

3.1

Global burden of disease: causes, levels, and intervention strategies

Ramanan Laxminarayan and Dean Jamison

Essentials

Recent decades have seen remarkable progress in quantifying the burden of disease in low- and middle-income countries and in gathering evidence on the effectiveness and cost-effectiveness of health interventions. This chapter reviews the major sources of death and disability in these countries and draws lessons from recent analytical work on the cost-effectiveness of interventions to address this disease burden. Four essential messages emerge:

- 1 Life expectancies worldwide improved dramatically from 1960 to 2002, with the largest increases being in low- and middle-income countries.
- 2 Improvements in immunization coverage, access to basic education, and spread of low-cost but powerful medical technologies—rather than income growth—appear to have been the primary causes of the gains in life expectancy.
- 3 The decline in childhood infectious disease burden has been partially offset by a dramatic, age-related increase in the incidence of HIV/AIDS and of chronic, noncommunicable diseases (cardiovascular disease, stroke, diabetes, cancer, psychiatric disorders), especially in low- and middle-income countries.
- 4 Cost-effective interventions can—if selected carefully and adopted widely—address the challenges of lowering under-5 and maternal mortality, and the burden of noncommunicable diseases.

Interventions that in appropriate circumstances can cost less (sometimes much less) than US\$100 per disability-adjusted life year (DALY) include:

- ◆ improving care of children <28 days old
- ◆ expanded immunization coverage with standard child vaccines
- ◆ adding vaccines against additional diseases to the standard child immunization program (particularly *Haemophilus influenzae* B, hepatitis B)
- ◆ switching to use of combination drugs against malaria (when resistant to previous standard treatments)
- ◆ some measures to prevent and treat HIV/AIDS
- ◆ taxing tobacco products
- ◆ treating acute myocardial infarction with an inexpensive set of drugs
- ◆ detecting and treating cervical cancer
- ◆ operating a basic surgical ward at the district hospital level that focuses on trauma, high-risk pregnancy, and other common surgically treatable conditions

Introduction

For low- and middle-income countries, where nearly four in five people on the planet live, the latter half of the 20th century was characterized by two important changes. First, life expectancies increased rapidly, largely because of wider use of childhood immunization and access to basic education, and diffusion of medical technologies led to declines in the prevalence of infectious diseases. Second, the incidence of noncommunicable diseases, such as cardiovascular disease, diabetes, and cancer, also rose sharply. Although population ageing is the main reason for that increase, adverse changes in lifestyle and other risk factors are also occurring, and this new wave of diseases is poised to hit low- and middle-income countries especially hard.

This chapter describes the changes in life expectancy and disease burden during the past two decades, the major health challenges at the beginning of the 21st century, and the most promising interventions to address these challenges.

Changes in life expectancy: trends and causes

Increasing life expectancies during the latter half of the 20th century marked a significant improvement in living standards for populations around the world (Table 3.1.1). Life expectancies in low- and middle-income countries increased by an average of 6.3 years per decade between 1960 and 1990 and at a slower pace of

Table 3.1.1 Levels and changes in life expectancy by World Bank region, 1960–2002

Region	Life expectancy (years)			Rate of change (years per decade)	
	1960	1990	2002	1960–90	1990–2002
Low- and middle-income countries	44	63	65	6.3	1.7
East Asia and the Pacific	39	67	70	9.3	2.5
(China)	(36)	(69)	(71)	(11)	(1.7)
Europe and Central Asia	–	69	69	–	0.0
Latin America and the Caribbean	56	68	71	4.0	2.5
Middle East and North Africa	47	64	69	5.7	4.2
South Asia	44	58	63	4.7	4.2
(India)	(44)	(59)	(64)	(5)	(4.6)
Sub-Saharan Africa	40	50	46	3.3	–3.3
High-income countries	69	76	78	2.3	1.7
World	50	65	67	5.0	1.7

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– = not available.

Note: Entries are the average of male and female life expectancies.

1.7 years in the century's final decade. Only in sub-Saharan Africa did life expectancy not increase at all, largely because of the HIV/AIDS epidemic.

Despite huge global improvements, many low- and middle-income countries have not shared in the gains, or have even fallen behind, and their citizens' poor health has impeded economic growth. Whereas income inequality between and within countries has increased, cross-country differences in life expectancy and overall welfare inequality have decreased markedly since 1950.

Income inequality explains the remaining health inequalities only partly. Dramatic improvements in health were achieved without significant income growth in Europe in the late 19th and early 20th centuries, and in Bangladesh, China, Costa Rica, Cuba, Sri Lanka, and the state of Kerala in India more recently. The rate of diffusion of knowledge about better interventions, and the willingness and ability to act on that new information, may determine the pace of a country's health improvement much more than its level of income.

Economic benefits of health

Better evidence is emerging on the economic consequences of good health, for both individuals and nations. Health has been found to be associated with greater individual productivity and living standards. Countries that have high levels of health but low levels of income tend to experience relatively faster economic growth. The initial health of a population has been identified as one of the most potent drivers of economic growth—among such well-established influences as the initial level of income per capita, geographical location, institutional environment, economic policy, initial level of education, and investments in education. An additional year of life

expectancy has been associated with a roughly 4% increase in gross domestic product (GDP) per capita in the long run.

Conversely, health declines can precipitate downward spirals, setting off impoverishment and further ill health. For example, the effect of HIV/AIDS on per capita GDP could prove devastating. Human capital is wasted as prime-age workers die. A high-mortality environment deters the next generation from investing in education and creating human capital. Orphan children may be forced to work to survive and may not get the education they need. Savings rates are likely to fall, and retirement becomes less feasible. A foreign company is less likely to invest in a country with a high HIV prevalence rate because of the threat to the firm's own workers, the prospect of high labour turnover, and the potential loss of workers trained by the firm.

Major causes of death and disease

In this section, we discuss causes of death and disease burden measured in DALYs (see Box 3.1.1) in two age categories: children under the age of 5 who succumb to neonatal conditions, measles, malaria, diarrhoeal disease, HIV/AIDS, and respiratory infections; and adults whose deaths are due to chronic, noncommunicable conditions, including cardiovascular disease, stroke, diabetes, cancer, and psychiatric disorders.

Child mortality

From 1960 to 2002, the rate of under-5 mortality around the world steadily declined, largely because of expanded childhood immunization coverage, improved water and sanitation, and wider provision of medical treatment, such as antibiotics for respiratory infections. From 1990 to 2001, however, the under-5 mortality rate increased or remained stagnant in 23 countries. In another 53 countries (including China), the decline in under-5 mortality was less than half the 4.3% per year required to reach the fourth Millennium Development Goal of reducing under-5 mortality by two-thirds in the period 1990–2005. Progress has been slow in sub-Saharan Africa because of HIV/AIDS and, until very recently, the increasing prevalence of malaria, which is now widely resistant to the first-line drugs chloroquine and sulphadoxine-pyrimethamine.

Every year, an estimated 4 million babies die in their first month, accounting for 38% of all deaths among children under 5. Causes of death include infections (neonatal sepsis, pneumonia, diarrhoea, and tetanus, 36%), complications due to preterm birth (27%) and asphyxia (23%) (Table 3.1.2). Saving most of these babies does not require intensive care. Sri Lanka, to take one low-income country as an example, has lowered its neonatal mortality rate to 15 per 1000, less than one-third of the rates typical in sub-Saharan

Box 3.1.1 Measuring disease burden: DALYs

One challenge in measuring the burden of disease is aggregating disease morbidity and mortality in a single metric. Disability-adjusted life years (DALYs) have come into wide use by researchers and international organizations. One DALY represents a year of potential life lost to premature death or a year of less-than-full health. DALYs are the principal metrics used in the measurement of the global burden of disease; see 'Further reading' section.

Table 3.1.2 Estimated causes of under-5 mortality worldwide, 2001 (in thousands)

Cause	Total	0–4 years	Neonatal (0–27 days)	Stillbirths
HIV/AIDS	340	340		
Diarrhoeal disease	1600	1600	116	
Measles	557	557		
Tetanus	187	187	187	
Malaria	1087	1087		
Respiratory infection and sepsis	1945	1945	1013	
Low birth weight	1301	1301	1098	
Birth asphyxia and birth trauma	739	739	739	
Congenital anomalies	439	439	321	
Injuries	310	310		
Other	5375	2101	446	3274
Total	13 874	10 600	3 900	3 274

Notes: 1. Of the estimated 13.9 million under-5 deaths in 2001, only 0.9% occurred in high-income countries. Thus the cause distribution of deaths in this table is essentially that of low- and middle-income countries.

2. 'Stillbirths' are defined as fetal loss in the third trimester of pregnancy. The total column includes stillbirths among under-5 deaths. About 33% of stillbirths occur after labour has begun—so-called intrapartum stillbirths. No good estimates exist for stillbirths by cause, but since some of the cause categories (e.g. birth asphyxia, birth trauma, congenital anomalies) are the same as for ages 0–4, some deaths categorized as 'other' will be distributed among the existing categories when estimates become available.

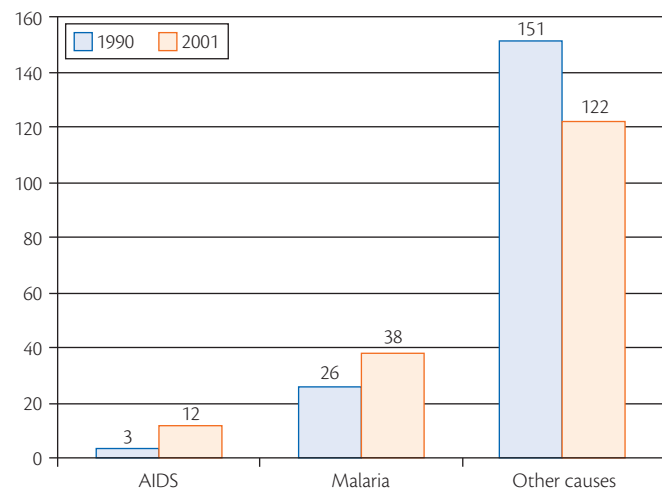
Data from Bryce J, et al. (2005). WHO estimates of the causes of death in children. *Lancet*, 365, 1147–52; Jamison DT, et al. (eds) (2006). *Priorities in health*. World Bank, Washington, DC; Mathers CD, Murray CJL, Lopez AD (2006). The burden of disease and mortality by condition: data, methods and results for the year 2001. In: Lopez AD, et al. (eds) *Global burden of disease and risk factors*. Oxford University Press, Oxford and New York.

Africa, without intensive care. Similar approaches would address the neglected global burden of over 3.2 million stillbirths each year.

Between 1990 and 2002, there were declining trends in deaths from acute respiratory infections (from 2.5 million to 1.9 million), diarrhoeal disease (from 2.4 million to 1.6 million), measles (from 0.8 million to 0.5 million), and injuries (from 0.6 million to 0.3 million). These improvements were partially offset by increases in under-5 mortality from malaria and HIV/AIDS (Fig. 3.1.1). From 1990 to 2001, child deaths due to malaria doubled from 5% to 10% worldwide and increased from 15% to 22% in sub-Saharan Africa, where few effective antimalarials are available.

Adult mortality

Ageing populations and changing lifestyles across the globe contribute to noncommunicable diseases that are imposing tremendous burdens. In 2001, cardiovascular disease, cancer, chronic respiratory illness, diabetes, and psychiatric conditions accounted for two-thirds of deaths in over-5 (see Table 3.1.3). Cardiovascular disease (including stroke) in low- and middle-income countries killed more than twice as many people in 2001 as did AIDS, malaria, and tuberculosis combined. In 2001, about 11.1 million people over the age of 5 in low and middle-income countries died of cardiovascular disease (including stroke), 4.9 million died of cancer,

**Fig. 3.1.1** Under-5 deaths from AIDS, malaria, and other causes per 1000 births in sub-Saharan Africa, 1990 and 2001.

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2.4 million died of chronic respiratory disease, and 0.7 million died of diabetes—altogether, 25.2 million of the total 38 million deaths in over-5s in developing countries that year (Table 3.1.3). Deaths from ischaemic heart disease and stroke are expected to triple in sub-Saharan Africa, Latin America, the Middle East, and North Africa.

The largest increase in noncommunicable diseases is predicted to occur in low- and middle-income countries, which continue to suffer the burden of communicable diseases like malaria, tuberculosis, and HIV/AIDS. This 'double burden' is reversing many of the gains from expanded immunization and clean water and sanitation. Noncommunicable conditions, generally chronic, are overwhelming fragile health systems that are struggling with short-duration morbidities imposed by communicable diseases.

In high-income countries, the likelihood of dying from a chronic disease has declined dramatically. Among men over 30 in the developed world, for example, death rates from heart disease dropped by more than 50% between 1970 and 2005, from 600 to 300 per 100 000 to 200 to 300 per 100 000. The death rate for Brazilian men was 300 per 100 000 in 1980 (compared with 500–600 in high-income countries) but has remained unchanged since. The World Bank predicts that chronic conditions will be the leading cause of death in low-income countries by 2015.

Cardiovascular diseases are responsible for 17 million deaths worldwide each year. Of these, 13 million deaths are in low- and middle-income countries and represent more than a quarter of all deaths in these countries. Most cardiovascular deaths result from ischaemic heart disease (5.7 million) or cerebrovascular disease (4.6 million). Because such deaths occur at older ages, they are a smaller fraction of the total disease burden in DALYs—12.9%.

Tobacco use accounts for a substantial and avoidable fraction of cardiovascular disease and cancers. In 2000, the number of tobacco-related deaths in developing countries about equalled the number in high-income countries; by 2030, developing countries may have more than twice as many. Controlling smoking is a crucial element of any nation's strategy for preventing cardiovascular

Table 3.1.3 Causes of death in low- and middle-income countries, age 5 and older

	Deaths (in millions)	Percentage of total (%)
Communicable, maternal, perinatal, and nutritional conditions		
TB	1.5	4.0
AIDS	2.2	5.8
Respiratory infections	1.5	4.0
Maternal conditions	0.5	1.3
Other	2.5	6.6
Subtotal	8.2	21.7
Noncommunicable disease		
Cancers	4.9	13.0
Diabetes	0.7	1.9
Ischaemic and hypertensive heart disease	6.5	17.2
Stroke	4.6	12.2
Chronic obstructive pulmonary disease	2.4	6.3
Other	6.1	16.1
Subtotal	25.2	66.7
Injuries		
Road traffic accidents	1.0	2.6
Suicides	0.7	1.9
Other	2.7	7.1
Subtotal	4.4	11.6
Total	37.8	100

Data aggregated from Mathers CD, Murray CJL, Lopez AD (2006). The burden of disease and mortality by condition: data, methods and results for the year 2001. In: Lopez AD, et al. (eds) *Global burden of disease and risk factors*. Oxford University Press, Oxford and New York.

disease and promoting health more generally. Preventing the initiation of smoking is important because addiction to nicotine makes stopping smoking very difficult, even for those who want to quit. However, far more lives could be saved between now and 2050 by helping current smokers to quit. Reducing smoking levels is well within the control of public policy. Taxation is the principal proven instrument, but complementary measures such as bans on smoking in public places and tobacco advertising are also important.

The main risk factors for cardiovascular disease, such as high blood pressure, high cholesterol, smoking, obesity, excessive alcohol use, physical inactivity and poor diet account for very large fractions of the deaths (and even more of the burden) from ischaemic heart disease (collectively accounting for 78% of deaths in low- and middle-income countries) and stroke (61%). Measures to reduce the levels of those risk factors are the goals for prevention. Unlike the favourable experience with controlling tobacco use, attempts to change behaviour leading to obesity, hypertension, and high cholesterol appear to have had little success at a population level. However, many promising approaches remain to be tried. Common sense suggests that they should be initiated even while efforts to develop and evaluate behaviour-change packages are ramped up.

If sustained behaviour change proves difficult to achieve, medications have the potential to reduce cardiovascular disease risks by 50% or more. Pharmaceutical interventions to manage two major factors, hypertension and high cholesterol, are well established and are highly cost-effective for people at high risk of a stroke or heart attack. The low cost and high effectiveness of drugs to prevent the recurrence of a cardiovascular event have made their long-term use potentially cost-effective in low-income environments.

Lifelong medication for cardiovascular disease, however, like medication for psychiatric disorders, requires not only low-cost drugs but also health care personnel and systems that can perform reliably at all levels and be accessible to patients. Thus vertical programmes that sidestep the inherent weaknesses of health care systems are not really an option for dealing with chronic diseases. Since 1992, work by Feachem and others has indicated treatment and prevention approaches that could be adapted to developing countries with budget constraints.

From a patient's perspective, unfamiliarity with the risk factors for chronic diseases and lack of experience in dealing with heart disease or cancer are particularly important. The economic impact of chronic diseases is likely to be even more pronounced than that of communicable diseases, since they typically disable and kill adults of working age. Low-cost but effective approaches to long-term management of chronic conditions need to be developed and implemented.

Neurological and psychiatric disorders lead to only about 1.4% of deaths in low- and middle-income countries (1.8% in high-income countries), but they cause suffering and disability far beyond what the mortality numbers suggest. About 10% of the disease burden in DALYs in low- and middle-income countries results from these conditions, much of it attributable to three major psychiatric diseases: unipolar major depression (3.1% of DALYs), bipolar disorder (0.6%), and schizophrenia (0.8%).

Setting disease control priorities

Recent work in health has focused on identifying cost-effective interventions that policy makers are currently ignoring or underfunding, as well as investments that are now prevalent but not cost-effective. Setting priorities rationally makes limited resources go further. Without demonstrably improved efficiency in health spending, aid agencies and development partners may be less willing to pay for expansions of health programmes. Improving efficiency does not, however, reduce the importance of increasing resources for implementing these interventions and meeting broader objectives, such as the Millennium Development Goals. These objectives are complementary.

The Disease Control Priorities Project (DCPP), a joint effort of the Fogarty International Center of the United States National Institutes of Health, the World Health Organization, and the World Bank (and with substantial funding from the Bill & Melinda Gates Foundation) has analysed the cost-effectiveness of a wide range of population-based and personal health interventions. The project was launched in 2001 to identify policy changes and intervention strategies for the health problems of countries in need. It follows on from the first edition of *Disease Control Priorities in Developing Countries* (1993) and the World Bank's 1993 World Development Report, *Investing in Health*, which attempted to make global comparisons of interventions to improve health in developing countries.

Here we present results from the DCPD on the most cost-effective interventions to improve health in low- and middle-income countries. Cost-effectiveness is presented as US\$/DALY averted, a metric that combines years of life lived with disability and years lost to premature death (see Box 3.1.1). Cost-effectiveness is only one consideration in allocating resources to specific diseases and interventions; epidemiological, medical, political, ethical, cultural, equity, and budgetary factors also matter. Interpreting the cost-effectiveness ratio as the 'price' of equivalent units of health using different interventions is a useful approach to deploying cost-effectiveness information alongside the other considerations in setting priorities. Cost-effectiveness information makes policy makers aware of differences in the price of improving health, using different interventions. All else being equal, those with a high price should be used less, whereas those with a low price should be used more.

Lowering under-5 mortality

Table 3.1.4 lists the most cost-effective interventions to reduce under-5 mortality and to prevent and treat HIV/AIDS and non-communicable diseases. Here we discuss interventions to lower under-5 mortality in detail.

Mortality of neonates and children under 5 can be greatly reduced with affordable interventions of proven effectiveness. Improvements can come from increasing coverage of preventive measures, such as breastfeeding, and expanding childhood vaccination programs beyond the traditional six antigens, in places where immunization coverage is already high and where new antigens, particularly pneumococcal and *Haemophilus influenzae* type B (Hib) vaccines, address diseases of significant burden. Implementation and increased coverage of interventions for acute respiratory infections, malaria, and diarrhoea should reduce the annual 6 million preventable deaths in this age group.

Adding essential care for newborn babies (warmth, cleanliness, and immediate breastfeeding), neonatal resuscitation, facility-based care of preterm babies and emergency care of ill neonates to the standard maternal and child health package has proved highly cost-effective in India (\$11–265 per year of life saved, or \$24–585 per DALY averted) and sub-Saharan Africa (\$25–360 per year of life saved, or \$46–657 per DALY averted); however, these interventions require a high initial investment. Addition of community-based interventions—promoting healthy behaviours, such as breastfeeding, providing extra care of moderately small babies at home through cleanliness, warmth, and exclusive breastfeeding, plus management of acute respiratory infections—to the maternal and child health package is likely to be highly cost-effective. A year of life saved could cost as little as \$100 to \$257 in India (\$221–568 per DALY averted) and \$100 to \$270 in sub-Saharan Africa (\$183–493).

Community-based approaches are now feasible in virtually all countries. If a midwife is available, resuscitation of newborns with a \$5 self-inflating bag could save lives at low cost in low- and middle-income countries. Provision of two tetanus toxoid immunizations to all pregnant women could avert more than 150 000 neonatal deaths every year. Improvement of maternal- and child-health services delivered through a combination of family-level and community-level care, outreach, and clinical care would increase the survival rates of newborn and older children and reduce stillbirths and maternal deaths.

Childhood vaccinations, long recognized as among the most cost-effective uses of resources, prevented more than 3 million

deaths worldwide in 2001. National immunization programs include vaccines against diphtheria, pertussis, and tetanus (DPT); tuberculosis; poliomyelitis; and measles at a cost of \$13 to \$24 per fully immunized child, depending on coverage levels and delivery strategy (health-facility based, special campaigns like national immunization days, or mobile team outreach). The estimated cost per death averted varies from less than \$275 (\$10 per DALY averted) in sub-Saharan Africa and South Asia to \$1754 (\$20 per DALY averted) in Europe and central Asia. The variation is largely attributable to differences in the underlying prevalence of disease. These same factors also affect the cost-effectiveness of scaling up coverage with the traditional Expanded Program on Immunization (EPI) vaccines. The cost per death averted varies by region, from \$162 in sub-Saharan Africa to more than \$1600 in Eastern Europe. Costs are less than \$20 per DALY averted in all regions other than Europe and central Asia. Cost-effectiveness of the tetanus toxoid vaccine also varies widely, from less than \$400 per death averted (\$14 per DALY averted) in sub-Saharan Africa and South Asia to more than \$190 000 (\$15 000 per DALY averted) in Europe and central Asia.

Including a second measles vaccination through routine immunizations or special campaigns costs \$23 to \$228 per death averted and less than \$4 per DALY averted in developing regions other than Europe and central Asia. New vaccines cost more per dose and are less cost-effective than the current EPI vaccines but might be worthwhile in regions of high disease prevalence. The pentavalent vaccine (DPT plus hepatitis B and Hib) has an estimated cost of \$1433 to \$40 000 per death averted and a cost-effectiveness of \$42 per DALY averted in sub-Saharan Africa, and more than \$245 elsewhere. Addition of a yellow fever vaccine costs between \$834 per death averted (\$26 per DALY averted) in sub-Saharan Africa and \$2810 (\$39) in Latin America and the Caribbean.

Multivalent pneumococcal conjugate vaccines could reduce the incidence of invasive pneumococcal disease while lowering antibiotic use and the likelihood of drug resistance. At \$50 per dose, however, these vaccines are unaffordable to most people in low- and middle-income countries. After confirmation of efficacy and subsequent licensing, new vaccines that protect against rotavirus, malaria, human papillomavirus (associated with cervical cancer), and dengue could be included in the EPI schedule.

Although more demanding of health system capacity than vaccination, patient treatment is also an efficient use of resources. Management in the community and at a health care facility might be comparably cost-effective, but community-based strategies hold promise for more rapid coverage. Treatment of nonsevere pneumonia at facilities with oral antimicrobials and paracetamol (\$24–424 per DALY averted) is slightly more cost-effective than similar treatment administered at home by a health care worker (\$139–733). Treatment of severe pneumonia in a hospital is more expensive (\$1486–14 719).

Of the interventions for diarrhoeal disease during the first year of life, breastfeeding promotion programmes (\$527–2001 per DALY averted), measles immunization (\$257–4565), and oral rehydration therapy (as low as \$132, for a cost per child of \$0.70) are more cost-effective than immunizations for rotavirus (\$1402–8357) or cholera (\$1658–8274). Lower prices and improved logistics for recently licensed rotavirus vaccines could make this intervention substantially more attractive. Because great reductions in mortality from this condition have already been achieved, the average case

Table 3.1.4 Cost-effectiveness of interventions to reduce under-5 mortality and to prevent and treat HIV/AIDS and noncommunicable diseases

Service or intervention	Cost per DALY (US\$)	Estimated DALYs averted per million US\$ spent
<i>Reducing under-5 mortality</i>		
Improving care of children under 28 days old (including resuscitation of newborns)	10–400	2500–100 000
Expanding immunization coverage with standard childhood vaccines	2–20	50 000–500 000
Adding vaccines against additional diseases to the standard child immunization programme (particularly Hib and HepB)	40–250	4000–24 000
Switching to the use of combination drugs (ACTs) against malaria where resistance exists to current inexpensive and previously highly effective drugs (sub-Saharan Africa)	8–20	50 000–125 000
<i>Preventing and treating HIV/AIDS</i>		
Preventing mother-to-child transmission (antiretroviral-nevirapine prophylaxis of the mother; breastfeeding substitutes)	50–200	5000–20 000
Treating STIs to interrupt HIV transmission	10–100	10 000–100 000
Using antiretroviral therapy that achieves high adherence for a large percentage of patients	350–500	2000–3000
Using antiretroviral therapy that achieves high adherence for only a small percentage of patients		Because of very limited gains by individual patients and the potential for adverse changes in population behaviour, it is possible that more life years would be lost than saved.
<i>Preventing and treating noncommunicable disease</i>		
Taxing tobacco products	3–50	24 000–330 000
Treating AMI (heart attacks) with an inexpensive set of drugs	10–25	40 000–100 000
Treating AMI with inexpensive drugs plus streptokinase (costs and DALYs for this intervention are in addition to what would have occurred with inexpensive drugs only)	600–750	1300–1600
Treating heart attack and stroke survivors for life with a daily polypill combining four or five off-patent preventive medications	700–1000	1000–1400
Performing coronary artery bypass grafting (bypass surgery) in specific identifiable high-risk cases—for example, disease of the left main coronary artery (incremental to treatment with polypill)	>25 000	<40
Using bypass surgery for less severe coronary artery disease (incremental to treatment with polypill)	Very high	Very small
<i>Other</i>		
Detecting and treating cervical cancer	15–50	20 000–60 000
Operating a basic surgical ward at the district hospital level that focuses on trauma, high-risk pregnancy, and other common surgically treatable conditions	70–250	4000–15 000

AMI; acute myocardial infarction.

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fatality rate from diarrhoea is now much lower than before oral rehydration therapy was introduced. Where none of these interventions has been adopted, diarrhoeal disease is still a major killer, and oral rehydration therapy and other measures are more cost-effective in preventing deaths even if diarrhoea incidence is unchanged. The situation is parallel with that for immunization: cost-effectiveness might look poor because of gains already achieved, but both continued and expanded coverage are needed. Similarly, improvements in water and sanitation (\$1118–14901 per DALY averted from diarrhoea) are less cost-effective where access to these amenities is adequate and other interventions against diarrhoea exist. In areas with little access to water and sanitation, however, improvements

can be highly cost-effective because they reduce incidence of illness (\$94 per DALY averted for installation of hand pumps and \$270 per DALY averted for provision and promotion of basic sanitation facilities).

Conclusions

The 20th century has seen enormous gains in human health, but important challenges remain. The double epidemiological burden of communicable diseases (including HIV/AIDS) plus noncommunicable diseases is the most daunting. Existing cost-effective interventions need to be adopted on a wider scale. For communicable

diseases, interventions that have been highly cost-effective in the past remain so despite emerging infections and drug resistance. Noncommunicable diseases, including ischaemic heart disease and stroke, can be prevented, importantly by comprehensive antismoking programmes, and managed effectively in low-income countries at a reasonable cost. Many interventions first developed in the industrialized world are now available in the developing world, but health care systems in low- and middle-income countries must first recognize the importance of the conditions. For health programmes to succeed, policy makers must have access to the best possible research and analysis to ensure that their investments in prevention and treatment save as many lives as possible.

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