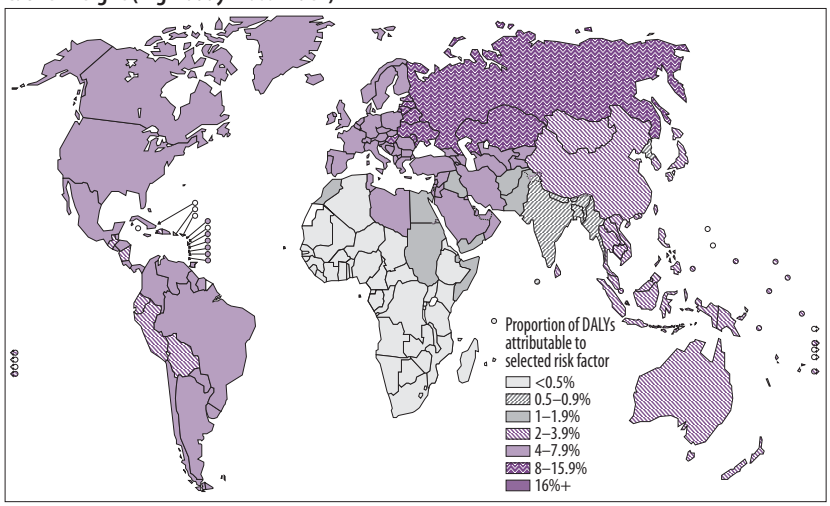
A. Blood pressure



B. Cholesterol



C. Overweight (high body mass index)



The values presented here are averages by subregion; variations occur within these subregions but are not shown here. For an explanation of subregions see the List of Member States by WHO Region and mortality stratum.

Worldwide, high blood pressure is estimated to cause 7.1 million deaths, about 13% of the total. Since most blood pressure related deaths or nonfatal events occur in middle age or the elderly, the loss of life years comprises a smaller proportion of the global total, but is nonetheless substantial (64.3 million DALYs, or 4.4% of the total). Of this disease burden, 20% occured in WPR-B, 19% in SEAR-D and 16% in EUR-C.

High cholesterol

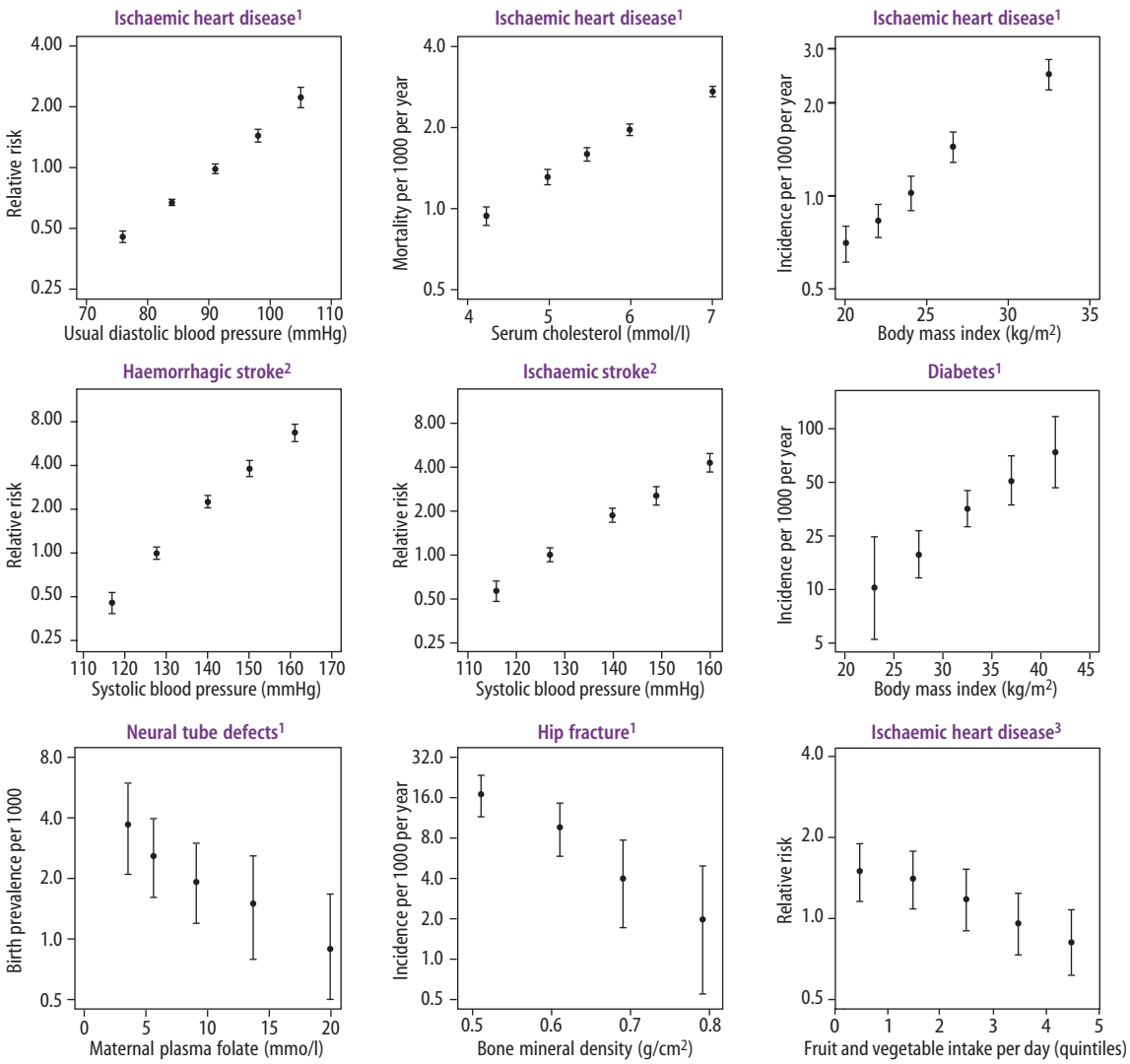
Cholesterol is a fat-like substance, found in the bloodstream as well as in bodily organs and nerve fibres. Most cholesterol in the body is made by the liver from a wide variety of foods, especially from saturated fats, such as those found in animal products. A diet high in saturated fat content, heredity, and various metabolic conditions such as diabetes mellitus influence an individual's level of cholesterol. Cholesterol levels usually rise steadily with age, more steeply in women, and stabilize after middle age. Mean cholesterol levels vary moderately between regions, although never more than 2.0 mmol/l in any age group.

Cholesterol is a key component in the development of atherosclerosis, the accumulation of fatty deposits on the inner lining of arteries. Mainly as a result of this, cholesterol increases the risks of ischaemic heart disease, ischaemic stroke and other vascular diseases. As with blood pressure, the risks of cholesterol are continuous and extend across almost all levels seen in different populations, even those with cholesterol levels much lower than those seen in North American and European populations.

High cholesterol is estimated to cause 18% of global cerebrovascular disease (mostly nonfatal events) and

56% of global ischaemic heart disease. Overall this amounts to about 4.4 million deaths (7.9% of total) and 40.4 million DALYs (2.8% of total). Of this total disease burden, 27% occurred in SEAR-D, 18% in EUR-C and 11% in WPR-B. In AMR-A and Europe, 5–12% of DALYs were attributable to suboptimal cholesterol levels. In most regions, the proportion of female deaths attributable to cholesterol is slightly higher than that for men.

Figure 4.4 Nine examples of continuous associations between risks and disease



The figure shows continuous dose–response associations for a number of risk factor–outcome combinations. Lack of thresholds to these associations suggests there is no biological justification for typical binary categorizations, such as "hypertension" or "hypercholesterolaemia".

[1] Law MR, Wald NJ. Risk factor thresholds: their existence under scrutiny. *BMJ* 2002; 324:1570-6.
[2] Eastern Stroke and Coronary Heart Disease Collaborative Group. Blood pressure, cholesterol and stroke in eastern Asia. *Lancet* 1998; 352:1801-07.
[3] Joshipura KJ, Hu FB, Manson JE, Stampfer MJ, Rimm EB, Speizer FE, Colditz G, Ascherio A, Rosner B, Spiegelman D, Willett WC. The effect of fruit and vegetable intake on risk for coronary heart disease. *Annals of Internal Medicine* 2001; 134(12):1106-14.

Obesity, overweight, and high body mass

The prevalence of overweight and obesity is commonly assessed using body mass index (BMI), a height/weight formula with a strong correlation to body fat content. WHO criteria define overweight as a BMI of at least 25 kg/m^2 and obesity as a BMI of at least 30 kg/m^2. These markers provide common benchmarks for assessment, but the risks of disease in all populations increase progressively from BMI levels of 20–22 kg/m^2.

Adult mean BMI levels of 20–23 kg/m^2 are found in Africa and Asia, while levels are 25–27 kg/m^2 across North America and Europe. BMI increases among middle-aged and elderly people, who are at greatest risk of health complications. Increases in free sugar and saturated fats, combined with reduced physical activity, have led to obesity rates that have risen three-fold or more since 1980 in some areas of North America, the United Kingdom, Eastern Europe, the Middle East, the Pacific Islands, Australasia and China. A new demographic transition in developing countries is producing rapid increases in BMI, particularly among the young. The affected population has increased to epidemic proportions, with more than one billion adults worldwide overweight and at least 300 million clinically obese *(19)*.

Overweight and obesity lead to adverse metabolic effects on blood pressure, cholesterol, triglycerides and insulin resistance. Risks of coronary heart disease, ischaemic stroke and type 2 diabetes mellitus increase steadily with increasing BMI. Type 2 diabetes mellitus – confined to older adults for most of the 20th century – now affects obese children even before puberty. Modest weight reduction reduces blood pressure and abnormal blood cholesterol and substantially lowers risk of type 2 diabetes. Raised BMI also increases the risks of cancer of the breast, colon, prostate, endometrium, kidney and gallbladder. Although mechanisms that trigger these increased cancer risks are not fully understood, they may relate to obesity-induced hormonal changes. Chronic overweight and obesity contribute significantly to osteoarthritis, a major cause of disability in adults.

In the analyses carried out for this report, approximately 58% of diabetes mellitius globally, 21% of ischaemic heart disease and 8–42% of certain cancers were attributable to BMI above 21 kg/m^2. This amounted to about 13% of deaths in EUR-B and EUR-C and 9–10% of deaths in AMR-A, AMR-B and EUR-A. High BMI causes 8–15% of DALYs in Europe and AMR-A, but less than 3% in Africa, AMR-D, South-East Asia, EMR-D and WPR-A. The proportions of DALYs caused by high BMI are slightly higher for women than for men.

Low fruit and vegetable intake

Fruit and vegetables are important components of a healthy diet. Accumulating evidence suggests that they could help prevent major diseases such as cardiovascular diseases *(20)* and certain cancers principally of the digestive system *(21)*. There are several mechanisms by which these protective effects may be mediated, involving antioxidants and other micronutrients, such as flavonoids, carotenoids, vitamin C and folic acid, as well as dietary fibre. These and other substances block or suppress the action of carcinogens and, as antioxidants, prevent oxidative DNA damage.

Fruit and vegetable intake varies considerably among countries, in large part reflecting the prevailing economic, cultural and agricultural environments. The analysis assessed the levels of mean dietary intake of fruit and vegetables (excluding potatoes) in each region, measured in grams per person per day. The estimated levels varied two-fold around the world, ranging from about 189 g/day in AMR-B to 455 g/day in EUR-A.

Low intake of fruit and vegetables is estimated to cause about 19% of gastrointestinal cancer, and about 31% of ischaemic heart disease and 11% of stroke worldwide. Overall,

2.7 million (4.9%) deaths and 26.7 million (1.8%) DALYs are attributable to low fruit and vegetable intake. Of the burden attributable to low fruit and vegetable intake, about 85% was from cardiovascular diseases and 15% from cancers. About 43% of the disease burden occurred in women and 15% in EUR-C, 29% in SEAR-D and 18% in WPR-B.

Physical inactivity

Opportunities for people to be physically active exist in the four major domains of their day-to-day lives: at work (especially if the job involves manual labour); for transport (for example, walking or cycling to work); in domestic duties (for example, housework or gathering fuel); or in leisure time (for example, participating in sports or recreational activities). In this report, physical inactivity is defined as doing very little or no physical activity in any of these domains.

There is no internationally agreed definition or measure of physical activity. Therefore, a number of direct and indirect data sources and a range of survey instruments and methodologies were used to estimate activity levels in these four domains. Most data were available for leisure-time activity, with fewer direct data available on occupational activity and little direct data available for activity relating to transport and domestic tasks. Also, this report only estimates the prevalence of physical inactivity among people aged 15 years and over. The global estimate for prevalence of physical inactivity among adults is 17%, ranging from 11% to 24% across subregions. Estimates for prevalence of some but insufficient activity (<2.5 hours per week of moderate activity) ranged from 31% to 51%, with a global average of 41% across the 14 subregions.

Physical activity reduces the risk of cardiovascular disease, some cancers and type 2 diabetes. These benefits are mediated through a number of mechanisms *(22)*. In general, physical activity improves glucose metabolism, reduces body fat and lowers blood pressure; these are the main ways in which it is thought to reduce the risk of cardiovascular diseases and diabetes. Physical activity may reduce the risk of colon cancer by effects on prostaglandins, reduced intestinal transit time, and higher antioxidant levels. Physical activity is also associated with lower risk of breast cancer, which may be the result of effects on hormonal metabolism. Participation in physical activity can improve musculoskeletal health, control body weight, and reduce symptoms of depression. The possible effects on musculoskeletal conditions such as osteoarthritis and low back pain, osteoporosis and falls, obesity, depression, anxiety and stress, as well as on prostate and other cancers are, however, not quantified here.

Overall physical inactivity was estimated to cause 1.9 million deaths and 19 million DALYs globally. Physical inactivity is estimated to cause, globally, about 10–16% of cases each of breast cancer, colon and rectal cancers and diabetes mellitus, and about 22% of ischaemic heart disease. Estimated attributable fractions are similar in men and women and are highest in AMR-B, EUR-C and WPR-B. In EUR-C, the proportion of deaths attributable to physical inactivity is 8–10%, and in AMR-A, EUR-A and EUR-B it is about 5–8%.

Sexual and reproductive health

Risk factors in the area of sexual and reproductive health can affect well-being in a number of ways (see Table 4.4). The largest risk by far is that posed by unsafe sex leading to infection with HIV/AIDS. Other potentially deleterious outcomes, such as other sexually transmitted infections, unwanted pregnancy or the psychological consequences of sexual violence are considered elsewhere in this report (see Figure 4.5).

Table 4.4 Selected major risks to health: sexual and reproductive health

Risk factor	Theoretical minimum exposure	Measured adverse outcomes of exposure
Unsafe sex	No unsafe sex	HIV/AIDS, sexually transmitted infections, cervical cancer
Lack of contraception	Use of modern contraceptives for all women who want to space or limit future pregnancies	Maternal mortality and morbidity

Unsafe sex

HIV/AIDS is the fourth biggest cause of mortality in the world. Currently, 28 million (70%) of the 40 million people with HIV infection are concentrated in Africa, but epidemics elsewhere in the world are growing rapidly. The rate of development of new cases is highest in Eastern Europe and central Asia *(23)*. Life expectancy at birth in sub-Saharan Africa is currently estimated at 47 years; without AIDS it is estimated that it would be around 62 years *(23)*. The consequences of HIV/AIDS extend beyond mortality; children are orphaned and entire economies can be affected.

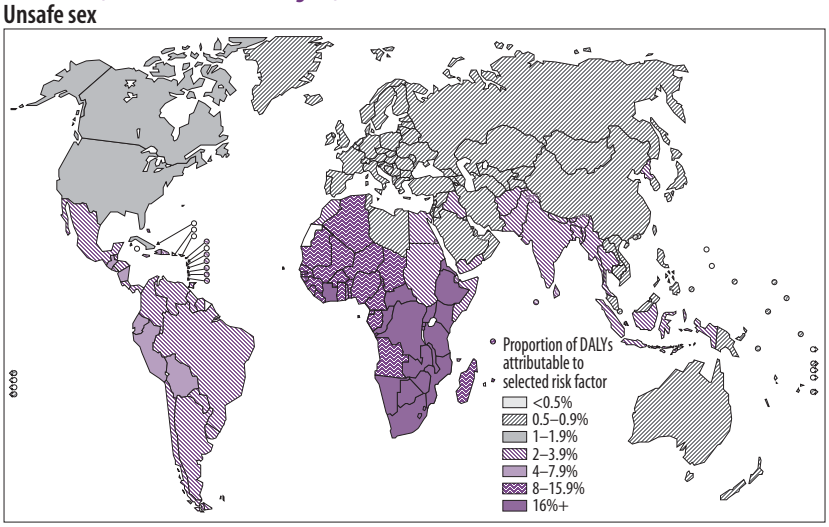
Most people infected with HIV do not know they are infected, making prevention and control more difficult. Various sexual practices contribute to the risk of sexually transmitted infections. They increase the risk of exposure to pathogens ("high risk sex") and the chance of being infected by the pathogens, given high risk sex. The spread of a sexually transmitted disease is also affected by the duration of infectiousness, which depends on treatment availability and effectiveness. Aspects of high risk sex include the number of sexual partners, the rate of change of sexual partners, who the sexual partners are, and the type of sex acts involved.

Sexual behaviour is difficult to measure, and estimates of the prevalence of high risk behaviour rely on self reports, where sampling is usually of individuals (rather than partnerships) and often excludes high risk individuals. Most of the infections prevalent in 2001 were acquired through heterosexual sex. This analysis estimates the burden of disease from unsafe sex between men and women, because epidemics driven by heterosexual contact are responsible for the most demographically significant consequences. No single measure of "unsafe sex" has been used, because sex is only unsafe with respect to the context in which it occurs. Therefore patterns of sexual behaviour have been described.

The prevalence of different sexual behaviours and characteristics varies greatly between countries and between regions. Current estimates suggest that more than 99% of the HIV infections prevalent in Africa in 2001 are attributable to unsafe sex. In the rest of the world, the 2001 estimates for the proportion of HIV/AIDS deaths attributable to unsafe sex range from about one-quarter in EUR-C to more than 90% in WPR-A.

Figure 4.5 Burden of disease attributable to sexual and reproductive health risks (% DALYs in each subregion)

Unsafe sex



The values presented here are averages by subregion; variations occur within these subregions but are not shown here. For an explanation of subregions see the List of Member States by WHO Region and mortality stratum.

Globally, about 2.9 million deaths (5.2% of total) and 91.9 million DALYs (6.3% of all) are attributable to unsafe sex. The vast majority of this burden results from HIV/AIDS occurring in the African region. About 59% of total unsafe sex disease burden occurs in AFR-E and about 15% in both AFR-D and SEAR-D. In addition, the African countries are unique in suffering more attributable burden in women than in men, as a result of unsafe sex.

Lack of contraception

The cause of unintended pregnancy is non-use, or ineffective use, of contraception. Contraceptive use can be categorized into modern methods (such as the oral contraceptive pill, barrier methods, the intrauterine device or sterilization), traditional methods (such as the rhythm method), and no method. Modern methods have the lowest probability of unintended pregnancy. The overall rates of contraceptive use, the effectiveness of the different methods, and the mix of methods used in a country will determine the risk of unintended pregnancy and its consequences.

Demographic health surveys indicate that the proportion of women aged from 15 to 29 years who currently use a modern method of contraception varies from 8% to 62% in the different subregions, and the prevalence of traditional methods ranges from 3% to 18%. If all women of this age group who want to either space or limit future pregnancies were using modern methods of contraception (the counterfactual distribution), then the prevalence of use would range from 43% to 85%. For these analyses it was assumed that there was full access to modern contraception for women in the AMR-A, EUR-A and WPR-A subregions. For most other regions, the difference between current levels and full access is approximately 35%. The use of modern methods is somewhat higher among women aged from 30 to 44 years. This group also has a higher proportion of women who wish to space or limit future pregnancies, so the differences between the current and counterfactual prevalences are similar to those in the younger age group.

Unintended pregnancy leads to unwanted and mistimed births, which have maternal and perinatal complications in the same way as wanted births. Similarly, stillbirths and miscarriages occur as pregnancy outcomes with some risk to the mother, irrespective of whether the pregnancy was intended or not. The likelihood of an abortion following an unintended pregnancy depends on whether the pregnancy is mistimed (that is, the woman wanted to get pregnant, but not within the next two years) or unwanted (that is, the woman did not want to conceive or did not want any more pregnancies). The risk of abortion-related complications is proportional to the risk of unsafe abortion, which is strongly related to the legality of abortion in the country concerned.

Worldwide, unplanned pregnancies were responsible for about 90% of unwanted births, the remainder being due to method failure. This amounted to 17% of maternal disease burden and 89% of unsafe abortions. Attributable fractions for maternal disease were highest in AMR-B, AMR-D, EUR-B and SEAR-D, ranging from 23% to 33%. The attributable fractions in these subregions for unsafe abortions were also the highest and ranged from 85% to 95%.

Throughout the world, lack of contraception caused about 149 000 (0.3%) deaths and 8.8 million (0.6%) DALYs. Africa, South-East Asia, AMR-D and EMR-D had the highest disease burden attributable to lack of contraception, ranging from 0.6% to 1.5% of deaths and 1.4% to 2.6% of DALYs in those subregions.

Addictive substances

Humans consume a wide variety of addictive substances. The addictive substances assessed quantitatively in this report included tobacco, alcohol and illicit drugs (see Table 4.5). Some summary results are shown in Figure 4.6.

Smoking and oral tobacco use

Tobacco is cultivated in many regions around the world and can be legally purchased in all countries. The dried leaf of the plant *nicotiana tabacum* is used for smoking, chewing or snuff. Comparable data on the prevalence of smoking are not widely available and are often inaccurate, especially when age-specific data are required. More importantly, current prevalence of smoking is a poor proxy for the cumulative hazards of smoking, which depend on several factors including the age at which smoking began, duration of smoking, number of cigarettes smoked per day, degree of inhalation, and cigarette characteristics such as tar and nicotine content or the type of filter. To overcome this problem the smoking impact ratio, which estimates excess lung cancer, is used as a marker for accumulated smoking risk.

There were large increases in smoking in developing countries, especially among males, over the last part of the 20th century *(24, 25)*. This contrasts with the steady but slow decreases, mostly among men, in many industrialized countries. Smoking rates remain relatively high in most former socialist economies. While prevalence of tobacco use has declined in some high income countries, it is increasing in some low and middle income countries, especially among young people and women.

Smoking causes substantially increased risk of mortality from lung cancer, upper aerodigestive cancer, several other cancers, heart disease, stroke, chronic respiratory disease and a range of other medical causes. As a result, in populations where smoking has been common for many decades, tobacco use accounts for a considerable proportion of mortality, as illustrated by estimates of smoking-attributable deaths in industrialized countries *(26)*. The first estimates of the health impacts of smoking in China and India have also shown substantially increased risk of mortality and disease among smokers *(27–30)*. Smoking also harms others – there are definite health risks from passive smoking (see Box 4.1) and smoking during pregnancy adversely affects fetal development. While cigarette smoking causes the majority of the adverse health effects of tobacco, chewing is also hazardous, causing oral cancer in particular, as does tobacco smoking via cigars or pipes.

Among industrialized countries, where smoking has been common, smoking is estimated to cause over 90% of lung cancer in men and about 70% of lung cancer among women. In addition, in these countries, the attributable fractions are 56–80% for chronic

Table 4.5 Selected major risks to health: addictive substances

Risk factor	Theoretical minimum exposure	Measured adverse outcomes of exposure
Tobacco	No tobacco use	Lung cancer, upper aerodigestive cancer, all other cancers, chronic obstructive pulmonary disease, other respiratory diseases, all vascular diseases
Alcohol	No alcohol use	Stroke, ischaemic heart disease, other cardiac diseases, hypertensive disease, diabetes mellitus, liver cancer, cancer of mouth and oropharynx, breast cancer, oesophagus cancer, other neoplasms, liver cirrhosis, epilepsy, alcohol use, falls, motor accidents, drownings, homicide, other intentional injuries, self-inflicted injuries, poisonings
Illicit drugs	No illicit drug use	HIV/AIDS, overdose, drug use disorder, suicide, trauma

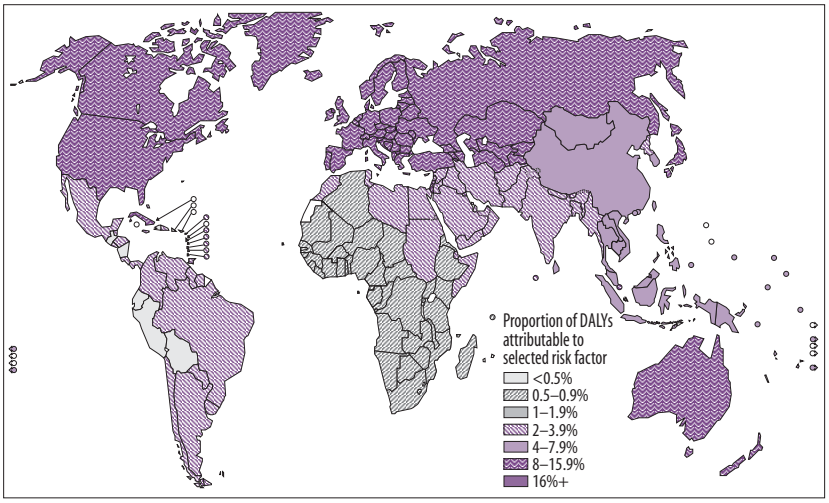
respiratory disease and 22% for cardiovascular disease. Worldwide, it is estimated that tobacco causes about 8.8% of deaths (4.9 million) and 4.1% of DALYs (59.1 million). The rapid evolution of the tobacco epidemic is illustrated by comparing these estimates for 2000 with those for 1990: there are at least a million more deaths attributable to tobacco, with the increase being most marked in developing countries. The extent of disease burden is consistently higher among groups known to have smoked longest – for example, attributable mortality is greater in males (13.3%) than females (3.8%). Worldwide, the attributable fractions for tobacco were about 12% for vascular disease, 66% for trachea bronchus and lung cancers and 38% for chronic respiratory disease, although the pattern varies by subregion. Approximately 16% of the global attributable burden occurred in WPR-B, 20% in SEAR-D and 14% in EUR-C.

Alcohol use

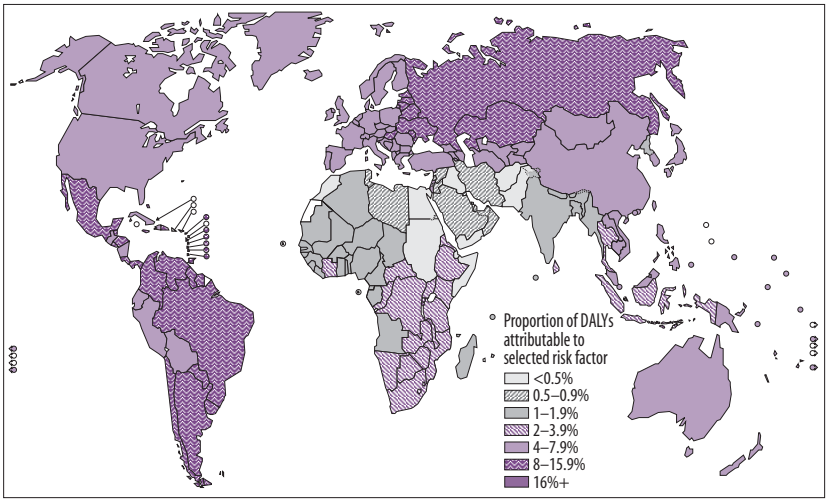
Alcohol has been consumed in human populations for millennia, but the considerable and varied adverse health effects, as well as some benefits, have only been characterized recently *(39, 40)*. Alcohol consumption has health and social consequences via intoxication (drunkenness), dependence (habitual, compulsive, long-term heavy drinking) and other biochemical effects. Intoxication is a powerful mediator for acute outcomes, such as car crashes or domestic violence, and can also cause chronic health and social problems. Alcohol dependence is a disorder in itself. There is increasing evidence that patterns of drinking are relevant to health as well as volume of alcohol consumed, binge drinking being hazardous.

Figure 4.6 Burden of disease attributable to tobacco, alcohol and illicit drugs (% DALYs in each subregion)

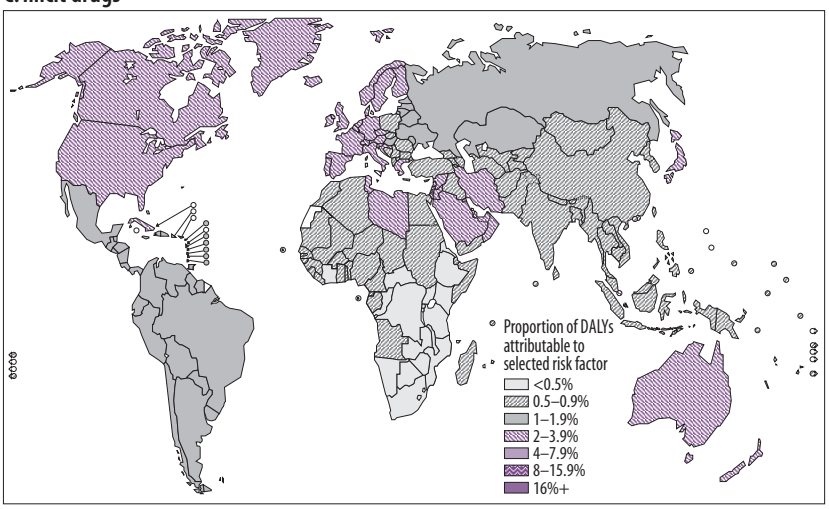
A. Tobacco



B. Alcohol



C. Illicit drugs



The values presented here are averages by subregion; variations occur within these subregions but are not shown here. For an explanation of subregions see the List of Member States by WHO Region and mortality stratum.

Global alcohol consumption has increased in recent decades, with most or all of this increase occurring in developing countries. Both average volume of alcohol consumption and patterns of drinking vary dramatically between subregions. Average volume of drinking is highest in Europe and North America, and lowest in the Eastern Mediterranean and SEAR-D. Patterns are most detrimental in EUR-C, AMR-B, AMR-D and AFR-E. Patterns are least detrimental in Western Europe (EUR-A) and the more economically established parts of the Western Pacific region (WPR-A).

Overall, there are causal relationships between average volume of alcohol consumption and more than 60 types of disease and injury. Most of these relationships are detrimental, but there are beneficial relationships with coronary heart disease, stroke and diabetes mellitus, provided low-to-moderate average volume of consumption is combined with non-binge patterns of drinking. For example, it is estimated that ischaemic stroke would be about 17% higher in AMR-A, EUR-A and WPR-A subregions if no-one consumed alcohol.

Worldwide, alcohol causes 3.2% of deaths (1.8 million) and 4.0% of DALYs (58.3 million). Of this global burden, 24%occurs in WPR-B, 16% in EUR-C, and 16% in AMR-B. This proportion is much higher in males (5.6% of deaths, 6.5% of DALYs) than females (0.6% of deaths, 1.3% of DALYs). Within subregions, the proportion of disease burden attributable to alcohol is greatest in the Americas and Europe, where it ranges from 8% to 18% of total burden for males and 2% to 4% for females. Besides the direct effects of intoxication and addiction resulting in alcohol use disorders, alcohol is estimated to cause about 20–30% of each of the following worldwide: oesophageal cancer, liver cancer, cirrhosis of the liver, homicide, epilepsy, and motor vehicle accidents. For males in EUR-C, 50–75% of drownings, oesophagus cancer, epilepsy, unintentional injuries, homicide, motor vehicle crashes and cirrhosis of the liver are attributed to alcohol.

Illicit drug use

Illicit drug use includes the non-medical use of a variety of drugs that are prohibited by international law. The current analysis focuses on the burden attributable to the injection of amphetamines and opioids, including cocaine and heroin. Other illegal drugs, such as ec-

Box 4.1 Environmental tobacco smoke

Environmental tobacco smoke (ETS) is a combination of exhaled smoke from active smokers and the smoke coming from smouldering tobacco between puffs. Also known as second-hand smoke or passive (involuntary) smoking, ETS causes disease in non-smokers; it contains all the same toxic components as mainstream tobacco smoke, although in somewhat different relative amounts.

ETS exposure is primarily dependent on the prevalence of smoking, including both commercial and non-commercial forms of tobacco. In addition, smoking intensity (the amount of tobacco smoked per smoker), differences in ventilation, and differences in places where people smoke affect the amount of ETS exposure that results per smoker.

Most studies on the health effects of ETS have focused on household and occupational exposures. People are also exposed in other environments, such as schools, transport systems, bars and restaurants. Exposure to ETS has been associated with lower respiratory infections, sudden infant death syndrome, asthma, ischaemic heart disease, otitis media, lung cancer and nasal-sinus cancer. In the United States, for example, several thousand lung cancer deaths are associated with ETS exposure each year. There is increasing evidence that ETS causes heart disease and in the United States alone it has been estimated to cause tens of thousands of premature deaths each year. There is evidence that even short-term exposures to ETS can increase the risk of coronary thrombosis by increasing blood platelet aggregation.

In addition, maternal smoking during pregnancy results in passive smoke exposure for the fetus (sometimes referred to as tertiary smoke), resulting in an increased risk of low birth weight and sudden infant death syndrome. The risk of sudden infant death syndrome is doubled when mothers smoke.

Protecting people from ETS exposure has a large role in policy debates about controlling active smoking, since ETS exposures affect not only smokers but also others around them, most importantly young children who are not in a position to protect themselves. Without major efforts to bring smoking and ETS exposure under control, the burden of disease from ETS will continue to increase in the future.

Sources: *(31–38)*.

stasy, solvents and cannabis have not been included because there is insufficient research to quantify their health risks globally.

Because the use of these drugs is illicit and often hidden, it is difficult to estimate the prevalence of their use and the occurrence of adverse health consequences. Despite these difficulties, it is apparent that illicit drugs cause considerable disease burden and their use is increasing in many countries, including those with little past history of such use *(41, 42)*.

The estimated prevalence of illicit drug use varies considerably across WHO regions. For example, estimates from the United Nations Drug Control Programme of the prevalence of opioid use in the past 12 months among people over the age of 15 years varies by an order of magnitude or more, from 0.02–0.04% in the Western Pacific region to 0.4–0.6% in the Eastern Mediterranean region. Cocaine use varies to a similar extent, but the prevalence of amphetamine use is estimated to be 0.1%–0.3% in most regions.

The mortality risks of illicit drugs increase with frequency and quantity of use *(43, 44)*. The most hazardous patterns are found among dependent users who typically inject drugs daily or near daily over periods of years. Studies of treated injecting opioid users show this pattern is associated with increased overall mortality, including that caused by HIV/AIDS, overdose, suicide and trauma. Other adverse health and social effects that could not be quantified include other bloodborne diseases such as hepatitis B and hepatitis C, and criminal activity associated with the drug habit.

Globally, 0.4% of deaths (0.2 million) and 0.8% of DALYs (11.2 million) are attributed to overall illicit drug use. Attributable burden is consistently several times higher among men than women. Illicit drugs account for the highest proportion of disease burden among low mortality, industrialized countries in the Americas, Eastern Mediterranean and European regions. In these areas illicit drug use accounts for 2–4% of all disease burden among men.

Environmental risks

The environment in which we live greatly affects our health. The household, workplace, outdoor and transportation environments pose risks to health in a number of different ways, from the poor quality of the air many people breathe to the hazards we face as a result of climate change (see Table 4.6). A range of selected environmental risk factors is assessed here and some summary results are shown in Figure 4.7.

Table 4.6 Selected major risks to health: environmental factors

Risk factor	Theoretical minimum exposure	Measured adverse outcomes of exposure
Unsafe water, sanitation and hygiene	Absence of transmission of diarrhoeal disease through water, sanitation and hygiene practices	Diarrhoea
Urban air pollution	7.5 μg/m^3 for $PM_{2.5}$	Cardiovascular mortality, respiratory mortality, lung cancer, mortality from acute respiratory infections in children
Indoor smoke from solid fuels	No solid fuel use	Acute respiratory infections in children, chronic obstructive pulmonary disease, lung cancer
Lead exposure	0.016 μg/dl blood lead levels	Cardiovascular disease, mild mental retardation
Climate change	1961–1990 concentrations	Diarrhoea, flood injury, malaria, malnutrition

Unsafe water, sanitation and hygiene

Adverse health outcomes are associated with ingestion of unsafe water, lack of access to water (linked to inadequate hygiene), lack of access to sanitation, contact with unsafe water, and inadequate management of water resources and systems, including in agriculture. Infectious diarrhoea makes the largest single contribution to the burden of disease associated with unsafe water, sanitation and hygiene.

Six broad scenarios were characterized; these included populations with no access to improved water sources or no basic sanitation; those with access to fully regulated water supply and sanitation services; and an ideal scenario in which no disease transmission is associated with this risk factor. In addition, schistosomiasis, trachoma, ascariasis, trichuriasis and hookworm disease were fully attributed to unsafe water, sanitation and hygiene.

Exposure prevalence was determined from the WHO/UNICEF Global Water Supply and Sanitation Assessment 2000. This provides a synthesis of major international surveys and national census reports, which provide data for 89% of the global population. In 2000, the percentage of people served with some form of improved water supply worldwide reached 82% (4.9 billion), while 60% (3.6 billion) had access to basic sanitation facilities. The vast majority of diarrhoeal disease in the world (88%) was attributable to unsafe water, sanitation and hygiene.

Approximately 3.1% of deaths (1.7 million) and 3.7% of DALYs (54.2 million) worldwide are attributable to unsafe water, sanitation and hygiene. Of this burden, about one-third occurred in Africa and one-third in SEAR-D. In these areas, as well as in EMR-D and AMR-D, 4–8% of all disease burden is attributable to unsafe water, sanitation and hygiene. Overall, 99.8% of deaths associated with this risk factor are in developing countries, and 90% are deaths of children.

Urban air pollution

The serious consequences of exposure to high levels of urban ambient air pollution were made clear in the mid-20th century when cities in Europe and the United States experienced air pollution episodes, such as the infamous 1952 London fog, that resulted in many deaths and hospital admissions. Subsequent clean air legislation and actions reduced ambient air pollution in many regions. However, recent epidemiological studies, using sensitive designs and analyses, have identified serious health effects of combustion-derived air pollution even at the low ambient concentrations typical of Western European and North American cities *(45)*. At the same time, the populations of the rapidly expanding megacities of Asia, Africa and Latin America are increasingly exposed to levels of ambient air pollution that rival and often exceed those experienced in industrialized countries in the first half of the 20th century *(46)*.

Urban air pollution is largely and increasingly the result of the combustion of fossil fuels for transport, power generation and other human activities. Combustion processes produce a complex mixture of pollutants that comprises both primary emissions, such as diesel soot particles and lead, and the products of atmospheric transformation, such as ozone and sulfate particles formed from the burning of sulfur-containing fuel.

Air pollution from combustion sources is associated with a broad spectrum of acute and chronic health effects *(47, 48)*, that may vary with the pollutant constituents. Particulate air pollution (i.e. particles small enough to be inhaled into the lung,) is consistently and independently related to the most serious effects, including lung cancer and other cardiopulmonary mortality *(44, 49, 50)*. Other constituents, such as lead and ozone, are also associated with serious health effects, and contribute to the burden of disease attributable to urban air

pollution. The analyses based on particulate matter estimate that ambient air pollution causes about 5% of trachea, bronchus and lung cancer, 2% of cardiorespiratory mortality and about 1% of respiratory infections mortality globally. This amounts to about 0.8 million (1.4%) deaths and 7.9 million (0.8%) DALYs. This burden predominantly occurs in developing countries, with 42% of attributable DALYs occurring in WPR-B and 19% in SEAR-D. Within subregions, the highest proportions of total burden occur in WPR-A, WPR-B, EUR-B and EUR-C, where ambient air pollution causes 0.6–1.4% of disease burden. These estimates consider only the impact of air pollution on mortality, and not morbidity, due to limitations in the epidemiologic database. If air pollution multiplies both incidence and mortality to the same extent, the burden of disease would be higher.

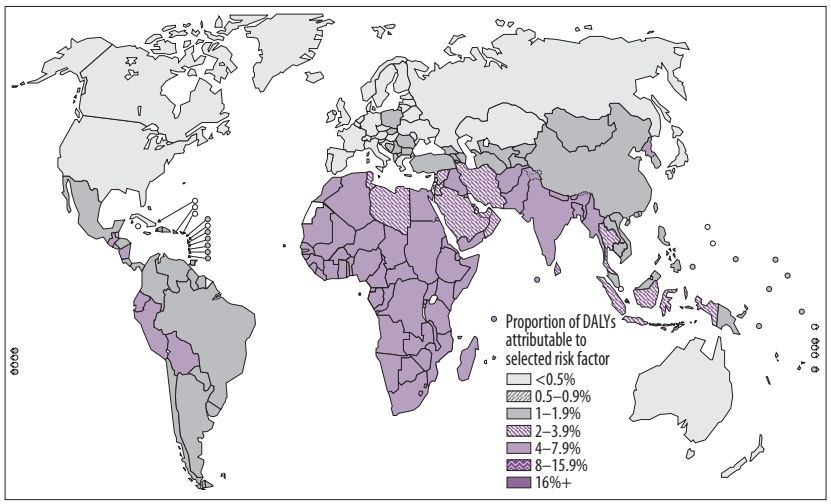
Indoor smoke from solid fuels

Although air pollutant emissions are dominated by outdoor sources, human exposures are a function of the level of pollution in places where people spend most of their time *(51–53)*. Human exposure to air pollution is thus dominated by the indoor environment. Cooking and heating with solid fuels such as dung, wood, agricultural residues or coal is likely to be the largest source of indoor air pollution globally. When used in simple cooking stoves, these fuels emit substantial amounts of pollutants, including respirable particles, carbon monoxide, nitrogen and sulfur oxides, and benzene.

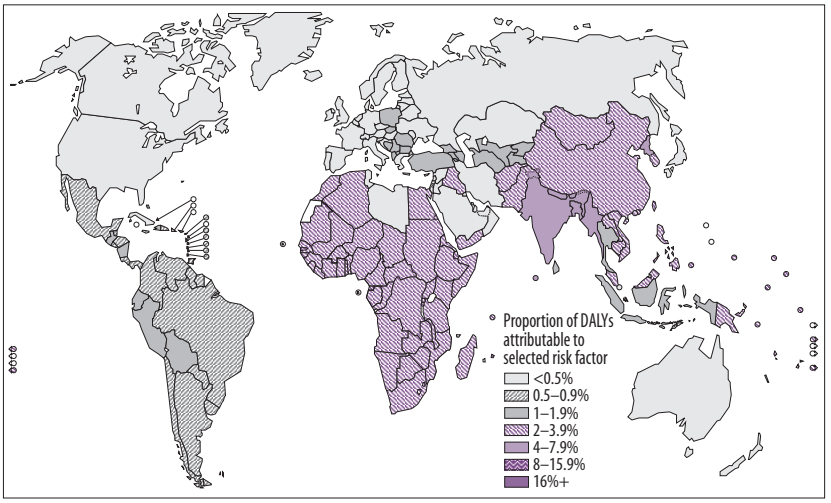
Nearly half the world continues to cook with solid fuels. This includes more than 75% of people in India, China and nearby countries, and

Figure 4.7 Burden of disease attributable to selected environmental risk factors (% DALYs in each subregion)

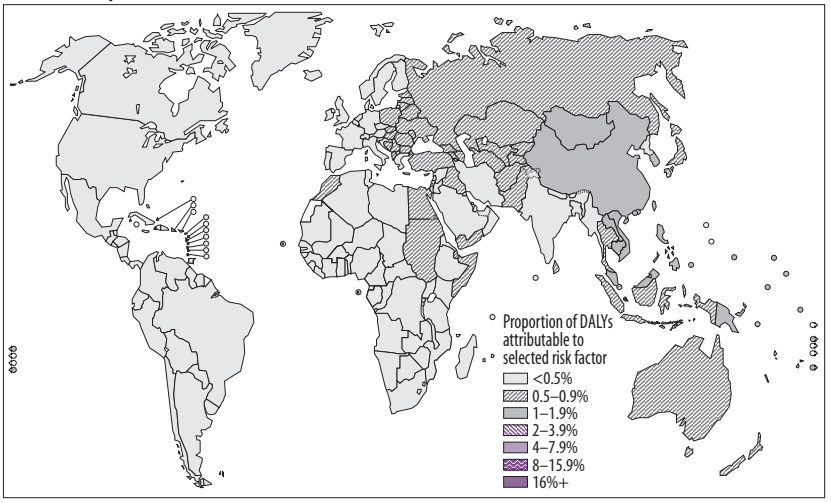
A. Unsafe water



B. Indoor smoke from solid fuels



C. Urban air pollution



The values presented here are averages by subregion; variations occur within these subregions but are not shown here. For an explanation of subregions see the List of Member States by WHO Region and mortality stratum.

50–75% of people in parts of South America and Africa. Limited ventilation is common in many developing countries and increases exposure, particularly for women and young children who spend much of their time indoors. Exposures have been measured at many times higher than WHO guidelines and national standards, and thus can be substantially greater than outdoors in cities with the most severe air pollution.

Studies have shown reasonably consistent and strong relationships between the indoor use of solid fuel and a number of diseases. These analyses estimate that indoor smoke from solid fuels causes about 35.7% of lower respiratory infections, 22.0% of chronic obstructive pulmonary disease and 1.5% of trachea, bronchus and lung cancer. Indoor air pollution may also be associated with tuberculosis, cataracts and asthma.

In total, 2.7% of DALYs worldwide are attributable to indoor smoke, 2.5% in males and 2.8% in females. Of this total attributable burden, about 32% occurs in Africa (AFR-D and AFR-E), 37% in SEAR-D and 16% in WPR-B. Among women, indoor air smoke causes approximately 3–4% of DALYs in AFR-D, AFR-E, EMR-D, SEAR-D and WPR-B. The most important interventions to reduce this impact are better ventilation, more efficient vented stoves, and cleaner fuels.

Many other risks to health accumulate in the indoor environment, and housing has a key role in determining their development and impact (see Box 4.2).

Lead exposure

Lead, because of its multiplicity of uses, is present in air, dust, soil and water. Lead enters the body mainly by ingestion or inhalation. Contamination of the environment has in-

Box 4.2 Housing and health

The primary purpose of buildings worldwide is to protect humans from the hazards and discomforts of outdoor environments and to offer a safe and convenient setting for living and human activity. Furthermore, people – especially in temperate and cold climates and in industrialized societies – spend most of their time indoors in buildings such as homes, offices, schools and day-care centres. This means that, from the perspective of exposure to environmental conditions and hazards, housing and indoor environments have important public health consequences for both physical and mental health.

The most extreme health impact of housing is found among the poorest sectors of societies in the form of a complete lack of housing, which affects millions of people worldwide. Lack of affordable housing for low-income households may mean diverting family resources from expenditure on food, education or health towards housing needs. Beyond this, both the physical structure of houses and their location can involve health risks.

Important parameters in indoor environments include the thermal climate, noise and light, and exposure to a large number of chemical, physical and biological pollutants and risk factors. While these parameters are also affected by human-related activities and outdoor sources (such as vehicle and industrial pollutants or local vegetation and insect ecology), human exposure is modified by housing characteristics such as building materials, number and size of rooms and windows, ventilation and energy technology. For example, a "leaky" house can lead to dampness and mould which may result in various forms of respiratory illness and allergic reactions; the use of building materials such asbestos or lead-based paint can increase exposure to these toxic substances; the use of inflammable or weak material such as wood, plastic or cardboard – particularly common in urban slums – poses increased risks of injuries; building design will influence exposure to disease vectors such as mosquitoes; inadequate ventilation or overcrowding will cause exposure to different pollutants and pathogens; poor lighting or heating will influence both physical and mental health as well as participation in activities such as education; and so on.

The location of housing and the organization of neighbourhoods also have public health implications, in particular in rapidly urbanizing developing countries, where a growing proportion of the population live in informal settlements or slums, often on the periphery of major cities. If housing is located on floodplains or steep hillsides, near sources of traffic, industrial activity, solid waste dumps or vector breeding sites, and away from services such as sanitation, transportation, schools or health facilities, public health will be affected directly (for example, through sanitation) or indirectly through access to food and education. In addition, organization of neighbourhoods has been shown to have an effect on mental and physical health, school attendance and performance, or prevalence of violence and crime.

Referring to housing as a "risk factor" would mask the important role that it plays in providing a setting for daily household and community activities. At the same time, it is important to acknowledge the important and complex roles that housing and neighbourhood design play in public health and to promote systematic inclusion of health in the design of housing, housing technology and the urban and regional planning processes.

Sources: *(54–56)*.

creased with industrial development and particularly the use of leaded petrol. Currently about 60 countries have phased out leaded petrol and approximately 85% of petrol sold worldwide is lead-free. Other important lead sources are more difficult to control, such as leaded kitchenware ceramics, water pipes and house paints.

Following control measures, lead levels have been steadily declining in industrialized countries but at least 5% of children still have elevated blood lead levels, with even higher rates in children of poorer households *(57)*. In many developing countries, where leaded gasoline is still used, lead can present a threat to more than half of children *(58)*. Rapidly increasing traffic loads have the potential to further increase blood lead levels. Worldwide, 120 million people are estimated to have lead levels of 5–10 μg/dl, with similar numbers above 10 μg/dl, and 40% of children have blood lead levels above 5 μg/dl. Overall, 97% of affected children live in developing regions. Industrial or cottage exposure to lead, such as from smelters or battery recycling, could only partly be assessed here, but can represent a large additional burden in certain regions.

Lead affects practically all body systems. Most toxic exposures occur at chronic low levels and can result in reductions in intelligence quotient (IQ) *(59)*, increased blood pressure, and a range of behavioural and developmental effects. The range and extent of adverse health effects has been appreciated only relatively recently. Furthermore, lead is now understood to be toxic, especially to children, at levels previously thought to be safe *(60)*. In more severe cases of poisoning, adverse health effects include gastrointestinal symptoms, anaemia, neurological damage and renal impairment *(61)*. Other adverse effects, such as reduction in IQ levels, behavioural disorders or renal function, can be discerned only through special examinations. These analyses estimate that lead results in about 234 000 (0.4%) deaths and 12.9 million (0.9%) DALYs. About one-fifth of this entire burden occurs in SEAR-D, and a further one-fifth in WPR-B.

Climate change

Humans are accustomed to climatic conditions varying daily, seasonally and yearly. The recent concern over global climate change arises from accumulating evidence that, in addition to this natural climate variability, average climatic conditions measured over extended periods (conventionally 30 years or longer) are now also changing *(62)*. The most recent report (2001) from the United Nations Intergovernmental Panel on Climate Change (IPCC) estimates that the global average land and sea surface temperature has increased by 0.6 ±0.2 °C since the mid-19th century, with most change occurring since 1976 *(63)*. The 1990s was the warmest decade on record. Warming has been observed in all continents, with the greatest temperature changes occurring at middle and high latitudes in the northern hemisphere. Patterns of precipitation have also changed: arid and semiarid regions are apparently becoming drier, while other areas, especially mid-to-high latitudes, are becoming wetter. There is also evidence that where precipitation has increased, there has been a disproportionate increase in the frequency of the heaviest precipitation events. The causes of this climate change are increasingly well understood. The IPCC concluded that "most of the warming observed over the last 50 years is likely to be attributable to human activities", most importantly the release of greenhouse gases from fossil fuels.

Climate model simulations have been used to estimate the effects of past, present and future greenhouse gas emissions on future climate. Based on a range of alternative development scenarios and model parameters, the IPCC concluded that if no specific actions are taken to reduce greenhouse gas emissions, global temperatures are likely to rise between 1.4 °C and 5.8 °C from 1990 to 2100. Such a rise would be faster than any rise encountered

since the inception of agriculture around 10 000 years ago. Predictions for precipitation and wind speed are less consistent, but also suggest significant changes.

Potential risks to human health from climate change would arise from increased exposures to thermal extremes (cardiovascular and respiratory mortality) and from increases in weather disasters (including deaths and injuries associated with floods). Other risks may arise because of the changing dynamics of disease vectors (such as malaria and dengue fever), the seasonality and incidence of various food-related and waterborne infections, the yields of agricultural crops, the range of plant and livestock pests and pathogens, the salination of coastal lands and freshwater supplies resulting from rising sea-levels, the climatically related production of photochemical air pollutants, spores and pollens, and the risk of conflict over depleted natural resources. Effects of climate change on human health can be expected to be mediated through complex interactions of physical, ecological, and social factors. These effects will undoubtedly have a greater impact on societies or individuals with scarce resources, where technologies are lacking, and where infrastructure and institutions (such as the health sector) are least able to adapt. For this reason, a better understanding of the role of socioeconomic and technological factors in shaping and mitigating these impacts is essential. Because of this complexity, current estimates of the potential health impacts of climate change are based on models with considerable uncertainty.

Climate change was estimated to be responsible in 2000 for approximately 2.4% of worldwide diarrhoea, 6% of malaria in some middle income countries and 7% of dengue fever in some industrialized countries. In total, the attributable mortality was 154 000 (0.3%) deaths and the attributable burden was 5.5 million (0.4%) DALYs. About 46% this burden occurred in SEAR-D, 23% in AFR-E and a further 14% in EMR-D.

Other environmental risks to health

Traffic and transport form another component of environmental hazard in society. Traffic-related burden includes not only injury, but also the consequences of pollution with lead and the effects on urban air quality. Furthermore, as with many exposures assessed

Box 4.3 Road traffic injuries

Road traffic injuries were estimated to account for over 1.2 million deaths worldwide in 2000, amounting to 2.3% of all deaths. Many such deaths occur in young adults, with significant loss of life, so the proportion of disease burden measured in disability-adjusted life years (DALYs) is greater – about 2.8% of the total. Over 90% of these deaths occur in the middle and low income countries, where death rates (21 and 24 deaths per 100 000 population, respectively) are approximately double the rates in high income countries (12 per 100 000 population).

Differences in road use between industrialized and developing countries have implications for intervention policies. Driver or occupant deaths accounted for approximately 50–60% of national road traffic fatalities in industrialized countries in 1999, with the vast majority occurring on rural roads. Pedestrian involvement was higher in urban areas, with evidence for increased risk among children and over-60-year-olds. In developing countries, a far higher proportion of road deaths occurs among vulnerable users (pedestrians, bicyclists, other non-motorized traffic, and motor cyclists and moped riders) and among passengers of buses and trucks.

Road traffic crashes are largely preventable. Approaches to improving road safety fall into three broad groups: engineering measures (e.g. road design and traffic management), vehicle design and equipment (e.g. helmets, seat belts and day-time running lights) and road user measures (e.g. speed limits, and restrictions on drinking and driving).

The prospects for prevention can be estimated from some interventions. For example, in Thailand the introduction of a new motor cycle helmet law was followed by a reduction in fatalities of 56%; in Denmark, improved traffic management and provision of cycle tracks was followed by a 35% drop in cyclist fatalities; and in Western Europe it was estimated that lowering average vehicle speeds by 5km/hour could yield a 25% reduction in fatalities. Based on a model developed in the United Kingdom, which takes into account the numbers of cars per capita, it is estimated that, if the countries with the higher road traffic injury rates were to lower these rates to those of other countries in each region, death rates would fall by between 8% and 80%. The scope for improvement is highest in the poorest countries. Worldwide, it is estimated that 44% of road traffic fatalities – or 20 million DALYs – per year could be avoided by this method.

Sources: *(64–70)*.

here, there are complex interactions with other exposures – for example, the lost opportunity for physical activity and the economic effects of transport and traffic. Considerations related to road traffic injuries are outlined in Box 4.3.

Selected occupational risks

Throughout the world many adults, and some children, spend most waking hours at work. While at work, people face a variety of hazards almost as numerous as the different types of work, including chemicals, biological agents, physical factors, adverse ergonomic conditions, allergens, a complex causal network of safety risks, and many and varied psychosocial factors. These may produce a wide range of health outcomes, including injuries, cancer, hearing loss, and respiratory, musculoskeletal, cardiovascular, reproductive, neurotoxic, skin and psychological disorders. Because of lack of adequate global data, only selected risk factors were evaluated in this report (see Table 4.7). The disease burden from these selected occupational risks amounts to 1.5% of the global burden in terms of DALYs.

Examples of other important work-related risk factors include pesticides, heavy metals, infectious organisms, and agents causing occupational asthma and chronic obstructive lung disease. Analyses at the global level may not show the magnitude of occupational risk factors, because only the workers employed in the jobs with those risks are affected. It is important to note that not only are the affected workers at high risk, but also that workplace risks are almost entirely preventable. For example, because health care workers constitute only 0.6% of the global population, hepatitis B in this group contributes negligibly to the global burden. These workers are, however, at high risk of hepatitis B, of which 40% is produced by sharps injuries (see Box 4.4). Policies to standardize needle usage and to increase immunization coverage will prevent these infections, which represent a heavy burden in the health personnel.

Stress at work has been shown in recent studies in industrialized nations to be associated with cardiovascular disease, but the risks will also exist in similar types of work in developing and industrializing nations. Policy-makers and decision-makers may wish to be guided by findings such as those illustrated in Box 4.5.

Table 4.7 Selected major risks to health: occupational hazards

Risk factor	Theoretical minimum exposure	Measured adverse outcomes of exposure
Work-related risk factors for injuries	Exposure corresponding to lowest rate of work-related fatalities observed: 1 per million per year for 16–17-year-olds employed as service workers in the United States	Injury
Work-related carcinogens	No work-related exposure above background to chemical or physical agents that cause cancer	Leukaemia, lung cancer
Selected airborne particulates	No work-related exposure	Chronic respiratory disease
Work-related ergonomic stressors	Physical workload at the level of that of managers and professionals	Lower back pain
Work-related noise	Less than 85 dB over eight working hours	Hearing loss

Work-related risk factors for injuries

Risk factors leading to injuries are present in every workplace. Industrial and agricultural workers have the highest risks, but even workers in offices, retail stores and schools are at risk *(73–75)*. Work-related falls, motor vehicle injuries, and contact with machinery result in nearly a thousand occupational deaths every day throughout the world. Disability is another consequence of work-related injury, sometimes requiring time lost from work, and sometimes resulting in a permanent inability to return to work. Reliable data about injuries are difficult to obtain, even in industrialized countries, because of variability in insurance coverage and in accuracy of the reporting systems. Nevertheless, occupational fatality rates reported in industrializing countries are at least two to five times higher than rates reported in industrialized countries *(76)*.

For this report, the numbers of workers at risk of injury were estimated by employment in broad occupational categories for each region, sex, and age. The corresponding fatal

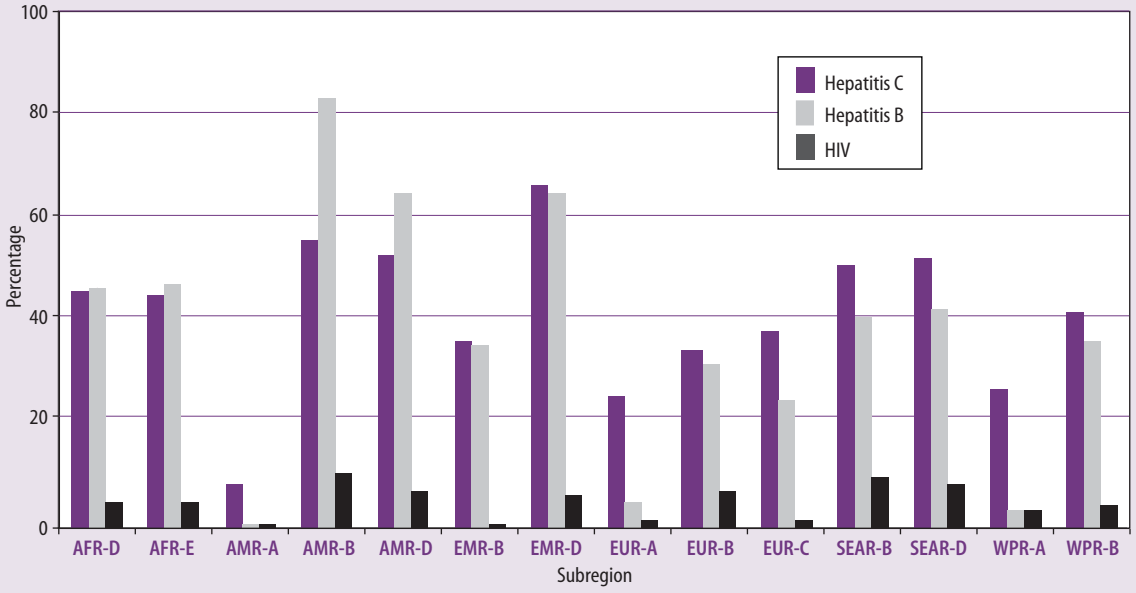
Box 4.4 Sharps injuries among health care workers

Health care workers are at risk of infection with bloodborne pathogens because of occupational exposure to blood and body fluids. Most exposures are caused by "sharps" – contaminated sharp objects, such as syringe needles, scalpels and broken glass. The three infections most commonly transmitted to health care workers are hepatitis B virus (HBV), hepatitis C virus (HCV) and human immunodeficiency virus (HIV).

Among the 35 million health care workers worldwide, about three million receive percutaneous exposures to bloodborne pathogens each year; 2 million of those to HBV, 0.9 million to HCV and 170 000 to HIV. These injuries may result in 15 000 HCV, 70 000 HBV and 500 HIV infections. More than 90% of these infections occur in developing countries. Worldwide, about 40% of HBV and HCV infections and 2.5% of HIV infections in health care workers are attributable to occupational sharps exposures.

These infections are for the major part preventable, as shown by the low rates achieved in certain countries that have engaged in serious prevention efforts, including training of health care workers, HBV immunization, post-exposure prophylaxis and improved waste management. In addition to the disease burden caused to health care workers, the functioning of the health care system may be reduced because of impaired working capacity, in particular in developing countries where the proportion of health care workers in the population is already small compared with that in developed countries.

Attributable fraction of HCV, HBV and HIV infections in health care workers 20–65 years of age, due to injuries with contaminated sharps[a]



[a]See the List of Member States by WHO Region and mortality stratum for an explanation of subregions.

injury rates were obtained from an extensive literature survey. The analysis showed that overall approximately 310 000 workers lose their lives each year as a result of occupational injuries that are unintentional (from machines, motor vehicles, falls, poisonings, falling objects, fires and drowning) and intentional (homicide). Most of these deaths are preventable *(77)*. Occupational injuries represent 0.9% of world DALYs (13.1 million) and 16% of DALYs attributable to unintentional injuries in the working population aged 15–69 years. This burden, with its heavy toll in human suffering and monetary costs, affects mainly the developing regions such as SEAR-D and WPR-B. These two regions represent almost half of the workforce of the world.

Work-related carcinogens

Many of the 150 chemical or biological agents classified as carcinogens are encountered in occupational settings *(78)*. The risk of developing cancer is influenced by the dose received, the potency of the carcinogen, the presence of other exposures (notably tobacco smoking), and individual susceptibility. Occupational cancers are entirely preventable through elimination of exposure, using proven occupational hygiene measures such as substitution of safer materials, enclosure of processes, and ventilation.

These analyses estimated the effects of occupational exposures to numerous known carcinogens on the occurrence of respiratory and bladder cancers, leukaemia, and mesothelioma.

Globally about 20–30% of the male and 5–20% of the female working-age population (people aged 15–64 years) may have been exposed during their working lives to lung carcinogens, including asbestos, arsenic, beryllium, cadmium, chromium, diesel exhaust, nickel and silica. Worldwide, these occupational exposures account for about 10.3% of cancer of the lung, trachea and bronchus, which is the most frequent occupational cancer. About 2.4% of leukaemia is attributable to occupational exposures worldwide. In total, the attributable mortality was 146 000 (0.3%) deaths and the attributable burden was 1.4 million (0.1%) DALYs.

Work-related airborne particulates

Millions of workers in a variety of occupations, such as mining, construction and abrasive blasting, are exposed to microscopic airborne particles of silica, asbestos and coal dust *(79–81)*. Inhalation of these particles may not only cause cancer of the lung, trachea and

Box 4.5 Coronary heart disease and work-related stress

Increasing evidence from industrialized countries links coronary heart disease with work-related stress, such as high psychological demands and low decision-making latitude among white-collar occupations including managers, administrators, supervisors and proprietors. Blue-collar workers are also at risk from high work pressure and cumulative workload, in combination with low-status control.

Low job control is associated with an increase in the risk of heart disease. Shiftwork, which tends to involve heavier work, more stress, less control, and less educated workers than regular day work, also increases risk. Mechanisms of action include disturbances to the circadian rhythm, fatigue, elevated levels of serum triglycerides, and the fact that shiftwork accentuates other risk factors for heart disease.

Overall, stress-related coronary heart disease is likely to be higher in blue-collar workers when the following factors are present: restricted discretion, shiftwork (particularly at night), imbalance between efforts and rewards, high demands, a poor psychosocial work environment, social isolation, physical inactivity, or occupational violence. These risk factors may be interactive. Recent estimates for Finland indicated that a substantial proportion of ischaemic heart disease results from the combined occupational risk factors of shift work, noise, exposure to engine exhausts, and environmental tobacco smoke.

Sources: *(71, 72)*.

bronchus, but also the non-malignant respiratory diseases silicosis, asbestos and coal and pneumoconiosis ("dusty lung").

Development of these diseases is influenced by the amount of exposure and the toxicity of the dust, and the diseases are characterized by long latency periods; therefore, even in countries in which exposures have been recognized and controlled, the disease rates are only gradually declining *(79)*. Rate trends in developing countries are mostly unknown but the magnitude of the problem is substantial *(81)*.

Studies estimate that 5–18% of asthma may be attributable to occupational exposure, with one review study suggesting a median value of 15% for the highest quality studies. One large population study estimates that 14% of chronic obstructive pulmonary disease is attributable to occupational causes. In total, the attributable mortality for chronic obstructive pulmonary disease was 243 000 (0.4%) deaths and the attributable burden was 3.0 million (0.2%) DALYs. Several tens of thousands of additional deaths are attributable to silica, asbestos and coal dust. At the global level, the burden appears low, but the risk to workers in mining, construction and other occupations is high. For example, most workers with long-term exposure to low-to-moderate silica concentrations will develop silicosis. These diseases are entirely preventable through efforts like those of the ILO/WHO global campaign to eliminate silicosis, including elimination of exposure through substitution of safer materials, wet methods, and ventilation.

Work-related ergonomic stressors

Low back pain is associated with many ergonomic stressors at work, including lifting and carrying of heavy loads, forceful movements, demanding physical work, whole-body vibration, frequent bending, twisting, and awkward postures *(82, 83)*. The factors leading to low back pain – physical, organizational and social factors at work, physical and social aspects of life outside the workplace, and physical and psychological characteristics of the individual – are complex and interrelated *(83)*. High rates of low back pain are reported for special groups of workers, such as farmers, nurses, heavy equipment operators, and construction workers *(84, 85)*. Although rarely life-threatening, low back pain causes much discomfort and can limit work, domestic and recreational activities.

Low back pain occurs frequently in industrialized countries; for example, half of all working Americans have back pain every year *(86)*. Although data from industrializing nations are limited, the rates reported in China are similar to those in industrialized countries (87). Much low back pain can be prevented, but successful intervention requires cooperation among partners, including management, labour, industrial engineers, ergonomists, medical practitioners and the scientific research community.

This analysis suggests that about 37% of back pain is attributable to occupational risk factors. Across regions, this varies comparatively little, from between 12% and 38% for women and between 31% and 45% for men. While not a cause of mortality, low back pain causes considerable morbidity, resulting in an estimated 0.8 million DALYs (0.1%) worldwide. It is a major cause of absence from work, and therefore induces a high economic loss *(84)*.

Work-related noise

Excess noise is one of the most common occupational hazards. Its most serious effect is irreversible hearing impairment. Noise-induced hearing loss typically begins in the frequency range of human voices, interfering with spoken communications. In the workplace, impaired communication sometimes leads to accidents. Exposure levels above 85 dB are

considered to be hazardous for workers and are found especially among mining, manufacturing and construction workers, particularly in developing countries *(88, 89)*.

These analyses used the WHO definition of hearing impairment, that establishes the threshold of hearing loss at 41 dB for 500, 1000, 2000 and 4000 Hz. A 25 dB threshold of hearing loss is more generally used in the occupational setting.

Based on the WHO definition, the analysis found that about 16% of hearing loss worldwide is attributable to occupational noise exposure. This amounted to about 415 000 (0.3%) DALYs. Overall, occupational noise was responsible for 4.2 million DALYs (0.3%). Noise-induced hearing loss is permanent and irreversible. It is also completely preventable. Fortunately, most occupational noise exposure can be minimized by the use of engineering controls to reduce noise at its source. A complete hearing loss prevention programme includes noise assessments, audiometric monitoring of workers' hearing, appropriate use of hearing protectors, worker education, record keeping, and programme evaluation *(90)*.

Other risks to health

Clearly, many thousands of other threats to health exist within and outside the categories outlined above. These include very large causes of disease burden, such as risk factors for tuberculosis (see Box 4.6) and malaria (which is currently responsible for 1.4% of global disease burden, with the vast majority of burden from this disease among children in sub-Saharan Africa). Genetics plays a substantial role in attributable burden (see Box 4.7). Technological developments could lead to considerable avoidable burden. In general, the approaches and methodology outlined in this report can be applied more widely, and as a

Box 4.6 Risk factors for tuberculosis

About 9 million new cases of tuberculosis (TB) occur each year. Including people who are also infected with HIV/AIDS, approximately 2 million patients die from TB annually. The global caseload is almost certainly rising, driven upwards in sub-Saharan Africa by the spread of HIV/AIDS and in Eastern Europe by the deterioration of health in general and of TB control in particular. There is a large reservoir of cases in Asia, and TB remains one of the most significant causes of ill-health and premature mortality.

One of the reasons for the persistent burden of tuberculosis is a failure to address the principal risk factors. The risks associated with TB can be put in three groups: the process of infection, progression to disease, and the outcome of a disease episode. Environmental factors that govern exposure to infecting bacilli include crowding, hospitalization, imprisonment, ventilation and the ambient prevalence of infectious (mostly sputum smear-positive) disease. Among factors that influence the progression to disease following infection, HIV co-infection is outstandingly important; others are age, sex, diabetes, tobacco, alcohol, TB strain virulence, and malnutrition. Factors that affect the outcome of a disease episode include where treatment is given (e.g. public or private sector), whether treatment is interrupted, and drug resistance. The adverse outcomes most commonly measured are treatment failure and death. Some other risk factors for TB are commonly invoked but ill defined, ethnicity and poverty among them. Ethnicity is often a marker for specific disadvantages, such as restricted access to health services.

While the study of risk factors is a necessary part of planning for TB control, it is not sufficient. Some major risk factors may not be amenable to change, at least as they are currently defined: there is nothing to be done about age per se, though one could investigate why, physiologically, adults are at greater risk of progressing to active disease than children. Further, the risk factor approach (based on observed variation) cannot be used to examine potentially effective interventions that do not yet exist. The absence of a new vaccine is not usually thought of as a risk factor for TB and yet common sense, backed by mathematical modelling, shows how effective immunization could be.

Despite some promising laboratory research, there is unlikely to be a new TB vaccine or drug before 2010. Meanwhile, the principal question for operational research is how to strengthen present curative services. With only 27% of new infectious cases being enrolled in DOTS therapeutic programmes, the main goal of TB control is to ensure broad national coverage rather than to target specific groups at risk. In this respect, it is important for patients to recognize the symptoms and know where to seek help, to receive the correct diagnosis and drug regimen, and to understand the importance of completing a course of treatment. There are some challenging questions here, whether or not they are framed in terms of risk factors: for a social intervention like DOTS, careful thought must be given to the design of case-control studies or randomized controlled trials, and still greater caution is needed when generalizing from the results.

Sources: *(91, 92)*.

result the potential for prevention by focusing on causes of disease can be further refined. Two other groups of risk factors are described below (see Table 4.8).

Unsafe health care practices

As well as their substantial benefits, health care practices may be a source of disease and death. In developing countries, nosocomial infections are increasingly recognized as a major problem in health care quality, although the burden of disease is difficult to estimate. Poor injection practices, including injection overuse and unsafe injection practices, constitute a subset that can be addressed because it is ubiquitous, has been studied in many countries and is associated with a particularly high toll of infection with bloodborne pathogens. Epidemiological studies have reported an association between injections and infection with bloodborne pathogens, including hepatitis B virus (HBV), hepatitis C virus (HCV) and human immunodeficiency virus (HIV) *(99–102)*. The causal nature of this association is supported by many criteria.

A safe injection is one that does not harm the recipient, the provider or the community. In reality, many injections in the world are unsafe. The risk to the community through unsafe sharps waste disposal has not been assessed, but is probably low. The risk to the provider (i.e. needlestick injuries, see Box 4.4) was studied among other occupational risks. The risk to the recipient is mainly secondary to the reuse of injection equipment.

Because injections are overused in many countries, unsafe injections have caused a substantial proportion of infection with bloodborne pathogens, accounting for an estimated 30% of hepatitis B virus infection, 31% of hepatitis C virus infection, 28% of liver cancer, 24% of cirrhosis and 5% of HIV infections. Overall, about 500 000 deaths (0.9%) are attributable to unsafe injection practices in medical settings worldwide, the attributable fractions are highest in South-East Asia, WPR-B and EMR-D. This results in about 10.5 million DALYs (0.7%), with 39% of this burden occurring in SEAR-D and 27% in WPR-B. In these areas,

Box 4.7 Genetics and attributable and avoidable burden

It is a common misconception that diseases are caused by *either* genetic *or* environmental factors; almost all diseases are caused by both. Although it is not possible to estimate the attributable burden of disease from "genetic causes", it is potentially possible to estimate the burden attributable to certain gene mutations or alleles.

Diseases caused by mutations in single genes, such as phenylketonuria, tend to be rare, whereas the genetic influences on common causes of morbidity and mortality are more complex. In some cases single gene mutations which carry a high risk of disease can be identified but do not necessarily have a major impact on the incidence of disease in populations. For example, gene mutations which confer a high risk of breast cancer are important for carriers of those mutations but are present in only a small proportion of women who develop breast cancer.

Recent developments in genetics offer substantial potential for health gain through increasing the understanding of the biological basis of diseases, identification of high-risk individuals enabling targeted risk factor modification, and the potential for tailored treatment. The greatest possible gains lie in more direct applications. Pharmacogenetics promises to allow drug prescribing to be tailored to individuals likely to have most benefit or least susceptibility to adverse drug reaction. More important yet may be the discovery of disease susceptibility genes that allow identification of a protein in which altered function affects the disease process. This in turn could lead to interventions. While the avoidable burden of genetic disease cannot yet be quantified, especially for common chronic diseases that are influenced by multiple genes, it is likely to be substantial even if only a small fraction of the attributable burden is reversed.

The coming decades will see improved prevention and treatment through appropriate mixes of new genetic and traditional preventive strategies. Nonetheless, ambitious targets need not await these new interventions. Combinations of primary prevention, focusing on major risk factors, and secondary prevention have already achieved substantial reductions in major chronic diseases in just a few decades, during which time gene pools did not essentially alter. For example, age-specific reductions of 25–75% have been achieved in breast cancer mortality in the United Kingdom and United States, coronary disease in the United States and Scandinavia, stroke in Japan, and lung cancer in the United Kingdom. The potential to repeat such successes will clearly be greater if preventive efforts can be augmented by appropriate genetic-based interventions.

Sources: *(93–98)*.

Table 4.8 Selected other major risks to health

Risk factor	Theoretical minimum exposure	Measured adverse outcomes of exposure
Unsafe health care injections	No contaminated injections	Acute infection with hepatitis B, hepatitis C and HIV; liver cirrhosis, liver cancer
Childhood sexual abuse	No abuse	Depression, panic disorder, alcohol abuse/dependence, post-traumatic stress disorder and suicide in adulthood

unsafe injections result in about 0.7–1.5% of all disease burden. These estimates are based upon a mathematical model that was validated by epidemiological studies in most regions in the case of HBV and HCV infection. In the case of HIV infection, there is more uncertainty about the region-specific estimates, due to a lack of epidemiological studies. However, studies have been conducted in sub-Saharan Africa, where most HIV infection occurs, providing more confidence in the overall magnitude of attributable burden, and pointing to the importance of this particular mode of HIV transmission.

Unsafe injections are one form of risk in medical settings; some of the other risks are illustrated in Box 4.8.

Abuse and violence

Abuse and violence are major causes of disease burden worldwide and there are many types: violence between individuals, including intimate partner violence, and collective violence orchestrated as part of wars and genocide. These are further outlined in Box 4.9. Child sexual abuse is another major component of burden resulting from abuse and violence in society.

Child sexual abuse (CSA) encompasses a range of sexual behaviours perpetrated by adults upon children. Abuse can be non-contact (including behaviours such as unwanted and inappropriate sexual solicitation or indecent exposure), contact (such as sexualized kissing, hugging, touching or fondling) or intercourse (including any penetrative act such as oral, anal or vaginal intercourse or attempted intercourse).

Box 4.8 Risks in the health care system

The complex combination of processes, technologies and human interactions that constitutes the modern health care delivery system not only brings significant benefits, but also an inevitable risk in the form of adverse events. This derives from the inherent risk of measurable harm in practice (human shortcomings), products (substandard or faulty products, side-effects of drugs or drug combinations, and hazards posed by medical devices), and procedures and systems (the possibility of failures at every point in the process of care giving). These risks are associated with different health care settings – hospitals, physicians' offices, nursing homes, pharmacies, and patients' homes.

Studies estimate the probability of patients suffering measurable harm in acute care hospitals at an alarming 16.6% in Australia, 3.8% in the United States, and around 10% in Denmark, the United Kingdom and a number of other European countries. Adverse events exact a high toll in disability and death, as well as in financial loss. Medical errors cause several tens of thousands of deaths annually in the United States alone. Although some deaths occur among people at high risk of death from their initial conditions, the loss of life years is still likely to be substantial. Estimates from the United Kingdom place the cost of additional hospital stays resulting from adverse events at approximately US$ 3 billion a year. The erosion of trust, confidence and satisfaction among the public and health care providers must be added to these costs.

The situation in developing and transitional countries is not well known, but could be worse than that in industrialized nations because of counterfeit and substandard drugs and inappropriate or poor equipment and infrastructure.

The systems view is that risk is shaped and provoked by "upstream" systemic factors that include an organization's strategy, its culture, its approach towards quality management and risk prevention, and its capacity for learning from failures. System change as a means to reduce risk is therefore more potentially effective than targeting individual practices or products.

Sources: *(103–115)*.

The prevalence of CSA is estimated from retrospective report and is higher than many find comfortable or plausible. In the review carried out as the basis for this report, prevalence estimates were available from 39 countries in 12 of the 14 country groupings, although data quality varied considerably between countries. After controlling for differences between studies, the prevalence of non-contact, contact and intercourse types of CSA in females was about 6%, 11% and 4%, respectively. In males it was about 2% for all categories. Thus over 800 million people worldwide may have experienced CSA, with over 500 million having experienced contact or intercourse types of abuse.

Not only is CSA common, it is also damaging. Research conducted in economically industrialized countries has shown that CSA increases the risk of a range mental disorders in later life, including depression, panic disorder, alcohol and drug abuse and dependence, post-traumatic stress disorder and suicide. Risks increase with the intrusiveness of the abuse.

Box 4.9 Violence

In 2000, violence caused 700 000 deaths in the world: about 50% by suicide, 30% by interpersonal violence, and 20% by collective violence.

Interpersonal violence

Interpersonal violence is defined as "the intentional use of physical force or power, threatened or actual, against another person that results in or has a high likelihood of resulting in injury, death, psychological harm, 'maldevelopment' or deprivation". As well as violence by strangers and acquaintances, it includes child maltreatment, spouse abuse, elder abuse and sexual violence. The true number of deaths is probably underestimated.

Worldwide, adolescents and young adults are the primary victims and perpetrators: interpersonal violence was the sixth leading cause of death among people aged 15–44 years in 2000. The highest estimated regional homicide rates per 100 000 population occurred in Africa (22.2) and the Americas (19.2), compared with Europe (8.4), the Eastern Mediterranean (7.1), South-East Asia (5.8) and the Western Pacific (3.4).

Many more people survive acts of interpersonal violence than die from them. Around 40 million children are maltreated each year. Rape and domestic violence account for 5% to 16% of healthy years of life lost by women of reproductive age. Between 10% and 50% of women experience physical violence at the hands of an intimate partner during their lifetime. Beyond the deaths and injuries, there are many profound health and psychological implications for victims, perpetrators and witnesses of interpersonal violence.

For individuals, risk factors include being a victim of child abuse and neglect, substance abuse, and being young and male. In families, marital discord, parental conflict, and low household socioeconomic status are important risks. In the community, low social capital and high crime levels contribute. In society generally, rapid social change, poverty and economic inequality, poor rule of law and high corruption, sex inequalities, high firearm availability, and collective violence are risk factors. In combination, these factors underlie the close relationship that exists between indicators of interpersonal violence and the socioeconomic context. Correlational studies show higher homicide rates among countries with lower per capita GDP. Findings consistently demonstrate that high levels of inequality coincide with high homicide rates and high rates of non-fatal violence among the poorest sectors of the population;

Interpersonal violence can be prevented and its destructive consequences lessened by focusing on these risk factors, ideally in combination and at different levels simultaneously. Home visits by nurses have shown effectiveness, as have various programmes on parent training, improving urban physical and socioeconomic structure, increasing protective knowledge in schools about sexual abuse, targeting the interaction between firearms and alcohol, and multimedia interventions aimed at reducing the social acceptability of violence. Almost all evaluations of such programmes have been conducted in industrialized countries. In the developing world it is projected that the burden of disease resulting from interpersonal violence will nearly double by 2020 unless preventive action is taken.

Collective violence

Collective violence is a broader term than war or conflict. It encompasses events such as genocide and applies when one group makes instrumental use of violence against another to achieve an objective. It is associated with major threats to health in what tend to be the world's poorer countries. In 2000, an estimated 310 000 deaths resulted directly from collective violence – mostly in Africa and South-East Asia.

Although a prominent feature of human history, collective violence has not received much systematic study. Today it is often characterized by varying degrees of state collapse or dysfunctional governance and a multiplicity of armed actors, often including child soldiers. Economic motivations or ethnic divisions have become more prominent causes of violence than political ideology. The results have often been indiscriminate attacks on civilians and degradation of social capital. Sometimes health infrastructure is specifically targeted, damaging access to water supplies and basic sanitation, and jeopardizing delivery of health interventions such as disease eradication programmes.

Indirect effects of collective violence arise from infectious disease, malnutrition, population displacement, psychosocial sequelae, and exacerbation of chronic disease. Mortality rates 80-fold higher than the baseline have been recorded in populations fleeing collective violence in Rwanda.

Risk factors for collective violence include the generalized availability of small arms, inequalities in access to educational, economic and political opportunities, and abuse of human rights. There is a need to combine efforts of the public health and social science sectors to guide progress in this area and to identify priority areas for intervention.

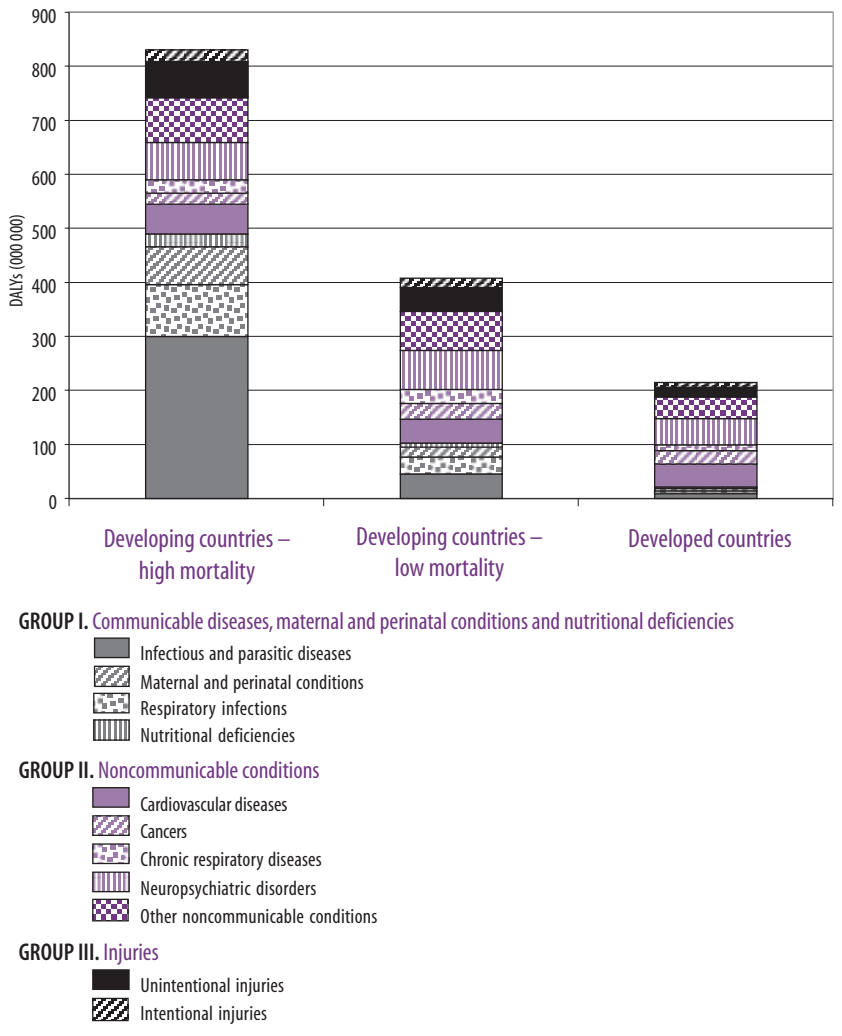
Sources: *(116, 117)*.

Uncertainty remains because of the lack of knowledge about the impact of cultural differences on CSA prevalence and its relationship with mental disorders. It is, however, certain that CSA causes a considerable burden of disease. It is estimated that about 33% of post-traumatic stress disorder in females and 21% in males is attributable to CSA. The attributable fraction for panic disorders is 11% worldwide, and CSA is estimated to cause about 5–8% of self-inflicted injuries, unipolar depression, and alcohol and drug use disorders. Overall, 0.1% of deaths worldwide (79 000) are attributable to CSA. Much of the burden is disabling rather than fatal, and occurs in the young. Thus CSA causes 8.2 million DALYS (0.6%); 0.4% in males and 0.8% in females. The highest proportion of burden (1–1.5% of total) occurs in females in AMR-A, SEAR-D, WPR-A and WPR-B.

Global patterns of risks to health

Three major groupings of countries can be defined by geography, state of economic and demographic development, and mortality patterns. As can be seen from Figure 4.8, these

Figure 4.8 Amount and patterns of burden of disease in developing and developed countries



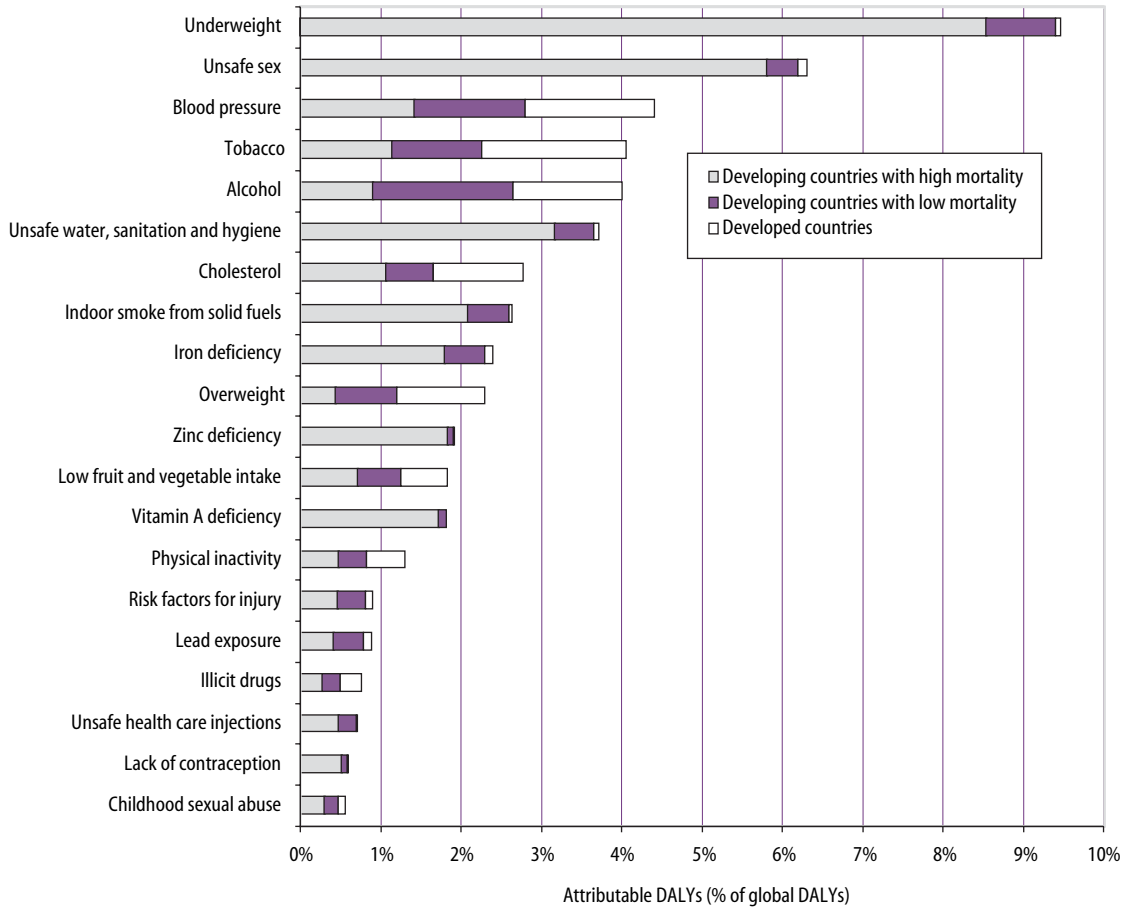
regions differ substantially in their disease patterns. This phenomenon reflects what is known as the "epidemiological transition" – as life expectancy increases, the major causes of death and disability in general shift from communicable, maternal and perinatal causes to chronic, noncommunicable ones. At present, about one-tenth of disease burden is caused by injury in all three regions.

The risk factors analysed in this report are responsible for a substantial proportion of the leading causes of death and disability in these regions, as shown by the mapping of risk factors to diseases and the range of population attributable fractions in Annex Tables 14, 15, and 16. Their ranking globally, and their distribution by broad region, is shown in Figure 4.9.

Additionally, the ranking of risks within major world regions, by level of development and affected disease or injury outcomes, is shown in Figure 4.10.

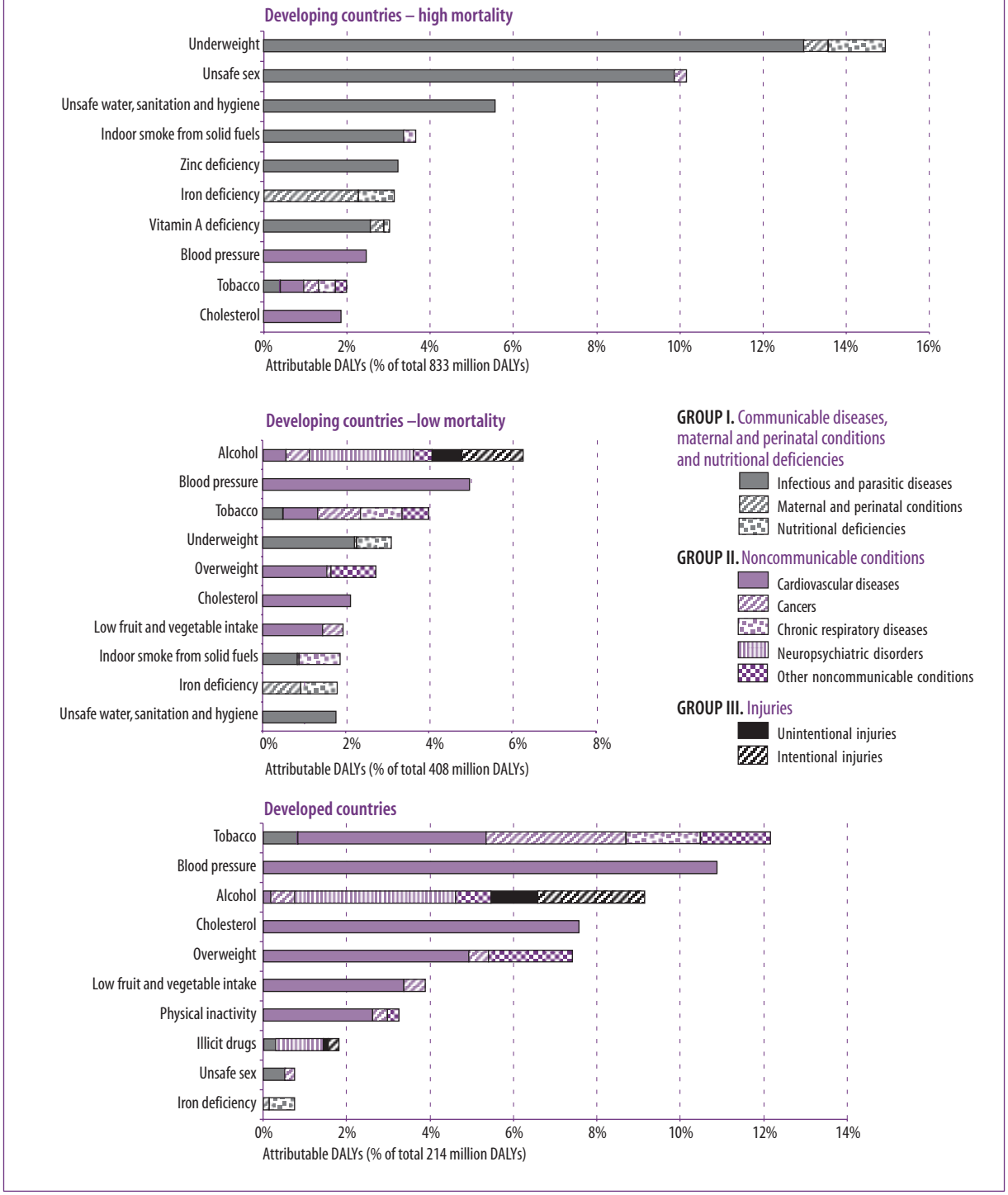
Perhaps the most striking finding is the extraordinary concentration of risks in the high mortality developing countries. Among these countries with just over two-fifths of the world's population, not only are the rates of disease and injury particularly high, but the contribution made by relatively few risk factors is particularly great. About one-sixth of the entire

Figure 4.9 Global distribution of burden of disease attributable to 20 leading selected risk factors



disease burden in these countries is attributed to underweight, with a substantial additional proportion attributable to micronutrient deficiencies. The burden resulting from these risks alone approaches that of the entire disease and injury burden in industrialized countries. Just over one-tenth of all disease burden in high mortality developing countries is

Figure 4.10 Burden of disease attributable to 10 selected leading risk factors, by level of development and type of affected outcome



attributable to unsafe sex, with unsafe water accounting for about 4–5% of the burden. In all the high mortality developing regions, underweight, unsafe water, sanitation and hygiene, and indoor smoke from solid fuels feature in the leading six of these selected risks. In addition, unsafe sex is the leading risk in AFR-E and second leading risk in AFR-D. Virtually all of the substantial burden attributable to these risks is borne by developing countries.

For industrialized countries, with just over one-fifth of the world's population , tobacco is the leading risk factor, accounting for about 12% of all disease and injury burden. For both sexes, alcohol and blood pressure account for 9–10% of DALYs, and cholesterol and body mass for 6–7% of DALYs. Alcohol, blood pressure, overweight, cholesterol and tobacco are the leading five risks for each subregion in the industrialized group, varying only in their rank order.

An intermediate picture is seen for the low mortality, developing regions, with alcohol, tobacco and high blood pressure each accounting for about 4–6% of disease burden. Alcohol is the leading cause, alone accounting for about 6.2%. Indoor smoke from solid fuels and unsafe water and hygiene also feature in the ten leading risk factors for these areas. This double burden is seen most clearly for body weight – underweight and overweight are each responsible for about 3% of disease burden. Overall, however, the pattern of leading risks already most closely resembles that in industrialized countries.

These results provide a cross-sectional indication of an epidemiological transition for risk factors. The epidemiological transition that accompanies economic development has traditionally been understood in terms of outcomes, that is, patterns of disease and injury. This report shows some key drivers of this transition – risk factors that shape the development of disease and injury patterns.

The gradient of burden attributable to leading risks and diseases has a bearing on the appropriate degree of focus of public heath initiatives. In all three broad regions the leading disease or injury outcomes account for about three or four times more burden than the tenth ranked outcomes. However, the leading risk factor accounts for about 16 times more burden than the tenth ranked risk factor from this selected group in the industrialized countries. The ratio is less extreme but still considerable for high mortality developing countries, where the leading risk (underweight) accounts for about eight times more burden than the tenth ranked risk (cholesterol). For the low mortality developing countries, the ratio is even less marked, being about four-fold. Clearly, highly focused public health initiatives could be comparatively effective in the richest and the poorest countries, whereas in middle income countries the public health agenda of tackling major risks may have to be taken up on wider fronts.

Looking at the selected risk factors by proportion of attributable burden might obscure the vast absolute amount of burden caused by risk factors in the large developing regions. Because such a large proportion of the world's population live in developing countries, and background disease rates and risk factor levels are often high, the absolute number of DALYs attributable to each risk factor is greater than that in developed countries. Even for risks traditionally thought to be "Western", such as elevated body mass or cholesterol, more burden now occurs in developing than developed countries. The shift appears to have occurred for tobacco in the 1990s – about a decade ago more tobacco deaths occurred in the developed than the developing world. This report suggests the predominance of tobacco burden has now begun to shift to the developing world.

The distribution of attributable deaths and DALYs by age and sex is shown in Tables 4.9 and 4.10 and in Annex Table 8. Underweight and micronutrient deficiency-related burden clearly affect children almost exclusively, as do unsafe water and climate change. The bur-

den in terms of DALYs due to other diet-related risks and occupational risks (except injury) is almost equally distributed among adults above and below the age of 60 years. The burden caused by addictive substances, unsafe sex, lack of contraception, risk factors for injury, unsafe health care injections and childhood sexual abuse mostly or almost all occurs in middle-aged adults. Diet-related and environmental risks and unsafe sex are about equally distributed among the sexes. However, about four-fifths of burden as a result of addictive substances, and about 60–90% of burden from separate occupational risks, occurs among men. Women suffer the majority of burden from childhood sexual abuse and all of the burden caused by a lack of contraception. Women are also affected more by those nutritional deficiencies that affect maternal conditions (iron and vitamin A deficiency).

One further major finding is the key role of nutrition in health worldwide. About one-fifth of the global disease burden can be attributed to the joint effects of protein–energy or micronutrient deficiency. In addition, almost as much burden again can be attributed to risk factors that have substantial dietary determinants – high blood pressure, cholesterol, overweight, and low fruit and vegetable intake. These patterns are not uniform within regions, however, and in some countries the transition has been much healthier than in others.The many and varied factors that determine national nutritional patterns are clearly a key determinant in achieving a healthier transition (see Box 4.10).

Putting it all together – what is possible?

Estimates of the joint effects of selected risk factors

The multicausal nature of disease often provides a choice among different preventive strategies and offers great potential benefit from simultaneous interventions. For example, modest reductions in blood pressure, obesity, cholesterol and tobacco use would more than halve cardiovascular disease incidence, if these reductions were population-wide and simultaneous. This section includes an assessment of gains in healthy life expectancy attributable to the leading 20 risk factors considered here.

As outlined previously, typically, population attributable fractions add up to less than the sum of components, because many diseases are caused by more than one risk factor. This is shown graphically in Figure 4.11, which shows the individual and joint contributions of three major risk factors to each major burden of disease outcome groups (group I: communicable, maternal, perinatal and nutritional conditions; group II: noncommunicable conditions; and group III: injuries) in three broad combinations of regions – demographically developed, developing low mortality, and developing high mortality. The size of each circle is proportional to the absolute disease burden.

This figure clearly shows how these selected major risks are responsible for a large fraction of current global disease burden, both across levels of development and type of outcome. It also shows how burden may be caused by more than one risk factor. The grouping by broad disease outcomes conceals some of the substantial population attributable fractions within the component clusters of disease. For example, of all childhood communicable diseases (including acute lower respiratory infection), 50% can be attributed to underweight, 23% to unsafe water, sanitation and hygiene, 13% to indoor smoke from solid fuels, and 63% to the joint effects of all three of these major risk factors. Similarly, 50% of cardiovascular diseases among those above the age of 30 years can be attributed to suboptimal blood pressure, 31% to high cholesterol and 14% to tobacco, yet the estimated joint effects of these three risks amount to about 65% of cardiovascular diseases in this group.

Using the assumptions outlined in Chapter 2, approximately 47% of global mortality can be attributed to the 20 leading risk factors and more than one-third attributed to the leading 10 risk factors. The likely impact of the 20 leading risks from the selected factors was estimated for 2000 in terms of potential gain in healthy life expectancy, as shown in Figure 4.12.

Had these risks not existed, then healthy life expectancy in 2000 might have been, on average, almost a decade greater globally. However, the gain varied considerably across regions, with the countries currently facing the world's largest risks to health having many times more healthy life years to gain than the richest countries. Thus the leading 20 risks were estimated to be responsible for 16 years lost in healthy life expectancy in AFR-E compared with slightly more than four years in WPR-A. Most of this was attributable to the leading few risks – for example, about 14 years lost in healthy life expectancy in AFR-E and 11 in AFR-D were attributable to the leading five risks in those regions. Notable also were the high mortality European regions of EUR-B and EUR-C, with particularly large attribut-

Table 4.9 Attributable mortality by risk factor, level of development and sex, 2000

	High mortality Developing countries AFR-D, AFR-E, AMR-D, EMR-D, SEAR-D		Low mortality Developing countries AMR-B, EMR-B, SEAR-B, WPR-B		Developed countries AMR-A, EUR-A, EUR-B, EUR-C, WPR-A	
	Males	Females	Males	Females	Males	Females
TOTAL DEATHS (000)	*13 758*	*12 654*	*8 584*	*7 373*	*6 890*	*6 601*
	(% total)	(% total)	(% total)	(% total)	(% total)	(% total)
Childhood and maternal undernutrition						
Underweight	12.6	13.4	1.8	1.9	0.1	0.1
Iron deficiency	2.2	3.0	0.8	1.0	0.1	0.2
Vitamin A deficiency	2.3	3.3	0.2	0.4	<0.1	<0.1
Zinc deficiency	2.8	3.0	0.2	0.2	<0.1	<0.1
Other diet-related risks and physical inactivity						
Blood pressure	7.4	7.5	12.7	15.1	20.1	23.9
Cholesterol	5.0	5.7	5.1	5.6	14.5	17.6
Overweight	1.1	2.0	4.2	5.6	9.6	11.5
Low fruit and vegetable intake	3.6	3.5	5.0	4.8	7.6	7.4
Physical inactivity	2.3	2.3	2.8	3.2	6.0	6.7
Sexual and reproductive health risks						
Unsafe sex	9.3	10.9	0.8	1.3	0.2	0.6
Lack of contraception	…	1.1	…	0.2	…	0.0
Addictive substances						
Tobacco	7.5	1.5	12.2	2.9	26.3	9.3
Alcohol	2.6	0.6	8.5	1.6	8.0	-0.3
Illicit drugs	0.5	0.1	0.6	0.1	0.6	0.3
Environmental risks						
Unsafe water, sanitation and hygiene	5.8	5.9	1.1	1.1	0.2	0.2
Urban air pollution	0.9	0.8	2.5	2.9	1.1	1.2
Indoor smoke from solid fuels	3.6	4.3	1.9	5.4	0.1	0.2
Lead exposure	0.4	0.3	0.5	0.3	0.7	0.4
Climate change	0.5	0.6	<0.1	<0.1	<0.1	<0.1
Occupational risks						
Risk factors for injury	1.0	0.1	1.4	0.1	0.4	0.0
Carcinogens	0.1	<0.1	0.5	0.2	0.8	0.2
Airborne particulates	0.3	<0.1	1.6	0.2	0.6	0.1
Ergonomic stressors	0.0	0.0	0.0	0.0	0.0	0.0
Noise	0.0	0.0	0.0	0.0	0.0	0.0
Other selected risks to health						
Unsafe health care injections	1.1	0.9	1.8	0.9	0.1	0.1
Childhood sexual abuse	0.1	0.2	0.1	0.2	0.1	0.1

able burden of healthy life expectancy, principally as a result of their large burden resulting from tobacco, alcohol, cholesterol and other major risks for noncommunicable diseases.

Such joint estimates have considerable uncertainty associated with them. As well as the technical assumptions necessary in making these estimates with limited data, the time-related issues should also be considered, with sequential rather than simultaneous changes occurring in real life. Thus there is the capacity of improved health to beget health. For example, improvements in nutritional status of children in developing countries might well lead to improved ability to avoid and reduce other risks in adulthood as well as the large, immediate threats of communicable diseases. For these reasons, it seems likely that these are conservative estimates of joint effects of major risks on healthy life expectancy.

The distribution of risks across levels of poverty as measured in this report, both within and between regions, suggests they are likely to explain a large proportion of current inequity in healthy life expectancy. The multicausal nature of many diseases means that tackling major risks at a population-wide level offers opportunities to lessen these differentials,

Table 4.10 Attributable DALYs by risk factor, level of development and sex, 2000

	High mortality Developing countries AFR-D, AFR-E, AMR-D, EMR-D, SEAR-D		Low mortality Developing countries AMR-B, EMR-B, SEAR-B, WPR-B		Developed countries AMR-A, EUR-A, EUR-B, EUR-C, WPR-A	
	Males	Females	Males	Females	Males	Females
TOTAL DALYs (000)	*420 711*	*412 052*	*223 181*	*185 316*	*117 670*	*96 543*
	(% total)	(% total)	(% total)	(% total)	(% total)	(% total)
Childhood and maternal undernutrition						
Underweight	14.9	15.0	3.0	3.3	0.4	0.4
Iron deficiency	2.8	3.5	1.5	2.2	0.5	1.0
Vitamin A deficiency	2.6	3.5	0.3	0.4	<0.1	<0.1
Zinc deficiency	3.2	3.2	0.3	0.3	0.1	0.1
Other diet-related risks and physical inactivity						
Blood pressure	2.6	2.4	4.9	5.1	11.2	10.6
Cholesterol	1.9	1.9	2.2	2.0	8.0	7.0
Overweight	0.6	1.0	2.3	3.2	6.9	8.1
Low fruit and vegetable intake	1.3	1.2	2.0	1.8	4.3	3.4
Physical inactivity	0.9	0.8	1.2	1.3	3.3	3.2
Sexual and reproductive health risks						
Unsafe sex	9.4	11.0	1.2	1.6	0.5	1.1
Lack of contraception	…	1.8	…	0.6	…	0.1
Addictive substances						
Tobacco	3.4	0.6	6.2	1.3	17.1	6.2
Alcohol	2.6	0.5	9.8	2.0	14.0	3.3
Illicit drugs	0.8	0.2	1.2	0.3	2.3	1.2
Environmental risks						
Unsafe water, sanitation and hygiene	5.5	5.6	1.7	1.8	0.4	0.4
Urban air pollution	0.4	0.3	1.0	0.9	0.6	0.5
Indoor smoke from solid fuels	3.7	3.6	1.5	2.3	0.2	0.3
Lead exposure	0.8	0.7	1.4	1.4	0.8	0.5
Climate change	0.6	0.7	0.1	0.1	<0.1	<0.1
Occupational risks						
Risk factors for injury	1.5	0.1	2.1	0.3	1.0	0.1
Carcinogens	0.1	<0.1	0.2	0.1	0.4	0.1
Airborne particulates	0.1	<0.1	0.8	0.1	0.4	0.1
Ergonomic stressors	<0.1	<0.1	0.1	0.1	0.1	0.1
Noise	0.3	0.1	0.5	0.3	0.4	0.3
Other selected risks to health						
Unsafe health care injections	0.9	0.8	1.1	0.5	0.1	0.1
Childhood sexual abuse	0.3	0.7	0.5	0.8	0.3	1.0

whatever their initial cause. The Commission on Macroeconomics and Health recently estimated that a 10% increase in life expectancy might increase GDP by 0.3% in the poorest countries of the world *(1)*. It is clear that many different combinations of reductions in these major risks could increase healthy life expectancy by at least 10% in these countries, especially if they were simultaneous and population-wide. Indeed, at least a quarter of all disease burden can be attributed to the leading three risks in high mortality developing areas and in developed regions, and at least one sixth in low mortality developing regions. Furthermore, these potential gains are averaged over a whole population, even though many people die from other causes. The average gain in healthy life expectancy would be much greater among those with averted events.

Estimates of avoidable burden

Current action to focus on risks to health can change the future but not alter the past. It is possible to avoid future disease burden, but nothing can be done about attributable burden. The main policy use of attributable burden estimates should therefore be to help assess avoidable burden. In addition to the uncertainty involved in estimating attributable burden, making estimates of avoidable burden is particularly challenging because of uncertainty concerning predictions in risk factors and burden, and reversibility of risks. Despite these reservations, the policy relevance of avoidable burden information is considerable and justifies making estimates, given that appropriate caution will be exercised regarding their uncertainty. To maximize policy relevance, estimates can be made particularly for small-to-moderate risk factor reductions; that is, those that are likely to be achievable in the short term. A full range of estimates is essential, however, since, for example, a 5% distributional transition for one risk factor may be cost-effective in one region, whereas a 50% distributional transition may be cost-effective in another. Similarly, in one region, the same resources might be required to achieve a distributional transition of 1% for one risk factor as to achieve a 10% transition for another. Wide ranges of risk reductions have been assessed in the following chapter. As an example, the likely effects of a 25% distributional transition are estimated: that is, a 25% transition from current levels towards the theoretical

Box 4.10 Healthy risk factor transition

The "nutritional transition" encompasses changes in a range of risk factors and diseases. As a country develops and more people buy processed food rather than growing and buying raw ingredients, an increasing proportion of calories tends to be drawn from sugars added to manufactured food and from relatively cheap oils. Alongside the change in diet, changes in food production and the technology of work and leisure lead to decreases in physical exercise. The consequent epidemic of diet-related noncommunicable diseases (obesity, diabetes, hypertension and cardiovascular disease) coexists with residual undernutrition, and is projected to increase rapidly. For example, in India and China, a shift in diet towards higher fat and lower carbohydrate is resulting in rapid increases in overweight – among all adults in China and mainly among urban residents and high income rural residents in India.

Countries which have completed the transition to overnutrition are experiencing a continual increase in levels of obesity, as high fat, high sugar and low exercise lifestyles permeate society. However, this transition may not be inevitable, and a key challenge for policy-makers is to generate a "healthier transition".

The Republic of Korea is an example of a country that has experienced rapid economic growth and the introduction of Western culture since the 1970s. There were large increases in the consumption of animal food products, and a fall in total cereal intake. Despite this, national efforts to retain elements of the traditional diet – very high in carbohydrates and vegetables – seem to have maintained low fat consumption and a low prevalence of obesity.

Civil society and government initiatives to retain the traditional diet and cooking methods in the Republic of Korea have been strong: mass media campaigns, such as television programmes, promote local foods, emphasizing their higher quality and the need to support local farmers. A unique training programme is offered by the Rural Development Administration. Since the 1980s, the Rural Living Science Institute has trained thousands of extension workers to provide monthly demonstrations of cooking methods for traditional Korean foods such as rice, kimchi (pickled and fermented Chinese cabbage) and fermented soybean food. These sessions are open to the general public in most districts in the country, and the programme appears to reach a large audience.

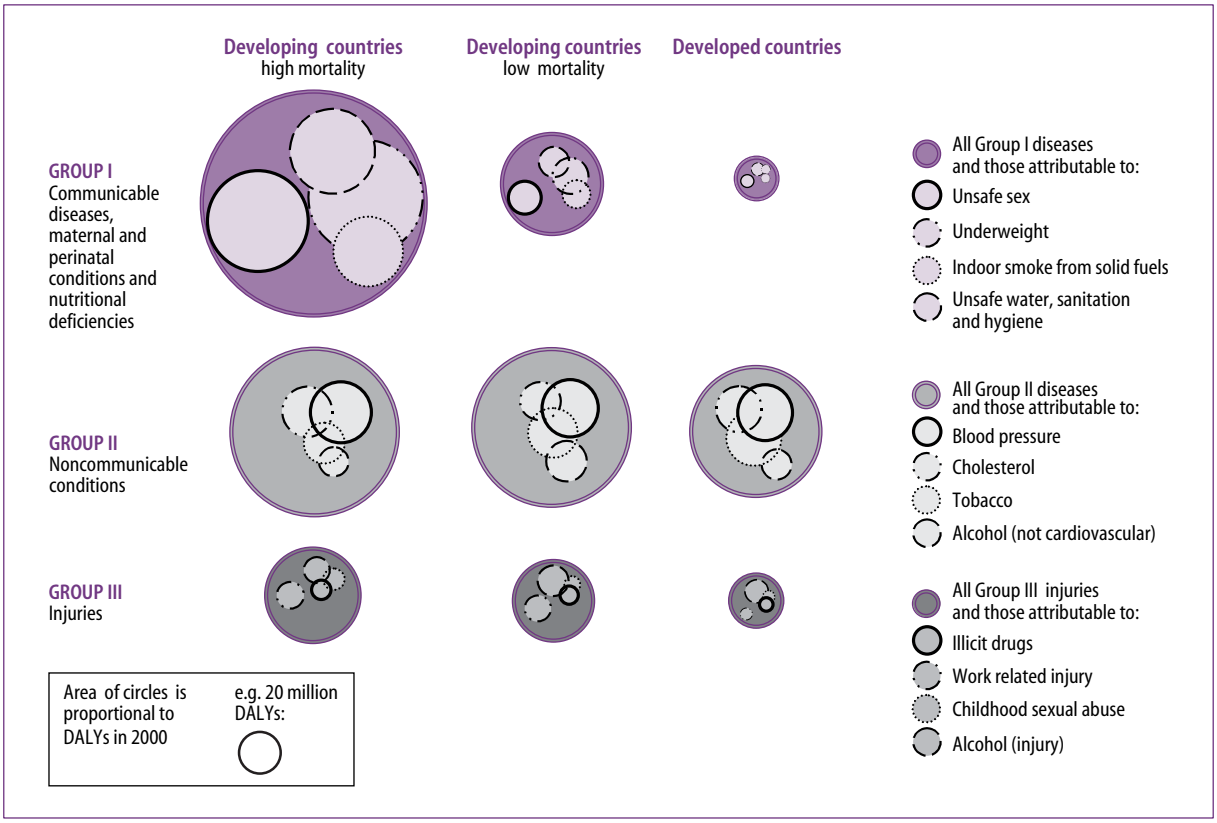
Sources: *(118–121)*.

minimum that occurs in 2000 and is maintained relative to "business as usual" exposure projections.

In this chapter, business as usual, or "drift", was first estimated to calculate what attributable burden would be in future years if there were no change in current trends in risk factor levels and distributions. For example, without further action it is predicted that in 2020 the disease burden attributable to tobacco will be nearly double its current levels. Similarly, there will be a one-third increase in the loss of healthy life as a result of overweight and obesity in 2020 compared with 2000. In contrast, 130 million DALYs per year are currently attributable to underweight, while it is estimated that 90 million will occur from this risk in 2010 even with all the benefits of economic development. Avoidable burden estimates the effects of changes in terms of deviations in risk levels from these predictions. Thus, avoidable burden is defined here as the fraction of total disease burden in a particular year that could be avoided with a specific reduction in current and future exposure compared to predicted current trends. The main estimates here are for a 25% distributional transition – roughly equated as a reduction of one quarter in current and future risk levels. The initial avoidable burden estimates are summarized in Tables 4.9 and 4.10 and Figure 4.13.

These estimates show, firstly, that underweight will remain one of the leading causes of avoidable burden in 2010 and 2020. This is despite the fact that the estimated global burdens attributable to childhood diseases, diarrhoea and other major causes of childhood mortality are expected to form a considerably lower proportion of the global disease burden in 2010 and 2020. For example, the business as usual trend for burden attributable to

Figure 4.11 Disease and risk factor burden

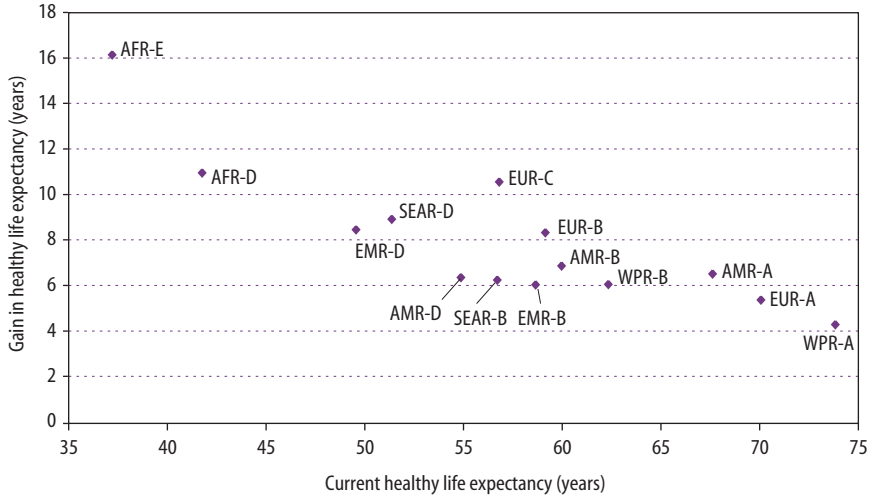


underweight suggests that it will be responsible for 90 million DALYs in 2010 and more than 60 million DALYs in 2020, with disease rates continuing to decline, but with increased population sizes. The risk factors of unsafe water, sanitation and hygiene, and indoor smoke from solid fuels assume lesser though still very substantial roles as causes of avoidable burden, as the exposure levels are predicted to decrease with economic development. The associated mortality and morbidity are also proportionally less important as a result of declining levels of related risk factors. Nonetheless, the avoidable burden remains substantial. Because these risks are high in the poor, both within and between countries, efforts to tackle them now are likely to reduce inequality significantly in the future.

The 10 leading risk factors in terms of avoidable burden in 2010 and 2020 are broadly similar to the 10 leading causes of attributable burden in 2000, although the ordering changes somewhat, reflecting expectations of demographic and social development. Most noticeably, the ranking of avoidable burden from reduction in unsafe sex is extremely high, making it the leading cause of avoidable burden and reflecting the benefits of preventing transmission and the continuing predicted epidemic of HIV/AIDS in some places where current effects are small but large increases may occur. If the benefits of reducing undernutrition and unsafe sex are additive, then a 25% reduction in these two risk factors alone would avoid an estimated 5% of global disease burden in 2010. These benefits would be substantially concentrated in sub-Saharan Africa, where the improvement in healthy life expectancy would be even greater.

The potential avoidable burden from decreases in the prevalence of unsafe sex are both substantial and rapid. For example, with a one-quarter reduction, a substantial number of deaths would be averted in 2010. These would mostly occur in young and middle-aged adults, and so the avoidable disease burden in terms of DALYs is even more substantial. Similarly, most of the benefits of reduction in alcohol consumption are rapidly achieved, since most of the attributable burden is to the result of injuries or neuropsychiatric diseases. One quarter reduction in alcohol use from its current trend could result in approximately

Figure 4.12 Estimated gain in healthy life expectancy with removal of 20 leading selected risk factors by subregion[a]



[a] See the List of Member States by WHO Region and mortality stratum for an explanation of subregions.

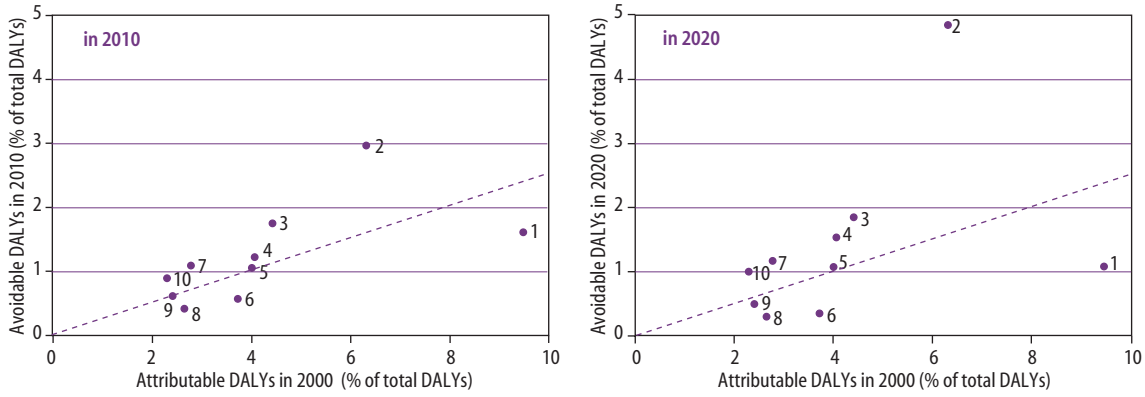
Table 4.11 Ranking of estimated attributable and avoidable burdens of 10 leading selected risk factors

Rank	Estimated attributable burden in 2000		Estimated avoidable burden after 25% distributional transition from 2001 in 2010		Estimated avoidable burden after 25% distributional transition from 2001 in 2020	
	DALYs (millions)	% total	DALYs (millions)	% total	DALYs (millions)	% total
1 Underweight	138	9.5	Unsafe sex	42	3.0	Unsafe sex	71	4.8
2 Unsafe sex	92	6.3	Blood pressure	25	1.7	Blood pressure	27	1.9
3 Blood pressure	64	4.4	Underweight	23	1.6	Tobacco	22	1.5
4 Tobacco	59	4.1	Tobacco	17	1.2	Cholesterol	17	1.2
5 Alcohol	58	4.0	Cholesterol	15	1.1	Underweight	16	1.1
6 Unsafe water, sanitation and hygiene	54	3.7	Alcohol	15	1.1	Alcohol	16	1.1
7 Cholesterol	40	2.8	Overweight	13	0.9	Overweight	15	1.0
8 Indoor smoke from solid fuels	39	2.6	Iron deficiency	9	0.6	Low fruit and vegetable intake	9	0.6
9 Iron deficiency	35	2.4	Low fruit and vegetable intake	9	0.6	Iron deficiency	7	0.5
10 Overweight	33	2.3	Unsafe water, sanitation and hygiene	8	0.6	Physical inactivity	6	0.4
Total DALYs	***1 455***			***1 417***			***1 459***	

15 million fewer DALYs in 2010. Shifting distributions of blood pressure and cholesterol by only a quarter of the distance towards the theoretical minimum from their current trends (on average by 5–10 mmHg systolic pressure or 0.3–0.6 mmol/l total cholesterol) could avert considerable disease burden. Such population-wide reductions could together avert a loss of tens of millions of years of healthy life, with most or all of the full potential reached before 2005 and the effects being approximately additive. Strategies to achieve this are outlined in the following chapter.

Another important feature of these estimates is the importance of reduction in tobacco use now. The benefits, although more delayed than those resulting from reduction of some other risks, are very large and long-lasting. This is seen in the estimated tens of millions of

Figure 4.13 Attributable DALYs in 2000 and avoidable DALYs in 2010 and 2020 following a 25% risk factor reduction from 2000, for 10 leading selected risk factors



Risk factors

1	Underweight	6	Unsafe water, sanitation and hygiene
2	Unsafe sex	7	Cholesterol
3	Blood pressure	8	Indoor smoke from solid fuels
4	Tobacco	9	Iron deficiency
5	Alcohol	10	Overweight

The figure shows attributable DALYs in 2000 plotted against avoidable DALYs in 2010 and 2020 following a 25% risk factor reduction from 2000, for 10 selected risks.
The risk factor reduction is a distributional transition starting in 2000 - see text for details.
The diagonal dotted line respresents the points at which the avoidable burden is 25% of the attributable burden, in terms of % global DALYs.

healthy life years to be saved in 2010 and 2020 as a result of preventing and reducing tobacco use. The potential avoidable burden from some other risks closely maps the attributable burden. For the risk factors that predominantly affect cardiovascular diseases (inadequate fruit and vegetable intake, physical inactivity, overweight, blood pressure and cholesterol) and for alcohol, the amount of disease burden avoidable in 2010 from a 25% reduction starting in 2000 is about one-third of the attributable burden in 2000. This "avoidability" is lower for underweight, micronutrient deficiencies, unsafe water, sanitation and hygiene, and indoor smoke from solid fuels – reflecting changing disease patterns as a result of the assumed demographic and social development – and for tobacco use, reflecting delayed benefits from cessation. In contrast, it is much higher for unsafe sex, reflecting the benefits of reduced communicable disease transmission and the predicted continuing HIV/AIDS epidemic.

However, these analyses only map out the potential for gain – what is required next are effective and cost-effective interventions to realize this potential.

The need for cost-effectiveness analyses

Large gains in health are not possible without focusing on efforts to diminish large threats to health. These analyses have shown some major causes of disease and injury burden. While the risk factors were selected from a countless array of possible risks, there are, of course, many other distal factors (for example, lack of education) or proximal factors (for example, fat intake or osteoporosis) that lead to substantial disease burden and were not estimated in this work. However, there may be relatively few others that have population attributable fractions of more than 5% of all disease and injury burden in a particular region.

While many big challenges to health remain, there are also many different ways of meeting them – involving personal health interventions, non-personal health interventions, and intersectoral action. Not everything can be done in all settings, so some way of setting priorities needs to be found. The next chapter identifies costs and the impact on population health of a variety of interventions, as the basis on which to develop strategies to reduce risk.

References

1. Commission on Macroeconomics and Health. *Macroeconomics and health: investing in health for economic development*. Geneva: World Health Organization; 2001.
2. *WHO global database on child growth and malnutrition*. Geneva: World Health Organization; 2002. Available from: URL: http://www.who.int/nutgrowthdb/
3. *Fourth report on the world nutrition situation: nutrition throughout the life cycle*. Geneva: United Nations Administrative Committee on Coordination Sub-Committee on Nutrition (ACC/SCN); 2000.
4. Rice AL, Sacco L, Hyder A, Black RE. Malnutrition as an underlying cause of childhood deaths associated with infectious diseases in developing countries. *Bulletin of the World Health Organization* 2000; 78:1207-21.
5. Grantham-McGregor SM, Ani CC. Undernutrition and mental development. In: Fernstrom JD, Uauy R, Arroyo P, editors. *Nutrition and brain*. Basel: Karger; 2001. Nestle Nutrition Workshop Series: Clinical and Performance Program Vol. 5. p. 1-18.
6. Pelletier DL. The relationship between child anthropometry and mortality in developing countries: implications for policy, programs and future research. *Journal of Nutrition* 1994; 124(Suppl.):2047S-81S.
7. Bleichrodt N. Developmental disorders associated with severe IDD. In: Hetzel BS, Dunn JT, Stansbury JB, editors. *The prevention and control of iodine deficiency disorders.* Amsterdam: Elsevier; 1987.
8. *Global prevalence of iodine deficiency disorders*. Geneva: World Health Organization; 1993. Micronutrient Deficiency Information System, Working Paper No.1.
9. Hetzel BS. Iodine deficiency disorders (IDD) and their eradication. *Lancet* 1983; 2: 1126-7.
10. Stoltzfus RJ, Dreyfuss ML. *Guidelines for the use of iron supplements to prevent and treat iron deficiency anemia.* Washington (DC): ILSI Press; 1998.
11. Sommer A, West KP, Jr. *Vitamin A deficiency: health, survival and vision*. New York: Oxford University Press; 1996.
12. Prasad AS. Discovery of human zinc deficiency and studies in an experimental human model. *American Journal of Clinical Nutrition* 1991; 53:403-12.
13. Sandstead HH. Zinc deficiency: a public health problem? *American Journal of Diseases of Children* 1991; 145:853-9.
14. *Infant and young child nutrition*. Geneva: World Health Organization; 2001. World Health Assembly Resolution WHA54.2.
15. Victora CG, Vaughan JP, Lombardi C, Fuchs SMC, Gigante LP, Smith PG, et al. Evidence for protection by breast-feeding against infant deaths from infectious diseases in Brazil. *Lancet* 1987; 2:319-22.
16. Prospective Studies Collaboration. Cholesterol, diastolic blood pressure, and stroke: 13 000 strokes in 45 000 people in 45 prospective cohorts. *Lancet* 1995; 346:1647-53.
17. Eastern Stroke and Coronary Heart Disease Collaborative Group. Blood pressure, cholesterol and stroke in eastern Asia. *Lancet* 1998; 352:1801-07.
18. Law MR, Wald NJ. Risk factor thresholds: their existence under scrutiny. *BMJ* 2002; 324:1570-6.
19. *Obesity: preventing and managing the global epidemic*. Geneva: World Health Organization; 2000. WHO Technical Report Series, No. 894.
20. Ness AR, Powles JW. Fruit and vegetables, and cardiovascular disease: a review. I*nternational Journal of Epidemiology* 1997; 26:1-13.
21. World Cancer Research Fund and American Institute for Cancer Research. *Food, nutrition and the prevention of cancer: a global perspective*. Washington (DC): American Institute for Cancer Research; 1997.
22. *Physical activity and health: a report of the Surgeon General.* Altanta (GA): US Department of Health and Human Services, Centers for Disease Control and Prevention; 1996.
23. *Report on the global HIV/AIDS epidemic.* Geneva: Joint United Nations Programme on HIV/AIDS; 2002.
24. Corrao MA, Guindon GE, Sharma N, Shokoohi DF, editors. *Tobacco control: country profiles*. Atlanta (GA): American Cancer Society; 2000.
25. World Health Organization. *Tobacco or health: a global status report*. Geneva: World Health Organization; 1997.
26. Peto R, Lopez AD, Boreham J, Thun M, Heath CW. Mortality from tobacco in developed countries: indirect estimates from national vital statistics. *Lancet* 1992; 339:1268-78.
27. Liu BQ, Peto R, Chen ZM, Boreham J, Wu YP, Li JY, et al. Emerging tobacco hazards in China. 1. Retrospective proportional mortality study of one million deaths. *BMJ* 1998; 317:1411-22.
28. Niu SR, Yang GH, Chen ZM, Wang JL, Wang GH, He XZ, et al. Emerging tobacco hazards in China. 2. Early mortality results from a prospective study. *BMJ* 1998; 317:1423-4.
29. Dikshit RP, Kanhere S. Tobacco habits and risk of lung, oropharyngeal and oral cavity cancer: a population-based case-control study in Bhopal, India. *International Journal of Epidemiology* 2000; 29:609-14.

30. Gupta PC, Mehta HC. Cohort study of all-cause mortality among tobacco users in Mumbai, India. *Bulletin of the World Health Organization* 2000; 78:877-83.
31. *Health effects of exposure to environmental tobacco smoke:* Sacramento: California Environmental Protection Agency (Cal/EPA), Office of Environmental Health Hazard Assessment; 1997. Smoking and Tobacco Control Monograph 10.
32. Environmental Protection Agency (EPA). *Respiratory health effects of passive smoking: lung cancer and other disorders.* Washington (DC): US Environmental Protection Agency, Office of Health and Environmental Assessment; 1992.
33. Glantz SA, Parmley WW. Passive smoking and heart disease. Epidemiology, physiology, and biochemistry. *Circulation* 1991; 83:1-12.
34. Hackshaw AK, Law MR, Wald NJ. The accumulated evidence on lung cancer and environmental tobacco smoke. *BMJ* 1997; 315:980-8.
35. Jha P. *Curbing the epidemic: governments and the economics of tobacco control.* Washington (DC): The World Bank; 1999.
36. Law MR, Morris JK, Wald NJ. Environmental tobacco smoke exposure and ischaemic heart disease: an evaluation of the evidence. *BMJ* 1997; 315:973-80.
37. Strachan DP, Cook DG, editors. *Health effects of passive smoking in children*. A set of nine review articles appearing in *Thorax* 1997: 52 and 1998: 53.
38. Thun M, Henley J, Apicella L. Epidemiologic studies of fatal and nonfatal cardiovascular disease and ETS exposure from spousal smoking. *Environmental Health Perspectives* 1999; 107:841-6.
39. English DR, Holman CDJ, Milne E, Winter MJ, Hulse GK, Codde G, et al. *The quantification of drug-caused morbidity and mortality in Australia 1995*. Canberra: Commonwealth Department of Human Services and Health; 1995.
40. Rehm J, Gutjahr E, Gmel G. Alcohol and all-cause mortality: a pooled analysis. *Contemporary Drug Problems* 2001c; 28:337-61.
41. United Nations Office for Drug Control and Crime Prevention. *World drug report 2000*. Oxford: Oxford University Press; 2000.
42. *Global illicit drug trends 2000*. Vienna: United Nations Drug Control Programme; 2000.
43. Frischer M, Green ST, Goldberg D. *Substance abuse related mortality: a worldwide review*. Vienna: United Nations International Drug Control Programme; 1994.
44. Hulse G, English D, Milne E, Holman C. The quantification of mortality resulting from the regular use of illicit opiates. *Addiction* 1999; 94: 221-30.
45. Pope CA III, Dockery DW. Epidemiology of particle effects. In: Holgate ST, Koren HS, Samet JM, Maynard RL, editors. *Air pollution and health*. San Diego (CA): Academic Press; 1999.
46. Krzyzanowski M, Schwela D. Patterns of air pollution in developing countries. In: Holgate ST, Koren HS, Samet JM, Maynard RL, editors. *Air pollution and health*. San Diego (CA): Academic Press; 1999.
47. Committee of the Environmental and Occupational Health Assembly of the American Thoracic Society (ATS). Health effects of outdoor air pollution, Part 1. *American Journal of Respiratory and Critical Care Medicine* 1996; 153:3-50.
48. Committee of the Environmental and Occupational Health Assembly of the American Thoracic Society (ATS). Health effects of outdoor air pollution, Part 2. *American Journal of Respiratory and Critical Care Medicine* 1996; 153:477-98.
49. *Airborne particles and health: HEI epidemiologic evidence.* Boston (MA): Health Effects Institute; 2001. HEI Perspectives June 2001.
50. Samet JM, Cohen AJ. Air pollution and lung cancer. In: Holgate ST, Koren HS, Samet JM, Maynard RL, editors. *Air pollution and health*. San Diego (CA): Academic Press; 1999.
51. Bruce N, Perez-Padilla R, Albalak R. Indoor air pollution in developing countries: a major environmental and public health challenge. *Bulletin of the World Health Organization* 2000; 78:1078-92.
52. Smith KR, Samet JM, Romieu I, Bruce N. Indoor air pollution in developing countries and ALRI in children. *Thorax* 2000; 55:518-32.
53. Smith KR. Inaugural article: national burden of disease in India from indoor air pollution. *Proceedings of the National Academy of Sciences of the United States of America* 2000; 97:13286-93.
54. Spengler JD, Chen Q. Indoor air quality factors in designing a healthy building. *Annual Review of Energy and the Environment* 2000: 25:567-600.
55. Bornehag C-G, Blomquist G, Gyntelberg F, Järvholm B, Malmberg P, Nielsen A, et al. Dampness in buildings and health. Nordic interdisciplinary review of the scientific evidence on associations between exposure to "dampness" and health effects, NORDDAMP. *Indoor Air* 2001; 11:72-86.
56. Wargocki P, Bischof W, Brundrett G, Fanger O, Gyntelberg F, Hanssen SO, et al. Ventilation and health. *Indoor Air* 2002; in press.

57. Centers for Disease Control and Prevention. Blood lead levels in young children – United States and selected states, 1996–1999. *Morbidity and Mortality Weekly Report* 2000; 49:1133-7.
58. Kaiser R, Henderson AK, Daley WR, Naughton M, Khan MH, Rahman M, et al. Blood lead levels of primary school children in Dhaka, Bangladesh. *Environmental Health Perspectives* 2001; 109(6):563-6.
59. Schwartz J. Low-level lead exposure and children's IQ: a meta-analysis and search for a threshold. *Environmental Research* 1994; 65:42-55.
60. Lanphear BP, Dietrich P, Auinger P, Cox C. Subclinical lead toxicity in US children and adolescents. *Public Health Reports* 2000; 115:6.
61. Agency for Toxic Substances and Disease Registry (ATSDR). *Toxicological profile for lead (update)*. Atlanta (GA): US Department of Health and Human Services; 1999.
62. Parry MC, Rosenzweig C, Iglesis A, Fischer G, Livermore M. Climate change and world food security: a new assessment. *Global Environmental Change – Human and Policy Dimensions* 1999; 9: S51-S67.
63. Intergovernmental Panel on Climate Change. *Climate change 2001. Vol. 1: The scientific basis. Vol. II: Impacts, adaptation and vulnerability. Vol. III: Mitigation. Vol. IV: Synthesis report*. Cambridge: Cambridge University Press; 2001.
64. *The world health report 2001 – Mental health: new understanding, new hope*. Geneva: World Health Organization; 2001. Statistical annex.
65. *International Road Traffic and Accident Database (IRTAD)*. Paris: Organisation for Economic Co-operation and Development; 2001. Available from: URL: http://www.bast.de/htdocs/fachthemen/irtad/english/englisch.html (accessed November 2001).
66. Khon Kaen Accident Prevention Committee. Methodology and results of implementation of Khon Kaen Accident Prevention Committee responding to Anti-knock Helmet Act for Motorcyclists. *Trauma Center Bulletin* 1996; 1(2):1-3.
67. *Safety of pedestrians and cyclists in urban areas*. Brussels: European Transport Safety Council; 1999.
68. Dora C, Phillips M, editors. *Transport, environment and health*. Copenhagen: World Health Organization Regional Office for Europe; 2000. European Series, No. 89.
69. Jacobs GD. The potential for road accident reduction in developing countries. *Transport Reviews* 1982; 2(2):213-24.
70. *Review of road safety in Asia and the Pacific*. New York: United Nations Economic and Social Commission for Asia and the Pacific (ESCAP); 1998.
71. Bosma H, Peter R, Siegrist J, Marmot M. Two alternative job stress models and the risk of coronary heart disease. *American Journal of Public Health* 1988; 88(1):68-74.
72. Nurminen M, Karjalainen A. Epidemiologic estimate of the proportion of fatalities related to occupational factors in Finland. *Scandinavian Journal of Work, Environment & Health* 2001; 27(3):161-213.
73. National Institute for Occupational Safety and Health. *Worker health chartbook*. Cincinnati (OH): National Institute for Occupational Safety and Health (NIOSH); 2000.
74. Driscoll TR, Mitchell RJ, Mandryk JA, Healey S, Hendrie AL, Hull BP. Work-related fatalities in Australia, 1989 to 1992: an overview. *Journal of Occupational Health and Safety - Australia New Zealand* 2001; 17:45-66.
75. European Union (Eurostat). *Accidents at work in the European Union in 1993*. Available from: URL: http://europa.eu.int/comm/employment_social/h&s/figures/ accidents93_en.htm
76. Loewenson R. Assessment of the health impact of occupational risk in Africa: current situation and methodological issues. *Epidemiology* 1999; 10:632-9.
77. National Occupational Health & Safety Commission (NOHSC). *The causes of occupational accidents.* Available from: URL: http://www.nohsc.gov.au
78. International Agency for Research on Cancer. *IARC Monographs Programme on the Evaluation of Carcinogenic Risks to Humans*. Available from: URL: http://193.51.164.11
79. National Institute for Occupational Safety and Health. *Work-related lung disease surveillance report 1999*. Cincinnati (OH): Division of Respiratory Disease Studies, National Institute for Occupational Safety and Health (NIOSH); 1999.
80. Loewenson R. Globalization and occupational health: a perspective from southern Africa. *Bulletin of the World Health Organization* 2001; 79:863-8.
81. Chen W, Zhuang Z, Attfield MD, Chen BT, Gao P, Harrison JC, et al. Exposure to silica and silicosis among tin miners in China: exposure-response analyses and risk assessment. *Occupational and Environmental Medicine* 2001; 58:31-7.
82. Bernard BP, editor. *Musculoskeletal disorders and workplace factors*. Cincinnati (OH): National Institute for Occupational Safety and Health (NIOSH); 1997. DHHS (NIOSH) Publication No. 97-141.
83. Institute of Medicine. *Musculoskeletal disorders and the workplace: low back and upper extremities*. Washington (DC): National Academy Press; 2001.

84. Leigh JP, Sheetz RM. Prevalence of back pain among full-time United States workers. *British Journal of Industrial Medicine* 1989; 46:651-7.
85. Columbia University of Health Sciences (CUHS). *Counselling to prevent low back pain. Guide to clinical preventive services*. 2nd ed. Available from: URL: http://cpmcnet.columbia.edu/texts/gcps/gcps0070.html
86. Nachemson AL. Advances in low-back pain. *Clinical Orthopedics and Related Research* 1985; 200:266-78.
87. Jin K, Sorock G, Courtney T, Lian Y, Yao Z, Matz S, et al. Risk factors for work-related low back pain in the People's Republic of China. *International Journal of Occupational and Environmental Health* 2000; 6:26-33.
88. European Agency for Safety and Health at Work (EASHW). *Monitoring the state of occupational safety and health in the European Union - pilot study*. Luxembourg: EASHW. Available from: URL: http://agency.osha.eu.int/publications/ reports/stateofosh/
89. Goelzer B, Hansen CH, Sehrndt GA, editors. *Occupational exposure to noise: evaluation, prevention and control*. Berlin: Dortmund for the World Health Organization (WHO) and the Federal Institute for Occupational Safety and Health (FIOSH); 2001.
90. National Institute for Occupational Safety and Health (NIOSH). Work-related hearing loss. Available from: URL: http://www.cdc.gov/niosh/hpworkrel.html
91. *Global tuberculosis control: surveillance, planning, financing*. Geneva: World Health Organization; 2002. WHO document WHO/CDS/TB/2002.295.
92. Rieder HL. Epidemiologic basis of tuberculosis control. Paris: International Union Against Tuberculosis and Lung Disease (IUATLD); 1999.
93. Holtzman NA. Marteau TM. Will genetics revolutionize medicine? *New England Journal of Medicine* 2000; 343:141-4.
94. Peto R, Boreham J, Clarke M, Davies C, Beral V. UK and USA breast cancer deaths down 25% in year 2000 at ages 20-69 years. *Lancet* 2000; 355:1822.
95. Hunink MG, Goldman L, Tosteson AN. Mittleman MA, Goldman PA, Williams LW, et al. The recent decline in mortality from coronary heart disease, 1980-1990. The effect of secular trends in risk factors and treatment. *JAMA* 1997; 277:535-42.
96. Vartiainen E, Puska P, Jousilahti P, Korhonen HJ, Tuomilehto J, Nissinen A. Twenty-year trends in coronary risk factors in north Karelia and in other areas of Finland. *International Journal of Epidemiology* 1994; 23:495-504.
97. Shimamoto T, Komachi Y, Inada H, Doi M, Iso H, Sato S, et al. Trends for coronary heart disease and stroke and their risk factors in Japan. *Circulation* 1989; 9(3):503-15.
98. Peto R, Darby S, Deo H, Silcocks P, Whitley E, Doll R. Smoking, smoking cessation, and lung cancer in the UK since 1950: combination of national statistics with two case-control studies. *BMJ* 2000; 321:323-9.
99. Kane A, Lloyd J, Zaffran M, Simonsen L, Kane M. Transmission of hepatitis B, hepatitis C and human immunodeficiency viruses through unsafe injections in the developing world: model-based regional estimates. *Bulletin of the World Health Organization* 1999; 77:801-7.
100. Miller M, Pisani E. The cost of unsafe injections. *Bulletin of the World Health Organization* 1999; 77:808-11.
101. Reeler AV. Anthropological perspectives on injections: a review. *Bulletin of the World Health Organization* 2000; 78:135-43.
102. Simonsen L, Kane A, Lloyd J, Zaffran M, Kane M. Unsafe injections in the developing world and transmission of bloodborne pathogens. *Bulletin of the World Health Organization* 1999; 77:789-800.
103. Wilson RM, Runciman WB, Gibberd RW, Harrison BT, Newby L, Hamilton JD. The Quality in Australian Health Care Study. *Medical Journal of Australia* 1995;163(9):458-71.
104. Wilson RM, Harrison BT, Gibberd RW, Hamilton JD. An analysis of the causes of adverse events from the Quality in Australian Health Care Study, *Medical Journal of Australia* 1999; 170(9):411-5.
105. Leape LL, Brennan TA, Laird N, Lawthers AG, Localio AR, Barnes BA, et al. The nature of adverse events in hospitalized patients. Results of the Harvard Medical Practice Study II. *New England Journal of Medicine* 1991; 324:377-84.
106. Brennan TA, Leape LL, Laird NM, Hebert L, Localio AR, Lawthers AG, et al. Incidence of adverse events and negligence in hospitalized patients. Results of the Harvard Medical Practice Study I. *New England Journal of Medicine* 1991; 324:370-6.
107. Schioler T, Lipczak H, Pedersen BL, Mogensen TS, Bech KB, Stockmarr A, et al. Danish Adverse Event Study. Incidence of adverse events in hospitals. A retrospective study of medical records. *Ugeskr Laeger* 2001; 163: 5370-8. In Danish; abstract in English.
108. Vincent C, Neale G, Woloshynowych M. Adverse events in British hospitals: preliminary retrospective record review. *BMJ* 2001; 322:517-9.
109. The quality of health care/hospital activities: Report by the Working Party on Quality Care in Hospitals of the Sub-Committee on Coordination. Leuven: Standing Committee of the Hospitals of the European Union (HOPE); 2000.

110. Kohn LT, Corrigan JM, Donaldson MS, editors. To err is human: building a safer health system. Washington: National Academy Press for the Institute of Medicine; 2000.

111. Department of Health. An organisation with a memory. Report of an expert group on learning from adverse events in the NHS chaired by the Chief Medical Officer. London: The Stationery Office; 2000.

112. Progress in essential drugs and medicines policy 1998–1999. Geneva: World Health Organization; 2000. WHO document WHO/EDM/2000.2.

113. Leape LL, Bates DW, Cullen DJ, Cooper J, Demonaco HJ, Gallivan T, et al. Systems analysis of adverse drug events. *JAMA* 1995; 274:35-43.

114. Kovner C, Gergen PJ. Nurse staffing levels and adverse events following surgery. *Image – the Journal of Nursing Scholarship* 1998; 30:315-21.

115. Morris AH. Protocol management of adult respiratory distress. *New Horizons* 1993; 1:593-602.

116. Meddings DR. Civilians and war. A review and historical overview of the involvement of non-combatant populations in conflict situations. *Medicine, Conflict, and Survival* 2001; 17:6-16.

117. Krug EG, Dahlberg LL, Mercy JA, Zwi A, Lozano-Ascencio R, editors. *World report on violence and health*. Geneva: World Health Organization; 2002.

118. Popkin BM, Horton S, Kim S, Mahal A, Shuigao J. Trends in diet, nutritional status and diet-related noncommunicable diseases in China and India: The economic costs of the nutrition transition. *Nutrition Reviews* 2001; 59: 379-90.

119. Popkin BM. An overview on the nutrition transition and its health implications: the Bellagio meeting. *Public Health Nutrition* 2002; 5:93-103.

120. Kim S, Moon S, Popkin BM. The nutrition transition in South Korea. *American Journal of Clinical Nutrition* 2000; 71:44-53.

121. Lee M-J, Popkin BM, Kim S. The unique aspects of the nutrition transition in South Korea: the retention of healthful elements in their traditional diet. *Public Health Nutrition* 2000; 5:197-203.