



Advancement of global health: key messages from the Disease Control Priorities Project

Ramanan Laxminarayan, Anne J Mills, Joel G Breman, Anthony R Measham, George Alleyne, Mariam Claeson, Prabhat Jha, Philip Musgrove, Jeffrey Chow, Sonbol Shahid-Salles, Dean T Jamison

The Disease Control Priorities Project (DCPP), a joint project of the Fogarty International Center of the US National Institutes of Health, the WHO, and The World Bank, was launched in 2001 to identify policy changes and intervention strategies for the health problems of low-income and middle-income countries. Nearly 500 experts worldwide compiled and reviewed the scientific research on a broad range of diseases and conditions, the results of which are published this week. A major product of DCPP, *Disease Control Priorities in Developing Countries*, 2nd edition (DCP2), focuses on the assessment of the cost-effectiveness of health-improving strategies (or interventions) for the conditions responsible for the greatest burden of disease. DCP2 also examines crosscutting issues crucial to the delivery of quality health services, including the organisation, financial support, and capacity of health systems. Here, we summarise the key messages of the project.

Rapid declines in mortality rates and overall improvement in health are among the least recognised advances of the second half of the 20th century. Life expectancy increased by an average of 6·3 years per decade worldwide between 1960 and 1990, albeit more slowly since then. Furthermore, cross-country differences in life expectancy have fallen greatly since 1950, although income inequality between and within countries has risen. Overall, if one properly accounts for convergence across countries in health conditions, global inequalities are falling.^{1,2}

Despite huge overall global improvements in health, many low-income and middle-income countries have not shared in the gains or have fallen further behind high-income countries. As well as affecting wellbeing, poor health impedes economic growth and poverty reduction. From 1990 to 2001 the mortality rate of those aged 5 years or younger increased or remained constant in 23 countries. In another 53 countries (including China), the fall in mortality in this age group was less than half the 4·3% per year required to reach the fourth Millennium Development Goal of reducing mortality in those younger than 5 years by two thirds by 2015.

Income inequality is only one reason for health inequality. The experiences of European countries in the late 19th and early 20th centuries³ and, more recently, of Bangladesh, China, Costa Rica, Cuba, Sri Lanka, and the Kerala state of India, among many others, indicate that improvements in health can arise without high or rapidly growing incomes and that the correct policies can greatly reduce mortality. Globalisation has helped to diffuse knowledge about the best interventions and methods for their delivery. Both experience and the results of analytical work suggest that the pace of such dissemination into a country, and the willingness and ability of those who live there to act on the information, governs the pace of health improvement much more than level of income does.^{4,5}

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Gates Foundation), was launched in 2001 to identify policy changes and intervention strategies for the health problems of countries in need.⁶⁻⁸ The project follows on from the first edition of the *Disease Control Priorities in Developing Countries*⁹ and the World Bank's 1993 Development Report,¹⁰ which attempted to make global comparisons of interventions to improve health in developing countries.

The aim of DCPP was to generate knowledge to assist decision makers in developing countries—especially those in the public sector—to realise the potential of affordable, effective interventions to rapidly improve the health and welfare of their populations. The main product of DCPP is a second, much expanded and updated revision of *Disease Control Priorities in Developing Countries*. The *Disease Control Priorities in Developing Countries*, 2nd edition (DCP2), has 73 wide-ranging chapters, compiled by almost 500 experts, covering disease conditions, their burdens and risk factors, intervention effectiveness and cost-effectiveness, health systems, and financing. Table 1 provides comparative disease burdens in low-income, middle-income, and high-income countries, and worldwide of major diseases. Here, we summarise the key messages about intervention priorities (table 2) and, to a lesser extent, those about health systems (panel 1), development assistance for health (panel 2), and research and product development priorities (panel 3).

Additionally, DCPP has resulted in an updated assessment of the global burden of disease and risk factors,⁷ a review of documented successes at improving population health,¹¹ and many other publications^{12,13} and working papers, including a major review of malaria's consequences.¹⁴

Intervention priorities

DCP2 identifies highly cost-effective opportunities to improve health that policymakers are ignoring or underfunding and details prevalent investments that are not cost effective. The perspective taken is that of allocation of public finances to meet social goals of improving population health and reducing financial risks

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Resources for the Future,

1616 P Street NW Suite 600,

Washington, DC 20036, USA

(R Laxminarayan PhD,

J Chow MEM); London School of

Hygiene and Tropical Medicine,

London, UK (Prof A J Mills PhD);

Fogarty International Center,

National Institutes of Health,

Bethesda, MD, USA

(J G Breman MD,

A R Measham MD,

P Musgrove PhD,

S Shahid-Salles MPH,

Prof D T Jamison PhD); Pan

American Health Organization,

Washington, DC, USA

(Sir G Alleyne MD); World Bank,

Washington, DC, USA

(M Claeson MD); Public Health

Sciences, University of Toronto,

and Centre for Global Health

Research, St Michael's Hospital,

McLaughlin Centre for

Molecular Medicine, Toronto,

Ontario, Canada (P Jha MD);

Global Health, Health Affairs,

Bethesda, MD, USA

(P Musgrove PhD); and

Population Reference Bureau,

Washington, DC, USA

(S Shahid-Salles MPH)

Correspondence to:

Dr Ramanan Laxminarayan

ramanan@rff.org

	Low-income and middle-income countries		High-income countries		Worldwide	
	DALY* (n=1 387 426)	DALY _{sa} † (n=1 260 643)	DALY* (n=149 161)	DALY _{sa} † (n=148 316)	DALY* (n=1 536 587)	DALY _{sa} † (n=1 412 600)
Communicable diseases, pregnancy outcomes, and nutritional deficiencies						
Total	39.8	33.6	5.7	5.4	36.5	30.5
Infections and parasitic diseases	23.1	21	2.3	2.2	21.1	18.9
Tuberculosis	2.6	2.8	0.1	0.1	2.3	2.5
Sexually transmitted infections (not HIV)	0.7	0.7	0.1	0.1	0.6	0.6
HIV/AIDS	5.1	5.3	0.4	0.4	4.7	4.8
Diarrhoeal diseases	4.2	2.6	0.3	0.3	3.9	2.6
Childhood diseases	3.1	2.4	0.1	0.1	2.8	2.4
Pertussis	0.8	0.7	0.1	0.1	0.8	0.6
Poliomyelitis	0	0	0	0	0	0
Diphtheria	0	0	0	0	0	0
Measles	1.7	1.5	0	0	1.5	1.4
Tetanus	0.6	0.5	0	0	0.5	0.4
Meningitis	0.4	0.4	0.1	0.1	0.4	0.3
Malaria	2.9	2.1	0	0	2.6	1.8
Other	4.1	4.2	1.1	1.1	3.8	4.2
Respiratory infections	6.3	4.6	1.7	1.7	5.8	4.3
Maternal conditions	1.9	2.1	0.3	0.3	1.7	1.9
Perinatal conditions	6.4	3.7	0.9	0.6	5.9	3.4
Low birthweight	3.1	1.4	0.3	0.2	2.8	1.5
Birth asphyxia and birth trauma	2.3	1.5	0.4	0.4	2.1	1.4
Other perinatal conditions	1.1	0.6	0.3	0.3	1	0.5
Nutritional deficiencies	2.1	2.2	0.6	0.6	2	2
Non-communicable conditions						
Total	48.9	52.4	86.7	87.2	52.6	56.4
Malignant neoplasms	5.4	5.9	17.4	17.4	6.6	7.1
Diabetes mellitus	1.1	1.3	2.8	2.8	1.3	1.4
Neuropsychiatric disorders	9.9	10.8	20.9	21	11	11.9
Unipolar major depression	3.1	3.4	5.6	5.7	3.4	3.7
Bipolar disorder	0.6	0.7	0.7	0.7	0.6	0.7
Schizophrenia	0.8	0.8	0.7	0.8	0.8	0.8
Other	5.4	5.9	13.8	13.9	6.2	6.7
Cardiovascular disease	12.9	14.2	20	20.1	13.6	14.7
Ischaemic heart disease	5.2	5.7	8.3	8.4	5.5	6
Cerebrovascular disease	4.5	5	6.3	6.3	4.7	5.1
Other	3.2	3.5	5.4	5.5	3.4	3.7
Respiratory diseases	4.2	4.5	6.6	6.6	4.4	4.7
Digestive diseases	3.8	4	4.4	4.4	3.8	4.1
Congenital anomalies	1.7	1.3	1	0.8	1.6	1.3
Other	9.9	10.9	13.7	13.8	10.3	11.2
Injuries						
Total	11.2	12.1	7.5	7.5	10.9	11.6
Unintentional	8.2	8.8	5.3	5.3	7.9	8.4
Road traffic accidents	2.3	2.5	2	2	2.3	2.5
Other	5.9	6.3	3.2	3.3	5.6	6.1
Intentional	3.1	3.4	2.3	2.3	3	3.2
Self-inflicted	1.3	1.4	1.7	1.7	1.3	1.4
Other	1.8	2	0.5	0.5	1.7	1.8

Data are %.* DALY calculated at 3% per year discount rate with no age-weights. † DALY_{sa} analogous to DALY except that it includes stillbirths in estimates of burden and assumes a gradual acquisition of life potential that allows burden associated with a death near the time of birth to grow gradually with age rather than instantaneously increasing from 0 to a high value at birth or some earlier time.

Table 1: Burden of disease in low-income and middle-income countries, high-income countries, and worldwide, 2001⁷

	Cost per DALY averted (\$)*	Thousands of DALYs averted*† per 20% increase in coverage	Burden of target diseases (millions of DALYs)*
Neglected low-cost opportunities in south Asia			
Childhood immunisation			
Increased coverage of traditional EPI programme	8	Not assessed	28.4
HIV/AIDS			
Voluntary counselling and testing	9–126	Not assessed	7.4
Peer-based programmes for at-risk groups (eg, commercial sex workers) to disseminate information, services (clean needles and condoms), and teach specific skills			
School-based interventions to disseminate information			
Prevention of mother-to-child transmission with antiretroviral therapy			
Surgical services and emergency care			
Surgical ward in district hospital, primarily for obstetrics, trauma, and injury	6–212	≥1.8	48.0–146.3
Staffed community ambulance			
Training of lay first-responders and volunteer paramedics			
Tuberculosis			
Childhood vaccination against endemic disease	8–263	Not assessed	13.9
Directly observed short-course chemotherapy			
Isoniazid treatment of epidemic disease			
Management of drug resistance			
Lower acute respiratory illnesses of children younger than age 5 years			
Community-based or facility-based case management of non-severe cases	28–264	0.7–1.8	9.7–26.4
Case management package, including community-based and facility-based care for non-severe cases and hospital-based care for severe cases			
Cardiovascular diseases			
Management of acute myocardial infarction with aspirin and β blocker	9–304	≥0.1	25.9–39.1
Primary prevention of coronary artery disease with legislation, substituting 2% of trans fat with polyunsaturated fat, at \$0.50 per adult			
Secondary prevention of congestive heart failure with ACE inhibitors and β blockers incremental to diuretics			
Secondary prevention of myocardial infarction and stroke with polypill, containing aspirin, β blocker, thiazide diuretic, ACE inhibitor, and statin			
Tobacco use and addiction			
Tax policy to increase price of cigarettes by 33%	14–374	≥2.5	15.7
Advertising bans, health information dissemination, tobacco supply reductions, and smoking restrictions			
Nicotine replacement therapy			
Maternal and neonatal care			
Increased primary-care coverage	127–394	≥1.3	37.7–47.8
Improved quality of comprehensive emergency obstetric care			
Improved overall quality and coverage of care			
Neonatal packages targeted at families, communities, and clinics			
Neglected low-cost opportunities in sub-Saharan Africa			
Childhood immunisation			
Second opportunity measles vaccination‡	1–5	Not assessed	Not assessed
Increased coverage of traditional EPI programme			
Traffic accidents			
Increased speeding penalties, and media and law enforcement	2–12	Not assessed	6.4
Speed bumps at most dangerous traffic intersections			
Malaria			
Insecticide-treated bed nets‡	2–24	20.8–37.6	35.4
Residual household spraying‡			
Intermittent preventive treatment during pregnancy‡			
Surgical services and emergency care			
Surgical ward in a district hospital, primarily for obstetrics, trauma, and injury	7–215	1.6–21.2	25–134.2
Staffed community ambulance			
Training of lay first-responders and volunteer paramedics			

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Childhood illnesses			
Integrated management of childhood illnesses‡	9-218	≥1.2	9.6-45.1
Case management of non-severe lower acute respiratory illnesses at community or facility level			
Case management package, including community-based or facility-based care for non-severe cases and hospital-based care for severe lower acute respiratory illnesses			
Breastfeeding to prevent malnutrition			
Cardiovascular disease			
Management of acute myocardial infarction with aspirin and β blocker	9-273	≥0.04	4.6
Primary prevention of coronary artery disease with legislation, substituting 2% of trans fat with polyunsaturated fat, at \$0.50 per adult			
Secondary prevention of congestive heart failure with ACE inhibitors and β blockers incremental to diuretics			
Secondary prevention of myocardial infarction and stroke with polypill, containing aspirin, β blocker, thiazide diuretic, ACE inhibitor, and statin			
HIV/AIDS			
Peer-based programmes for at-risk groups (eg, commercial sex workers) to disseminate information and teach specific skills	6-377	Not assessed	56.8
Voluntary counselling and testing			
Diagnosis and treatment of sexually-transmitted diseases‡			
Condom promotion and distribution‡			
Prevention and treatment of coinfection with Mycobacterium tuberculosis‡			
Blood and needle safety programmes			
Prevention of mother-to-child transmission with antiretroviral therapy			
Maternal and neonatal care			
Increased primary-care coverage	82-409	≥2.8	29.8-37.7
Improved quality of comprehensive emergency obstetric care			
Improved overall quality and coverage of care			
Neonatal packages targeted at families, communities, and clinics			
High-cost interventions in south Asia			
Depression			
Episodic treatment with new antidepressant drug (SSRI)	1003-1449	0.4-0.8	14.6
Episodic or maintenance psychosocial treatment plus treatment with new antidepressant drug (SSRI)			
High blood pressure and cholesterol			
Primary prevention of stroke and ischaemic and hypertensive heart disease with aspirin, β blocker, and statin, incremental to policy-induced behaviour change, at 15% risk of cardiovascular disease event over 10 years	1120-1932	≥6.7	48.6
Primary prevention of stroke and ischaemic and hypertensive heart disease with a polypill, containing aspirin, β blocker, thiazide diuretic, ACE inhibitor, and statin, at 15% risk of cardiovascular disease event over 10 years			
Lifestyle diseases			
Primary prevention of diabetes, ischaemic heart disease, and stroke through policy that replaces saturated fat with monounsaturated fat in manufactured foods, accompanied by a public education campaign	1325-1865	1.3-1.8	39.5
Primary prevention of diabetes, ischaemic heart disease, and stroke through legislation that reduces salt content plus public education			
Stroke (ischaemic)			
Acute management with recombinant tissue plasminogen activator within 48 h of onset	1630-2967	0.03-0.4	2.2-9.2
Acute management with heparin within 48 h of onset			
Secondary prevention with carotid endarterectomy			
Diarrhoeal diseases			
Oral rehydration therapy if package cost is >\$2.30 per child per episode	500-6390	0.02-2.5	22.3
Rotavirus or cholera immunisation			
Tuberculosis			
Isoniazid treatment for latent endemic disease in patients uninfected with HIV	5588-9189	Not assessed	13.9
Schizophrenia and bipolar disorder			
Antipsychotic medication and psychosocial treatment for schizophrenia	1743-17702	0.02-0.12	2.2-2.9
Valproate and psychosocial treatment for bipolar disorder			
Cardiovascular diseases			
Management of acute myocardial infarction with streptokinase or tissue plasminogen activator, incremental to aspirin and β blocker	638-24040	0.04-0.3	25.9
Secondary prevention of ischaemic heart disease with statin, incremental to aspirin, β blocker, and ACE inhibitor			
Secondary prevention of ischaemic heart disease with coronary artery bypass graft			

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High-cost interventions in sub-Saharan Africa

Diarrhoeal diseases			
Oral rehydration therapy if cost per episode is >\$2-80 per child	500-1658	0-1-4-6	22
Rotavirus or cholera immunisation			
HIV/AIDS			
Home care treatment‡	673-1494	Not assessed	5-6-8
Antiretroviral therapy in populations with low adherence‡			
Traffic accidents			
Random driver breath tests	973-2146	≥0-05	6-2-6-4
Enforcement of seatbelt laws			
Child restraint promotion			
High blood pressure and cholesterol			
Primary prevention of stroke and ischaemic and hypertensive heart disease with aspirin, β blocker, and statin, incremental to policy-induced behaviour change, at 15% risk of cardiovascular disease event over 10 years	1920	Not assessed	10-6
Lifestyle diseases			
Primary prevention of diabetes, ischaemic heart disease, and stroke through policy that replaces saturated fat with monounsaturated fat in manufactured foods, accompanied by a public education campaign	1766-2356	1-4-1-8	9-6
Primary prevention of diabetes, ischaemic heart disease, and stroke through legislation that reduces salt content plus public education			
Stroke (ischaemic)			
Acute management with recombinant tissue plasminogen activator within 48 h of onset	1284-2940	0-02-0-3	0-9-3-6
Acute management with heparin within 48 h of onset			
Secondary prevention with carotid endarterectomy			
Tuberculosis			
Isoniazid treatment for latent endemic disease in patients uninfected with HIV	4129-5506	Not assessed	8-1
Cardiovascular diseases			
Management of acute myocardial infarction with streptokinase or tissue plasminogen activator, incremental to aspirin and β blocker	634-26 813	0-03-0-2	4-6
Secondary prevention of ischaemic heart disease with statin, incremental to aspirin, β blocker, and ACE inhibitor			
Secondary prevention of ischaemic heart disease with coronary artery bypass graft			

*Ranges represent variation in point estimates of cost-effectiveness, DALYs averted, or burden of disease for different interventions. Point estimates of cost-effectiveness and DALYs averted obtained from DCP2⁶ or calculated as midpoint of range estimates reported. Burden of disease estimates obtained from reference 7. †Avertable DALYs per 20% increase in treatment coverage in a hypothetical sample population of 1 million people. ‡Only assessed for sub-Saharan Africa.

Table 2: Neglected low-cost opportunities and high-cost interventions in south Asia and sub-Saharan Africa

of ill-health. Careful selection of priorities makes limited resources go further and encourages aid agencies and development partners to invest in the expansion of health programmes. Improved efficiency does not reduce the importance of increasing resources for the implementation of these interventions and meeting of broader objectives, such as the Millennium Development Goals. These objectives are complementary.

Cost-effectiveness is presented as US\$ per disability-adjusted life year (DALY) averted. DALYs combine years lived with disability and years lost to premature death in a single metric. Cost-effectiveness is only one consideration in allocating resources to specific diseases and interventions; epidemiological, medical, political, ethical, cultural, and budgetary factors also affect such decisions. Interpretation of the cost-effectiveness ratio as the price of equivalent units of health, using different interventions, is a useful approach to deploy cost-effectiveness information alongside these other considerations in setting priorities. Cost-effectiveness information makes policymakers aware of differences in the price of improving health with different interventions. Interventions with a high price

should, all else being equal, be used less, whereas those with a low price should be used to a greater extent.

The cost-effectiveness-related findings in DCP2 are subject to several caveats, and we encourage readers to note the order of magnitude of each estimate rather than the specific number. Final estimates were calculated either with cost-effectiveness numbers drawn from published work or with standardised resource costs adapted from WHO's CHOICE project.¹⁵ Also, the cost-effectiveness estimates are not varied with the scale of the intervention, and apply to countries in which institutional and technical capacity in relation to health is close to the average for their World Bank region. The estimates are based on the best available data, which are often weak. Pharmacological and other interventions within health-care services are over-represented in our assessment—environmental, agricultural, legal, and health promoting interventions have received less attention, primarily because of the complexity of evaluating them.

Figure 1 and figure 2 show cost-effectiveness estimates for 94 clusters of interventions (representing 218 interventions). Cost-effectiveness ranges should not

Panel 1: Strengthening of health systems

Strengthening health system performance is a wide-ranging subject, likely to require action on many fronts and management levels. It requires attention to the various functions of the health system, especially the various dimensions of management, as well as to associations between the system, its clients (patients), and their communities. Evidence for which approaches work best is limited

Stewardship and regulation

- Strengthen accountability of health systems to communities and ensure users have a voice and can influence priorities—in Burkina Faso, participation by communities in public primary health-care clinics increased immunisation coverage, essential drug availability, and proportion of women with two or more prenatal visits
- Revise regulations that govern private providers—regulations are often outdated and poorly enforced; revision of regulations to permit drug shops to stock a small set of oral antibiotics, for example, would allow more constructive engagement between sales staff and inspectors as well as increase drug availability

Organisational structures

- Distinguish more clearly the roles of purchaser and provider within public services—though there are few successful examples and major reforms have encountered severe implementation difficulties
- Achieve the appropriate balance of vertical and horizontal modes of organisation and management of service provision—the pendulum swings between focused, disease-specific support and broader health-service or health-system support. Disease-focused efforts make most sense in situations of weak institutional capacity, poor controls on use of public money, and highly constrained resource availability. But such efforts should be designed and implemented in ways that support longer-term system strengthening
- Use contracts with non-governmental organisations to deliver services where government capacity is weak—eg, in remote areas—or public provision less effective—eg, some HIV prevention interventions. In Cambodia, results of a comparison of government provision with two forms of contracting to non-governmental organisations showed that increases in coverage of key interventions were higher in the contracted districts, and that the poor especially benefited

Human resources

- Reduce migration of doctors and nurses, which severely affects health services, especially in some sub-Saharan African countries
- Improve recruitment and retention:
 - Employ less internationally mobile cadres
 - Reward local employment with performance-related pay as in the successful Chinese national tuberculosis programme (requires good regulatory framework, skilled managerial resources, and careful monitoring to counter adverse effects)
 - Offer non-financial incentives—make staff feel their work is valued and provide them with the capacity to work effectively

Targeting resources

- Use resource-allocation formulae to help ensure geographical equity
- Use financial incentives and subsidies to encourage uptake of priority interventions
- Provide information, tools, and training to help managers adapt services and resources to local disease burden—the experience of the Tanzania Essential Health Interventions Project shows the subsequent possible health gains

be interpreted as statistical confidence intervals but rather as a range of “best estimates” that incorporate variation across interventions in the cluster as well as geographical variation. Ranges for the cost-effectiveness ratios are also attributable to variations in the ratios of individual interventions in each group and in the epidemiological settings where the interventions were assessed. A population-based primary intervention in a low-prevalence area is usually less cost effective than the same intervention in a high-prevalence area. Figure 1 shows interventions that deal with high-burden diseases, and figure 2 those that deal with relatively low-burden diseases. All results are in US\$ discounted to the year 2001 at 3% yearly. No age weights are applied when calculating DALYs. Chapter 2 of DCP2 provides a more complete discussion of cost-effectiveness analysis guidelines provided to chapter authors and the quality of

evidence on which the estimates reported here are based.¹⁶

In the figures, intervention clusters are presented in order of increasing (worsening) cost-effectiveness ratios. Observations about specific clusters of interventions follow.

Prevention and control of tuberculosis

Treatment of all forms of active tuberculosis with DOTS is among the most cost effective of interventions (\$5–35 per DALY averted except in Europe and central Asia). An internationally-recommended strategy, DOTS has five components: political commitment; case detection by sputum smear microscopy, mostly among self-referring symptomatic patients; standard short-course chemotherapy administered under proper case-management conditions, including directly observed

therapy; a system to ensure regular drug supplies; and a standard recording and reporting system, including the assessment of treatment outcomes. The BCG vaccination for children is also cost effective (\$40–170 per DALY averted) as a measure to reduce the burden in children of tuberculosis-associated meningitis and miliary tuberculosis. Because BCG hardly affects the huge burden of pulmonary tuberculosis in adults, development of a new vaccine targeting adults is highly desirable. Treatment of latent tuberculosis in patients not coinfecting with HIV is less cost effective (\$4000–25 000 per DALY averted) than treatment of those who are coinfecting (\$16–230). Antiretroviral therapy for HIV/AIDS is most cost effective when used to extend the life of patients who have been successfully treated for tuberculosis.

Multidrug resistant tuberculosis (MDR-TB) is two to ten times more expensive to treat than drug-susceptible disease; prevention of its emergence and spread should be a priority. Management of MDR-TB with a standardised regimen, including second-line drugs, costs about \$70–450 per DALY averted. Individualised treatment regimens for MDR-TB—with drug combinations adjusted for each patient's resistance pattern—are more costly but yield higher cure rates. As such, and though such treatment is harder to implement on a large scale, it could be as cost effective as standardised treatment with regimens that use second-line drugs.

Irrespective of resistance profile, management of tuberculosis in individuals with HIV requires higher investments than that needed for the basic directly observed treatment strategy. Nevertheless, the cost is still typically less than \$1 per day of healthy life gained—a strong argument for integrating such interventions into an enhanced tuberculosis control strategy.

Prevention and treatment of HIV/AIDS

Despite the scale and relentless growth of the HIV/AIDS epidemic, cost-effective interventions have been developed for both prevention and treatment.

Prevention

Although remarkably little rigorous assessment has been done, population-based programmes to prevent infection with HIV seem to be very cost effective where prevalence is high and the epidemic generalised beyond high-risk groups into the broader population. These programmes include peer-based education for high-risk groups, including sex workers and injection drug users (\$1–74 per DALY averted); voluntary testing and counselling (\$14–261); and social marketing, promotion, and distribution of condoms (\$19–205). Programmes to improve the safety of blood and needles, although highly cost effective (\$4–51), avert only a limited burden of disease in areas of generalised epidemics. In parts of south, east, and central Asia, where injection drug use

Panel 2: Development assistance for health

Why?

- Major health gains for the poor can be achieved relatively inexpensively by strategically focused development assistance
- Development assistance in health can be effective with good policies in place even in weak institutional environments
- Development assistance in health can foster good policies and facilitate transition to them—aid works better, the better the policy environment

How?

- Development partners and governments pursue major shifts in human resource and budgetary allocations toward specific high-payoff investments in health
- Focus health-system development on a limited set of priority goals—controlling HIV/AIDS, meeting health-related Millennium Development Goals, and controlling smoking
- Design development assistance for health to reduce leakage to other sectors and lower transaction costs—eg, using performance-based budget-support

fuels rapidly increasing HIV epidemics, harm-reduction programmes, including clean needle exchanges, should be a priority.

Prevention of mother-to-child transmission of HIV, using a single dose of nevirapine to both mother and baby at birth, in generalised epidemic settings is both cost effective and capable of averting great disease burden. Treatment of sexually transmitted infections to lower the risk of HIV transmission, although less well proven, also seems to be highly cost effective (\$16–105 per DALY averted).

Treatment

Treatment of most opportunistic infections in people with HIV/AIDS is cost effective (\$10–500 per DALY averted), and is becoming more so as an increasing number of people receive antiretroviral treatment. Only a few studies¹⁷ have assessed the cost-effectiveness of antiretroviral treatment, and these are limited to clinical trials and not directly applicable to the resource-poor settings where use of antiretroviral treatment is increasing. Cost-effectiveness is affected by drug prices and adherence rates, and omits the non-health effects of HIV/AIDS and the effect of treatment on prevention of transmission. In settings where treatment costs are low and adherence rates high, antiretroviral treatment is moderately cost effective (\$350–500 per DALY averted); however, treatment can be poor value for money if low adherence allows drug resistance to emerge and proliferate. How to achieve necessary adherence levels (80–90%) on a large scale at an affordable cost in resource-poor settings is a research priority.

Illnesses and mortality in children

Mortality of neonates and of children younger than age 5 years can be greatly reduced at an affordable cost, with interventions of proven effectiveness in low-

Panel 3: Research and development priorities

Unprecedented health gains in the past century resulted directly from knowledge gained through research, the development of new drugs, vaccines, and diagnostics, and improved technologies. Better, newer interventions to further reduce major causes of disease burden in low-income and middle-income countries are needed

Why?

- Convergence towards a predominance of non-communicable diseases in most regions of the world underscores need for greater research focus on cardiovascular diseases, cancer, diabetes, and neuropsychiatric conditions
- Continued threat of preventable communicable diseases, maternal mortality, and tropical diseases in sub-Saharan Africa and parts of south Asia
- Emergence of potentially devastating pandemics, such as avian (H5N1) influenza and obesity, as leading public-health concerns
- High burden of intentional and non-intentional injuries
- Many cost-effective interventions do not yield their full potential for several reasons:
 - Weak health systems, with limited infrastructure, and financial and human resources
 - Insufficient transfer of knowledge and technologies from one context to another
 - Limited capacity for disease surveillance and disease modelling
 - Limited research capabilities

Research priorities

- Discovery and approval of new and better drugs, vaccines, and diagnostics
- Improved understanding of major determinants and disease risk factors in various epidemiological, socioeconomic, and cultural contexts
- Epidemiological surveillance at country level and worldwide
- Development of new and better intervention strategies that are locally appropriate and affordable; this calls for stronger focus on developing treatment algorithms and guidelines, improved intervention packaging, better information about intervention costs and cost-effectiveness, expanded delivery of health services, and well functioning health systems, as well as improved policy instruments

Key recommendations

- Use results of cost-effectiveness analyses to improve investment of limited resources
- Expand use of successful public-private partnerships for product development
- Do operational research on delivering important interventions that might rely on lifelong medication—eg, psychiatric disorders, HIV/AIDS, cardiovascular disease, and diabetes
- Identify health problems shared by industrialised and low-income and middle-income countries
- Increase potential of information technology
- Increase global health research capacity to attract and keep productive scientists in developing world
- Create a global health architecture that allocates a larger share of development assistance for health to research and development with a focus on neglected conditions

income settings. Improvements are likely to follow an increase in coverage of preventive measures, such as breastfeeding, and expansion of childhood vaccination programmes beyond the traditional six antigens in places where coverage is high and where new antigens address diseases of significant burden, particularly pneumococcal and *Haemophilus influenzae* type b vaccines. Implementation and increased coverage of curative interventions for acute respiratory infections, malaria, and diarrhoea should reduce the figure of 6 million preventable deaths every year in this age group.

Neonatal mortality

An estimated 4 million babies younger than age 28 days die every year, accounting for 38% of all deaths in children younger than age 5 years. Causes of death include infections (36%, including neonatal sepsis, pneumonia, diarrhoea, and tetanus), complications due

to preterm birth (27%), and asphyxia (23%). Intensive care is not needed to save most of these babies. Low-income countries—for instance, Sri Lanka—have achieved neonatal mortality rates of 15 per 1000 without intensive care; less than a third of the neonatal mortality rates typical in sub-Saharan Africa.

Inclusion of 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 proven 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, provision of such care depends on great 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

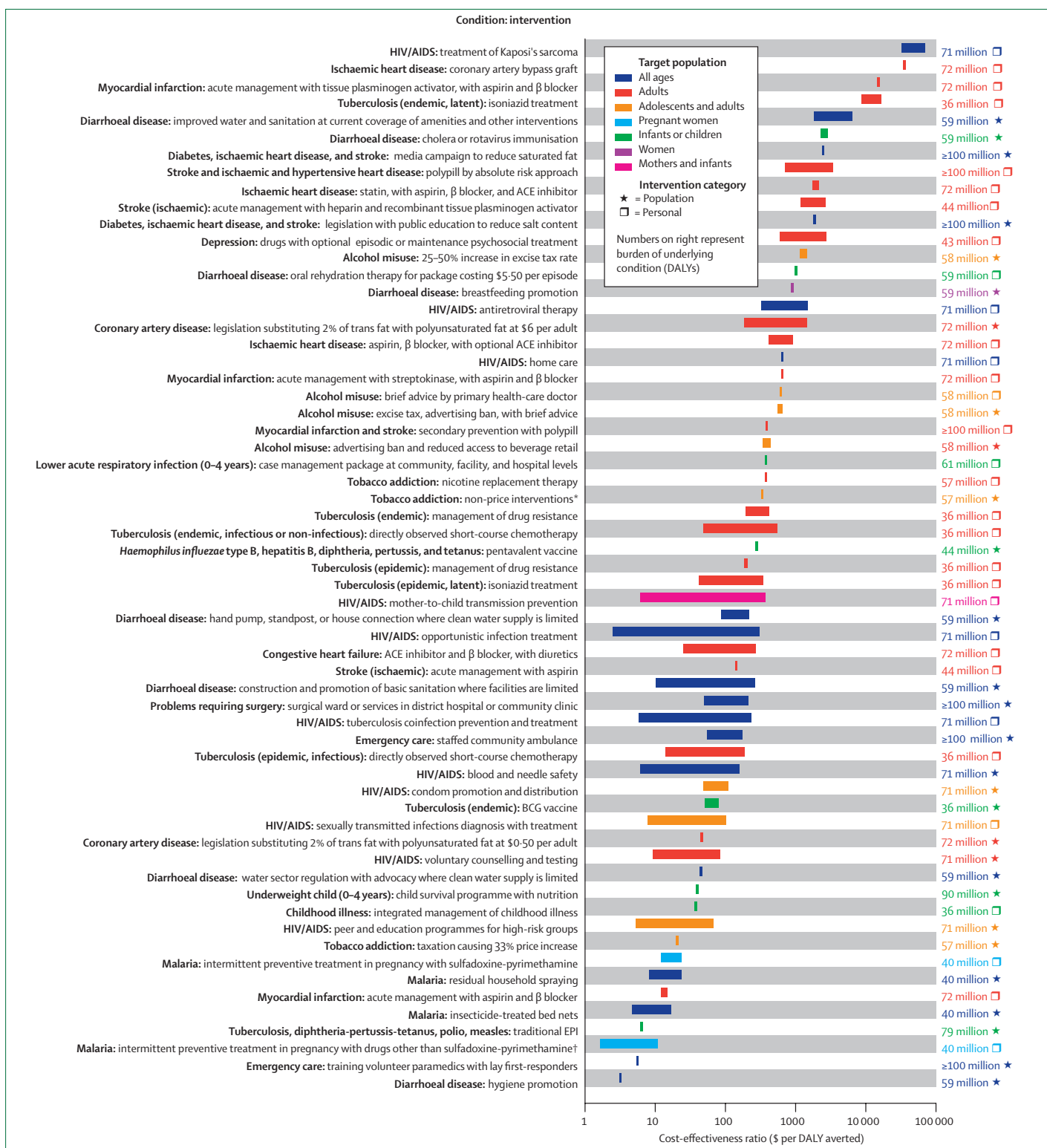


Figure 1: Cost-effectiveness of interventions related to high-burden diseases in low-income and middle-income countries (>35 million DALYs)

Bars=range in point estimates of cost-effectiveness ratios for specific interventions included in each intervention cluster and do not represent variation across regions or statistical confidence intervals. Point estimates obtained from DCP2, calculated as midpoint of range estimates reported, or calculated from a population-weighted average of region-specific estimates reported. Only interventions with cost-effectiveness reported in terms of DALYs are included in figure. *Advertising bans, smoking restrictions, supply reduction, and information dissemination. †Chloroquine=first line drug; artemisinin-based combination therapy=second-line drug; and sulfadoxine-pyrimethamine=first-line or second-line drug.

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 \$100–257 in India (\$221–568 per DALY averted) and \$100–270 in sub-Saharan Africa (\$183–493). These approaches are feasible now in virtually all countries.

Resuscitation of newborn children with a self-inflating bag that costs as little as \$5 in low-income and middle-income countries can save lives at low cost if a midwife is available. Provision of two tetanus toxoid immunisations 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.

Vaccine-preventable diseases in childhood

Childhood vaccinations, long recognised as among the most cost effective uses of resources, prevented more than 3 million deaths worldwide in 2001. National immunisation programmes include vaccines against tuberculosis, diphtheria, tetanus, pertussis, poliomyelitis, and measles at a cost per fully immunised child of \$13–24, depending on coverage levels and type of delivery strategy (health-facility based, campaigns, or mobile teams outreach). The estimated cost per death averted varies from less than \$275 (under \$10 per DALY averted) in sub-Saharan Africa and south Asia to \$1754 (\$20 per DALY averted) in Europe and central Asia. This pronounced 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 opportunity for measles vaccination through routine or campaign based approaches costs \$23–228 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–hepatitis B–Hib) has an estimated cost per death of \$1433–40 000 and a cost-effectiveness of \$42 per DALY averted in sub-Saharan Africa and greater 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 per DALY averted) 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-income and middle-income countries. After confirmation of efficacy and subsequent licensing, new vaccines that protect against rotavirus, malaria, human papilloma virus-associated cervical cancer, and dengue should be included in the EPI schedule.

Acute respiratory infections

Although vaccination is essential, patients' management is also an efficient use of financial resources, although more demanding of health-system capacity. Management in the community or at a health-care facility might be comparably cost effective, but community-based strategies hold promise for more rapid coverage. Treatment of non-severe 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 rather than at home is more expensive (\$1486–14 719).

Diarrhoeal disease

Of the interventions for diarrhoeal disease during the first year of life, breastfeeding promotion programmes (\$527–2001 per DALY averted), measles immunisation (\$257–4565), and oral rehydration therapy (as low as \$132, for a cost per child of \$0.70) are relatively cost effective compared with rotavirus immunisations (\$1402–8357) and cholera immunisations (\$1658–8274). Because great reductions in mortality from this condition have already been achieved, the average case 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 to that for immunisation: 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 diarrhoeal disease) are less cost effective where access to these amenities is adequate and other interventions against diarrhoeal disease 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).

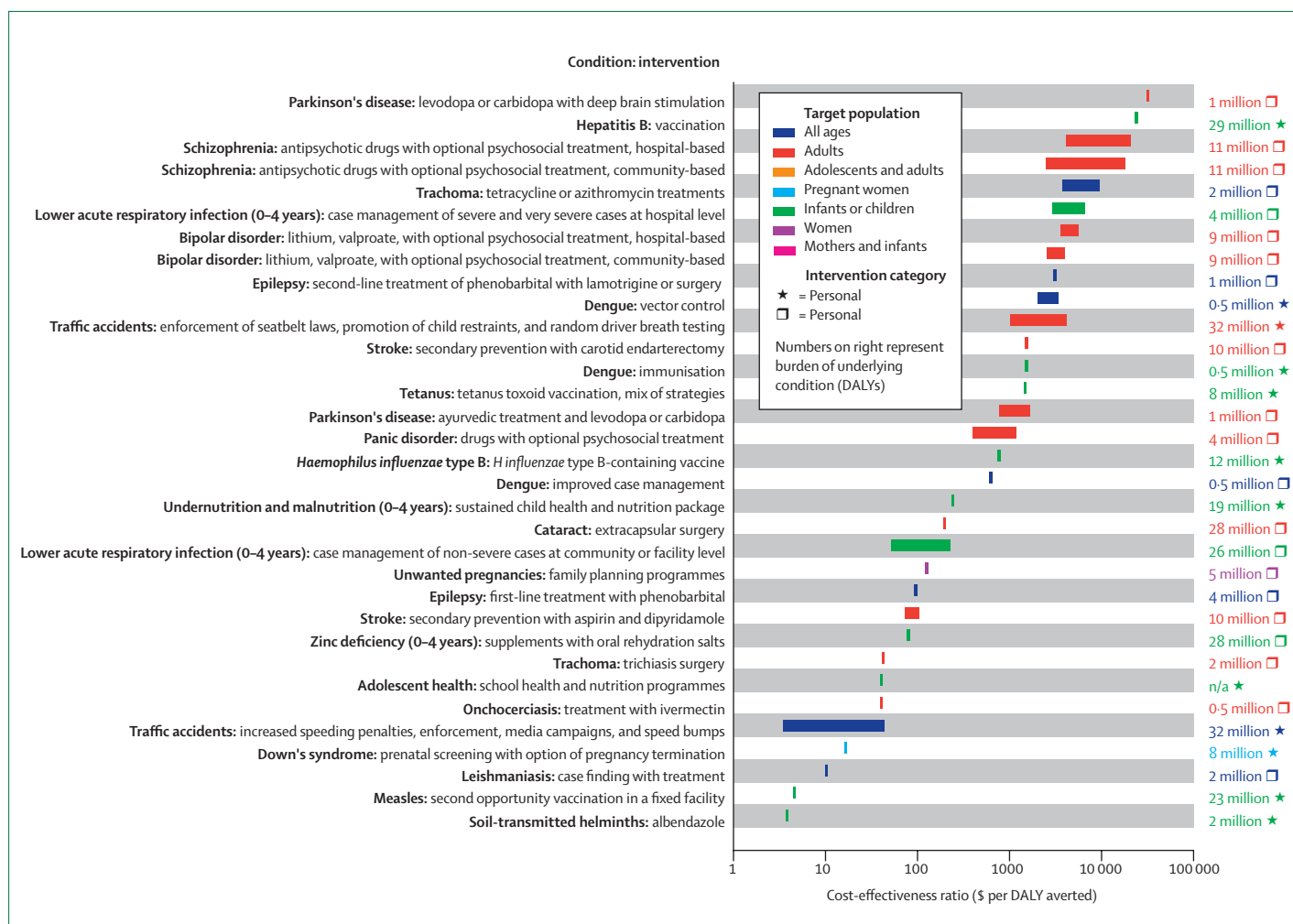


Figure 2: Cost-effectiveness of interventions related to low-burden diseases in low-income and middle-income countries (<35 million DALYs)

Bars=range in point estimates of cost-effectiveness ratios for specific interventions included in each intervention cluster and do not represent variation across regions or statistical confidence intervals. Point estimates obtained from DCP2, calculated as midpoint of range estimates reported, or calculated from a population-weighted average of region-specific estimates reported. Only interventions with cost-effectiveness reported in terms of DALYs are included in figure.

Integrated management of childhood illnesses

An integrated package, consisting of exclusive breastfeeding, vitamin A and zinc supplementation, screening for immunisation, and management of pneumonia, malaria, and diarrhoea—including oral rehydration therapy—costs about \$4.10 per child in sub-Saharan Africa and is cost effective (\$38 per DALY averted) when coverage is at least 50%. Constant attention to quality is especially important when introducing packages of diverse interventions.

Inherited disorders of haemoglobin

Inherited disorders of haemoglobin, including sickle cell anaemia and the thalassaemias, affect about 500 000 babies every year and have a high mortality rate. Expensive prenatal screening for sickle cell disease can be replaced by much cheaper screening of newborn babies and by counselling. Antibiotic prophylaxis is moderately cost

effective at preventing death in the first few years (\$8000–12 000 per death averted, or \$300–400 per DALY averted). At \$10 000 or more per DALY averted, however, the repeated transfusions needed for some thalassaemias are unaffordable to all but the rich in low-income and middle-income countries; bone-marrow transplant, seldom needed, costs even more. A strategy that worked in Cyprus, Greece, and Italy, countries with previously high incidence rates of thalassaemias, involved the screening of couples to ascertain their risk of having an affected child, followed by prenatal testing—a relatively expensive proposition—only of couples at high risk.

Tropical diseases

Despite health researchers' neglect of predominantly tropical diseases, interventions to control—and in some cases eliminate—these diseases rank among the most cost effective of all options.

Malaria

Prevention and effective treatment options of this disease are highly cost effective and can yield large health gains in areas where malaria is endemic. Methods of prevention include insecticide-treated bednets (\$5–17 per DALY averted) and indoor residual spraying with DDT, malathion, deltamethrin, or cyhalothrin (\$9–24 per DALY averted for sub-Saharan Africa).

Intermittent preventive treatment of malaria during pregnancy, using sulfadoxine-pyrimethamine, is a highly cost-effective (\$13–24 per DALY averted) means of reducing neonatal mortality, mainly from low birthweight, and severe maternal anaemia. Changing of first-line treatment for malaria from chloroquine, an ineffective drug in much of the world, to an artemisinin-based combination offers faster cures and potential reductions in transmission, with cost-effectiveness of better than \$150 per DALY averted. A change to sulfadoxine-pyrimethamine might be slightly more cost effective initially because this drug costs less than artemisinin-based combinations; however, this advantage would probably be eroded quickly because of the expected rapid growth of parasite resistance.

Lymphatic filariasis, onchocerciasis, and Chagas' disease

Yearly drug administration to the entire population at risk for long enough to interrupt transmission represents a cost-effective way to eliminate lymphatic filariasis in high prevalence areas (\$4–8 per DALY averted). An alternative is to fortify salt with diethylcarbamazine (\$1–3) and to use ivermectin where onchocerciasis is coendemic. Onchocerciasis control programmes have been highly successful in west Africa: investigators estimate the cost-effectiveness of community-directed ivermectin treatment at roughly \$7 per DALY averted when the drug is provided free of charge. The cost of vector control to prevent—and perhaps eliminate—Chagas' disease is about \$260 per DALY averted.

Leishmaniasis and African trypanosomiasis

Intervention opportunities exist even for tropical diseases for which control measures are less effective. Improved management of patients with dengue (\$587 per DALY averted) is more cost effective than environmental management or insecticides (more than \$2000). Treatment for leishmaniasis is extremely cost effective (\$315 per death averted and \$9 per DALY averted), as is treating patients with African trypanosomiasis in the second stage of the disease, using melarsoprol or eflornithine (\$10–20 per DALY averted).

Helminthic infections

Helminthic infections, although not a great cause of death in tropical regions, have a great effect on wellbeing, growth, and physical fitness, and on school attendance, worker productivity, and earning potential. Mass school-based treatment of soil-transmitted helminths

(*Ascaris lumbricoides*, *Trichuris trichuria*, and hookworm) with albendazole costs \$2–9 per DALY averted. Although the cost of treating schistosomiasis with praziquantel is much higher (\$336–692), a combination of albendazole and praziquantel is extremely cost effective (\$8–19).

Reproductive health

Given the hugely disproportionate burden of maternal and neonatal deaths in low-income and middle-income countries,⁶ identifying affordable, easy-to-implement preventive interventions is a priority. Improved primary-level coverage with a package of prenatal and delivery care is very cost effective in lowering both maternal and perinatal deaths (\$3337–6129 per death averted and \$92–148 per DALY averted) as are improvements in quality of prenatal and delivery care (\$2729–5107 per death averted and \$82–142 per DALY averted). Notably, improving the quality of care and expanding coverage are comparably cost effective.

Nutrition

Direct and indirect effects of undernutrition and micronutrient deficiencies account for about a third of the disease burden in low-income and middle-income countries.¹⁸ Interventions to prevent malnutrition, such as breastfeeding support programmes (\$3–11 per DALY averted and \$100–300 per death averted) and growth monitoring and counselling (\$8–11 per DALY averted), are moderately cheap. Large-scale community health and nutrition programmes that promote such interventions and better child feeding practices can reduce stunting—and the sequelae of cognitive impairment, increased susceptibility to obesity, and later chronic disease—by an additional 1–2 percentage points per year at an annual cost of \$5–10 per child or \$200–250 per DALY averted, often without the need for additional food. Micronutrient intake can be supplemented with capsules or by fortifying sugar, salt, water, or other essentials. For vitamin A deficiencies, capsule distribution (\$6–12 per DALY averted) is more cost effective than sugar fortification (\$33–35), especially where the prevalence of vitamin A deficiency is low. Fortification of salt, sugar, and cereal to correct iron deficiency and of water and salt to correct iodine deficiency is less expensive than distributing supplements for mild deficiency, though pregnant women and severely anaemic or iodine-deficient people might still need to take a supplement. Overall cost-effectiveness is \$66–70 per DALY averted for iron fortification and \$34–36 per DALY averted for iodine fortification.

Cancer prevention and treatment

Initial treatment costs between \$1300 and \$6200 per year of life saved for the more treatable cancers of the cervix, breast, oral cavity, colon, and rectum, and between \$53 000 and \$163 000 per year of life saved for less treatable liver, lung, stomach, and oesophagus cancers. Postmastectomy radiation might be cost effective in developing countries,

where the cost of treatment can be lower than in developed countries. Palliative care for terminally ill patients is a challenge, especially where opioid drugs, a cost-effective option, are in short supply.

Biennial screening by clinical breast examination is estimated to be cost effective at \$552 per life-year saved for women from age 40–60 years, indicating the large proportion of tumours with a poor prognosis in developing countries. In this setting, clinical breast examination is more cost effective than mammography: mammograms every 2 years save 10% more life-years than yearly clinical breast examination, but the cost is more than 100% higher. As with any screening programme, cost-effectiveness is greater with higher underlying prevalence.

Mental and neurological disorders

Mental disorders are heterogeneous conditions that vary considerably in intervention cost and associated burden reduction. Treatments for depression are much more cost effective in general than are those for bipolar disorder and schizophrenia. For the latter two disorders, the potentially great benefits to family members and to society as a whole are not captured by DALYs and should be balanced against the relatively high cost of improving health for some individuals. For many disorders, drugs are effective, especially when combined with psychosocial treatment, including group therapy, family interventions, and cognitive-behavioural approaches to managing symptoms and improving adherence to medications. Stigma is a major challenge, for which creative interventions are needed.

Schizophrenia and bipolar disorder

Community-based drug treatment accompanied by psychosocial treatment is the most cost-effective approach for these severe mental disorders. Newer antipsychotic and mood-stabilising drugs have become less expensive; even so, they are less cost effective than drugs that have been available for a while. A combination of haloperidol and family psychoeducation is typically much more cost effective (\$1743–4847 per DALY averted) than a combination of a new antipsychotic drug (risperidone) with family psychoeducation (\$10 232–14 481) in the treatment of schizophrenia. For bipolar affective disorder, family psychoeducation is more cost effective when combined with the older medication lithium (\$1587–4928 per DALY averted) than with valproate (\$2765–5908).

Depression and panic disorder

Treatment for the more common disorders of depression and anxiety is more cost effective than treatment for the more severe disorders; interventions are less expensive and the reduction in disability is greater. For depression, drug therapy with tricyclic antidepressants (imipramine or amitriptyline) costs \$478–1288 per DALY averted. Management of chronic depression to reduce relapses is similarly cost effective (\$749–1760). Use of newer

medications with fewer side-effects and potentially greater compliance (an advantage for long-term use)—for example fluoxetine, a generic selective serotonin reuptake inhibitor (SSRI)—increases costs (\$1229–2459 per DALY averted). Finally, the treatment of panic disorder with tricyclic antidepressants (\$305–619) and SSRIs (\$567–865) is more cost effective than treatment with tricyclic antidepressants combined with psychosocial interventions. Psychosocial treatment without drugs is comparably cost effective (\$338–927).

Tricyclic antidepressants are more cost effective than benzodiazepines, which are still often prescribed for anxiety disorders and produce dependence in many patients. A package of mental-health interventions to address all four disorders costs between \$1429 and \$2902 per DALY averted, depending on the region.

Parkinson's disease and epilepsy

Traditional Indian ayurvedic treatment is relatively cost effective for Parkinson's disease (\$750 per DALY averted) compared with a combination of levodopa and carbidopa (\$1500) to treat the debilitating symptoms and delay the progress of the disease, or deep-brain stimulation (\$31 000).

Cost-effective options exist for epilepsy—eg, phenobarbital to help control seizures (\$89 per DALY averted)—but few eligible patients receive treatment. Options such as lamotrigine or surgery are significantly less cost effective than phenobarbital for first-line treatment; however, they are cost effective for the small proportion of patients who do not respond to phenobarbital. The emphasis must be on extending treatment with phenobarbital to the many who do not receive it.

Prevention and treatment of cardiovascular disease

Cardiovascular diseases, including ischaemic heart disease, congestive heart failure, and stroke, account for more than a quarter of all deaths in low-income and middle-income countries; treatment is likely to account for an increasing proportion of health-care expenditure in these countries.

Population-based primary prevention

Interventions to modify lifestyles can effectively lower the risk of coronary artery disease and stroke at a moderately low cost without expensive health infrastructure. Replacing dietary trans fat with polyunsaturated fat is likely to be effective in settings where trans fat intake is high. If such replacement occurs during manufacture rather than through changes in individual behaviour, the cost would be \$25–73 per DALY averted. Replacement of saturated fat with monounsaturated fat in manufactured foods accompanied by a public education campaign is relatively expensive (\$1865–4012 per DALY averted), although the cost per DALY averted is highly sensitive to the relative risk reduction in cardiovascular events as well as the cost per individual. Reduction of salt levels in manufactured

foods through a combination of legislation and education campaigns is also expensive (\$1325–3056 per DALY averted), but could be much more cost effective in populations with a high salt intake. Little evidence is available on the cost-effectiveness of programmes to encourage exercise and other behavioural changes.

Personal interventions

Prevention strategies targeted at individuals at high risk for cardiovascular disease—measured as a combination of non-optimal blood pressure, poor lifestyle, poor nutrition, tobacco and alcohol use, and genetic risk factors—can be effective, especially when implemented in tandem with population-based measures. A previous cardiovascular event reliably predicts a second event. Single-pill combinations of blood pressure-lowering medications, statins, and aspirin offer the dual benefit of lowering the risk of cardiovascular disease and facilitating compliance with the drug regimen. A hypothetical multidrug regimen, including aspirin, a β blocker, a thiazide diuretic, an angiotensin-converting-enzyme (ACE) inhibitor, and a statin might be implemented at a cost of \$721–1065 per DALY averted compared with no treatment in a population with an underlying 10-year risk of cardiovascular disease of 35%. The use of a multidrug regimen for prevention in patients with a lower underlying risk improves health benefits, but costs increase more than proportionately.

Acute management of cardiovascular disease

The cost of treating acute myocardial infarction with aspirin and β blockers is less than \$25 per DALY averted in all regions. Relatively more expensive interventions that offer marginally greater effectiveness include thrombolytics, such as streptokinase (\$630–730 per DALY averted), and tissue plasminogen activator (\$16 000).

In regions with poor access to hospitals, a combination of aspirin plus the β blocker atenolol is highly cost effective in preventing the recurrence of a vascular event (\$386–545 per DALY averted). The incremental cost-effectiveness of sequentially adding an ACE inhibitor such as enalapril (\$660–866), a statin such as lovastatin (\$1700–2000), and coronary artery bypass graft (more than \$24 000 per DALY averted) to the baseline therapy is less favourable. In all regions, treating congestive heart failure with enalapril and the β blocker metoprolol is also highly cost effective (about \$200 per DALY averted).

Acute management and secondary prevention of stroke

Treatment of acute ischaemic stroke with aspirin costs \$150 per DALY averted. The use of a tissue plasminogen activator (\$1300) and anticoagulants such as heparin or warfarin (\$2700) is relatively cost ineffective. Aspirin is the cheapest option for secondary prevention of ischaemic stroke (\$3·80 per single percentage point decrease in the risk of a second stroke within 2 years, or \$70 per DALY averted). Since having had a stroke indicates an individual

to be at high risk for subsequent ischaemic heart disease, it will generally make sense to use more than aspirin for secondary prevention. The combination of the antiplatelet medication dipyridamole and aspirin is equally cost effective (\$93 per DALY averted). By contrast, carotid endarterectomy is a costly option for secondary prevention (\$1500 per DALY averted).

Strategies for injury prevention

Economic development and increased motor vehicle use have led to a rise in traffic-related deaths and injuries; these events account for roughly a third of the burden from all unintentional injuries in low-income and middle-income countries.

Speed bumps are the most cost effective method of prevention, costing less than \$5 per DALY averted in all regions if installed at the most dangerous junctions that account for 10% of junction-related deaths. Increased speeding penalties, media coverage, and enforcement of traffic laws are only slightly less cost effective. Motorcycle helmet legislation (\$467 per DALY averted in Thailand), bicycle helmet legislation (\$107 per DALY averted in China), and improved enforcement of traffic codes through a combination of policing and information campaigns (\$5–169 per DALY averted) cost more, but deserve greater attention, given the growing health burden associated with rising vehicle ownership. Seat belts and child restraints are effective in the developed world; lowering their costs and encouraging their routine use should improve cost-effectiveness in low-income and middle-income countries.

Interventions to reduce intentional violence, both self-inflicted (suicides) and interpersonal (homicides and war-related deaths), include changing cultural norms, reducing access to guns and deadly pesticides, and improving criminal justice and social welfare systems, but these interventions are difficult to assess with a cost-effectiveness framework, and a cost-benefit analysis is more appropriate. Findings of studies in developed countries show that behavioural, legal, and regulatory interventions cost less than the money they save, in some cases by an order of magnitude. Provision of shelters for victims of domestic violence in the USA results in a benefit–cost ratio of 6·8–18·4 to one. Interventions for troubled young people to reduce criminal activity include mentoring (with net benefits ranging from \$231 to \$4651 per participant), family therapy (\$14 545–60 721), and aggression replacement therapy (\$8519–34 071).

Conditions that require surgery

Types of surgery that are highly cost effective include care to injury victims (eg, those with head trauma and burns); handling of obstetric complications (eg, obstructed labour or haemorrhage); and elective surgery for conditions that seriously affect quality of life (eg, cataracts and otitis media). In areas of high prevalence, cataract surgery can be highly cost effective (about \$100 per DALY averted).

Many surgical interventions—resuscitation and airway management with simple procedures such as chest tubes and tracheostomy, and management of fractures and of burns covering less than 30% of the body—require only the facilities offered by district hospitals. The quality of surgery and the risk of complications vary widely, and adequate health-service capacity is an important consideration. For the typical surgical facility in a district hospital in a low-income or middle-income country, the average cost per DALY averted for a representative set of surgical procedures is between \$70 and \$230. General surgery at a district hospital is cost effective in south Asia and sub-Saharan Africa because of low infrastructure costs and high avertable disease burden. Surgical interventions with poor cost-effectiveness include first-line treatment of epilepsy, which helps only patients who are resistant to drug treatment, and percutaneous transluminal coronary angioplasty for cardiovascular events.

Alcohol and tobacco use

The growing prevalence of smoking, especially in women in low-income and middle-income countries, seriously threatens health. Interventions to reduce tobacco use are not only highly cost effective, but they can avert a large burden of deaths. Tobacco tax increases often increase tax revenues as well as discouraging smoking initiation and encouraging smokers to quit. The cost-effectiveness of increasing cigarette prices by 33% ranges from \$13 to \$195 per DALY averted globally, with a better cost-effectiveness ratio (\$3–42 per DALY averted) in low-income countries. Nicotine replacement therapy (\$55–751) and non-price interventions, including banning advertising, providing health education information, and forbidding smoking in public places, are relatively less cost effective (\$54–674) in low-income countries, but still belong in any tobacco control programme. Comprehensive tobacco control programmes that use price and non-price interventions, and which aim specifically to help the current 1·1 billion smokers quit, should be increasingly implemented, especially now that more than 110 countries have adopted the global Framework Convention on Tobacco Control.

Where high-risk alcohol use is prevalent—especially in Europe and central Asia, Latin America and the Caribbean, and sub-Saharan Africa—tax increases to lower alcohol use are very cost effective (\$105–225 per DALY averted). Where high-risk use is less prevalent—east Asia and the Pacific and south Asia—tax-based policies can be among the least cost-effective interventions (more than \$2500 per DALY averted). Advertising bans are among the most cost-effective of all interventions to reduce high-risk drinking in all regions (\$134–280). In east Asia and the Pacific, a comprehensive ban on advertising and reduced access to retail outlets are highly cost-effective interventions (\$123–146). In many regions, random breath testing is one of the least cost-effective interventions (\$973–1856); however, in southeast Asia, averting the burden associated with drink driving is an important

priority, addressed effectively through random breath testing and stricter enforcement of drink-driving laws (\$531 per DALY averted). Provision of brief advice to high-risk drinkers by a primary care physician is of intermediate cost-effectiveness (\$480–819) in all regions; combining this advice with a tax on alcohol should improve cost-effectiveness (\$260–533), except in sub-Saharan Africa.

Delivering interventions

Interventions are rarely freestanding, but are delivered through a service infrastructure. Community health status is correlated with the quality of health-service facilities, which can be enhanced even in resource-constrained settings, with greatest potential for improving quality at low cost. Intervention and service quality greatly affect cost-effectiveness, and improving quality can be an efficient use of resources. Improvement of the quality of care of acute respiratory infections through an educational activity for providers costs from \$132–\$800 per life saved (\$4–28 per DALY averted) when initial intervention quality is poor and infections are widespread. Quality improvements cost \$2000–5000 per life saved (\$70–176 per DALY averted) with better baseline quality, low disease prevalence, or both. Educational interventions to improve treatment for diarrhoea can be extremely cost effective (less than \$18 per DALY averted), depending on these two factors.

In DCP2, cost-effectiveness analysis was done not just of specific interventions, but also for levels of care (eg, primary care, district hospitals, surgery). Evidence suggests that it is highly cost effective to develop a well functioning general primary-care system, encompassing local–district hospital levels, which can address up to 90% of health-care demand in developing countries.

The cost per death averted of training lay first-responders to emergencies and volunteer paramedics is between \$130 and \$283 (\$5–11 per DALY averted), depending on the region. Ambulances equipped with trained paramedics can avert deaths at a cost of \$1148–3479 (\$46–137 per DALY averted) in urban settings and \$3457–10449 (\$140–410) in rural settings. Evidence about district and referral hospitals is limited, but indicates that basic district-level hospital care could be highly cost effective (\$13–104 per DALY averted).

Strengthening of referral hospitals has various benefits that are difficult to quantify, including providing more complex clinical care to referred cases, disseminating appropriate health technologies, and lending clinical, managerial, and administrative support to other health-care levels.

Strengthening health systems

Cost-effectiveness data for interventions and packages indicate what a reasonably well functioning health system can achieve. They represent potential cost-effectiveness and need to be supplemented with evidence and guidance on how health systems can provide interventions effectively, efficiently, and equitably. Although we have

dealt mainly with the chapters in DCP2 that deal with intervention selection, one of the chapters in the book provides a more extended summary of findings concerning health systems.¹⁹ Panel 1 summarises the key points in this chapter. To accelerate progress towards the health-related Millennium Development Goals and ensure that the poor are not left behind requires new thinking about effective service delivery for priority interventions. Human resources for health is one of the biggest challenges that faces health systems.

Conclusion

Improvements made to health constitute an enormous success for human welfare in the 20th century. Four important challenges face the world, however, at the dawn of the 21st century: high levels and rapid growth of non-communicable conditions in developing countries; the unchecked HIV/AIDS pandemic; the possibility of a successor to the influenza pandemic of 1918; and the persistence in many countries and population subgroups of high but preventable levels of mortality and disability from malaria, tuberculosis, diarrhoea, and pneumonia.

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. Non-communicable diseases, including ischaemic heart disease and stroke, can be prevented, importantly by comprehensive tobacco control programmes, and managed effectively in low-income countries at a reasonable cost. Many interventions first developed in the industrial world are now largely available in the developing world, challenging health-care systems in low-income and middle-income countries to recognise the importance of these conditions and respond to them.

For prevention and treatment programmes to work, policymakers must have access to the best possible research and analysis to ensure that their health investments save as many lives as possible. The demographic, epidemiological, and economic information in DCP2 should help to fill an important gap, but knowledge alone is not sufficient. Increasing the flow of resources to health, drawing on both donor support and national spending, is essential to purchase the cost-effective interventions described in the book.

Conflict of interest statement

We declare that we have no conflict of interest.

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