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REVIEW

The double burden of communicable and non-communicable diseases in developing countries

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Summary Now, at the dawn of the third millennium, non-communicable diseases are sweeping the entire globe. There is an increasing trend in developing countries, where the demographic and socio-economic transition imposes more constraints on dealing with the double burden of infectious and non-infectious diseases in a poor environment, characterized by ill-health systems. It is predicted that, by 2020, non-communicable diseases will cause seven out of every ten deaths in developing countries. Among non-communicable diseases, special attention is devoted to cardiovascular disease, diabetes, cancer and chronic pulmonary disease. The burden of these conditions affects countries worldwide but with a growing trend in developing countries. Preventative strategies must take into account the growing trend of risk factors correlated to these diseases. In parallel, despite the success of vaccination programmes for polio and some childhood diseases, other diseases like AIDS, tuberculosis, malaria and dengue are still out of control in many regions of the globe. This paper is a brief review of recent literature dealing with communicable and non-communicable diseases in developing countries. It gives a global view of the main diseases and their impact on populations living in low- and middle-income nations.

1. Introduction

For centuries, communicable diseases (CD) were the main cause of death around the world. Life expectancy was often limited by uncontrolled epidemics. After the Second World War, with medical research achievements in terms of vaccination, antibiotics and improvement of life conditions, non-communicable diseases (NCD) began to cause major problems in industrialized countries. Heart disease, cancer, diabetes, chronic pulmonary and mental disease became a real burden for health systems in developed countries. For a while,

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Table 1 Evolution and projection of communicable and non-communicable diseases in developing countries (in millions)

Year	Non-communicable diseases *n* (%)	Communicable diseases + maternal + perinatal + nutritional *n* (%)	Injuries *n* (%)	Total *n* (%)
1990	18.7 (47)	16.6 (42)	4.2 (11)	39.5 (100)
2000	25.0 (56)	14.6 (33)	5.0 (11)	45.0 (100)
2020	36.6 (69)	09.0 (17)	7.4 (14)	53.0 (100)

Sources: Burden of Disease Unit, 1990; Mathers et al., 2003; WHO, 2003a.

these diseases were associated with economic development and regarded as diseases of the rich. Now, at the dawn of the third millennium, NCDs appeared to be sweeping the entire globe, with an increasing trend in developing countries (Table 1). If the present trend is maintained, it is predicted that, by 2020, NCDs will account for 80% of the global burden of disease, causing seven out of every ten deaths in developing nations, compared with less than half today (WHO, 2002). In parallel, infectious diseases continue to be the major cause of mortality in developing countries. Well-known existing, emerging and re-emerging diseases like tuberculosis (TB), cholera, meningitis, hepatitis, malaria, dengue, yellow fever, AIDS, Ebola, SARS and others are causing suffering and mortality to a wide population in the developing countries and developed countries are also at risk (WHO, 2003c).

Beyond mortality statistics, different methods can be considered to quantify the burden of disease. In order to overcome the specific problems of each country, the most frequently used method is the approach that measures the global burden of CDs and NCDs in terms of disability adjusted life years (DALY), which is a combination of years of life lost (YLL) through premature death and years lived with disability (YLD). Thus, one DALY is thought of as one lost year of healthy life (Mathers et al., 2003; Murray and Lopez, 1996). For example, deaths from being underweight every year rob the world's poorest children of an estimated total of 130 million years of healthy life (WHO, 2002).

2. Non-communicable diseases

According to the WHO Annual Report (WHO, 2002), it has been estimated that, in 2001, approximately 60% of the 56.5 million total reported deaths in the world and approximately 46% of the global burden of disease were attributable to chronic diseases and cardiovascular diseases (CVD) in particular. Although HIV/AIDS, malaria, TB, haemorrhagic dengue and other infectious diseases are predominant in Africa, Asia and Latin America, deaths caused by chronic diseases dominate the mortality statistics in five out of six regions of WHO, and 79% of all deaths attributable to chronic diseases occur in developing countries. Incidence and prevalence of obesity, diabetes, cancers, respiratory diseases and other NCDs are increasing all over the world (Murray and Lopez, 1996). Contrary to widely held beliefs, the problem is not limited to developed countries (Boutayeb and Boutayeb, 2005); it constitutes a major concern for health authorities in developing countries (Alwan, 1997).

2.1. Cardiovascular diseases

These diseases cause around 17 million deaths, representing approximately one-third of all deaths occurring in the world. Nearly 80% of these deaths occur in low- and middle-income countries where the trend is increasing (Reddy and Yusuf, 1998; Yusuf et al., 2001), indicating that by the year 2010 CVD will be the leading cause of death, as a consequence of lifestyle changes brought about by industrialization and urbanization in nations undergoing the demographic and socio-economic transition (Lenfant, 2001) (Table 2). In some countries of the East Mediterranean Region (EMR), 40% of all deaths are caused by CVD (Alwan, 1997; Tazi et al., 2003). The costly and prolonged care of CVD in poorer countries often diverts scarce family and societal resources to medical care. Consequently, the lower socio-economic groups have greater prevalence of risk factors, higher incidence of disease and higher mortality (Reddy, 2002).

2.2. Diabetes

According to the statistics released by the International Diabetes Federation (IDF, 2003), the number of diabetics in the world is expected to increase from 194 million in 2003 to 330 million in 2030 with three in four living in developing countries. In some countries of the Middle East, one in four deaths in adults aged between 35 and 64 years is attributable to diabetes. Moreover, in developed countries most people with diabetes are above the

Table 2 Deaths caused worldwide by specific diseases in 1990 and 2002 (in thousands)

Disease	Deaths and % disease	
	1990 *n* (%)	2002 *n* (%)
Ischaemic heart disease	6260 (12.4)	7000 (12.6)
Cerebrovascular disease	4380 (8.7)	5400 (9.6)
Lower respiratory diseases	4300 (8.5)	3700 (6.6)
Chronic obstructive pulmonary disease	2211 (4.4)	2700 (4.8)
Cancer (all types)	6200 (11.2)	7100 (12.6)
Diabetes	2400 (5.0)	3200 (5.6)

Sources: Burden of Disease Unit, 1990; Mathers et al., 2003; WHO, 2003a.

age of retirement, whereas in developing nations those most frequently affected are aged between 35 and 64 and this makes the burden in terms of DALYs and YLDs heavier in poorer countries (Boutayeb et al., 2004). The burden is exacerbated by micro- and macro-vascular complications leading to blindness, amputations, kidney failure and heart disease (Boutayeb and Twizell, 2004).

2.3. Cancer

Worldwide, cancer is a major cause of mortality and morbidity. Over 10 million new cases and over 7 million deaths from cancer occurred in 2000 (Shibuya et al., 2002). The contribution of developing countries was 53% for incidence and 56% for deaths. But the future is more alarming since, by 2020, the total number of new cases is expected to increase by 29% in developed countries whereas, in developing countries an increase of 73% is expected, largely as a result of ageing, urbanization and change in dietary habits (Mathers et al., 1999). Lung, breast, stomach, colorectal and liver cancer are the most frequent in developing countries.

Early detection, in particular for breast and cervical cancer, and control of risk factors like tobacco and alcohol should be the cornerstone of preventative strategies (Boutayeb and Boutayeb, 2005). Indeed, it is estimated that over one-third of cancers are preventable and another one-third are potentially curable provided they are detected early in their course (Alwan, 1997).

2.4. Other non-communicable diseases

Other NCDs contribute to the burden of disease in developing countries; these include chronic respiratory diseases such as asthma and chronic obstructive pulmonary disease (Ait-Khaled et al., 2001), mental and depressive disorders, osteoarthritis, hearing loss and disorders of vision (WHO, 2003a). Finally, conditions such as high blood pressure and obesity may have a double impact either as diseases or as risk factors for other NCDs (James et al., 2001; WHO, 2004).

3. Communicable diseases

With malnutrition as a common contributor, the six biggest infectious killers are HIV/AIDS, malaria, TB, acute respiratory infections, diarrhoeal disease and vaccine-preventable diseases, claiming altogether more than 14 million people per year (Brundtland, 2002) (Table 3). Despite the success of vaccination programmes for polio and many childhood diseases, other infections like AIDS, TB, malaria and dengue are still out of control in many developing countries. Children remain at high risk. Indeed, in 2002, of the 57 million deaths reported, 10.5 million deaths were among children of less than 5 years of age, of which 98% were in developing countries (Jones et al., 2003; WHO, 2003a, 2005) (Table 4).

3.1. AIDS

By the end of 2002, 22 million people had lost their lives to AIDS, and an estimated 34–46 million others are now infected with the virus (WHO, 2004). Ninety-five percent of all HIV infections occur

Table 3 Main causes of mortality due to infectious diseases, 2001 (in millions)

Disease	Deaths per year	% in developing countries
Respiratory infections	3.9	90.9%
AIDS	3.0	92.1%
Diarrhoeal diseases	1.9	97.7%
Tuberculosis	1.9	83.6%
Malaria	1.1	Nearly 100%

Source: WHO, 2003c.

Table 4 Leading causes of deaths in children in developing countries in 2002 (in thousands)

	No.	% of all deaths
Perinatal conditions	2375	23.1%
Lower respiratory infections	1856	18.1%
Diarrhoeal diseases	1566	15.2%
Malaria	1098	10.7%
Measles	551	5.4%
Congenital anomalies	386	3.8%
HIV/AIDS	370	3.6%
Pertussis	301	2.9%
Tetanus	185	1.8%
Protein-energy malnutrition	138	1.3%
Other causes	1437	14.0%
Total	10263	100%

Sources: Mathers et al., 2003; WHO, 2003a.

in developing countries, especially in sub-Saharan Africa, dramatically cutting life expectancy and leaving a legacy of millions of orphans. Seven countries already have a prevalence of HIV over 20% (Table 5). If the present trend persists, by 2020 AIDS will have caused more deaths than any other disease epidemic in history (WHO, 2003c). Even if a vaccine for HIV were discovered today, 40 million people would still die prematurely as a result of AIDS. In countries with a high prevalence of HIV/AIDS, devastating consequences are already strikingly apparent and life expectancy is dropping to below 40 years in some countries. Details of this alarming multidimensional problem can be found in the recent UN report (UN, 2004), which summarizes more than 200 studies devoted to the impact of HIV/AIDS on individuals, families and households; on agricultural sustainability; on business; on the health sector; on education; and on national economic growth.

Table 5 The most affected countries according to HIV prevalence in 2001

≥20%	10—20%	5—10%
Botswana 36.5%	Malawi 16.1%	Côte d'Ivoire 9.6%
Zimbabwe 33.9%	Kenya 15.0%	Rwanda 9.1%
Swaziland 33.7%	Centr Afric Rep 12.9%	Burundi 8.3%
Lesotho 30.1%	Mozambique 12.8%	Tanzania 7.8%
Namibia 22.2%	Cameroon 11.8%	Djibouti 7.1%
Zambia 21.6%		Congo 7.1%
South Africa 21.3%		Sierra Leone 6.7%
		Liberia 6.5%
		Ethiopia 6.5%
		Burkina Faso 6.4%
		Togo 6.0%
		Nigeria 5.8%
		Angola 5.5%

Source: UN, 2004.

3.2. Tuberculosis

Tuberculosis is among the top 10 causes of global mortality (Borgdorff et al., 2002; Dye et al., 1999). It has been estimated that approximately one-third of the world's population is infected with the tuberculosis bacillus, and that each year 8 million people develop tuberculosis disease and about 2 million die of it. The highest incidence rates are found in Africa and Southeast Asia. The HIV/AIDS epidemic and multidrug resistance have worsened the TB situation over the last two decades. Tuberculosis is a leading killer of people with HIV, and 80% of TB patients are HIV-positive in countries with high prevalence of HIV (Dye, 1999; Ruxin et al., 2005). It is estimated that TB costs more than US$3.3 billion a year in lost productivity.

3.3. Malaria

The WHO statistics indicate that malaria claims more than 1 million lives a year. Beyond mortality, the disease affects more than 300 million every year with a high handicapping rate. Children, pregnant women and vulnerable people in general are the most exposed. Moreover, malnutrition and other diseases like pulmonary infections constitute a favourable environment for the spread of malaria. Countries in tropical Africa bear the brunt of malaria, accounting for more than 90% of all cases occurring worldwide each year (Ruxin et al., 2005). The disease is estimated to cost Africa more than US$12 billion annually by its direct effect, but on top of that it has slowed economic growth in the region by 1.3% per year (Bartram et al., 2005).

3.4. Other communicable diseases

In 1999, it was estimated that preventable sexually transmitted diseases (STD) caused 340 million infections worldwide in the population aged 15—49 years. However, in the era of AIDS and the high level of politicization and priority given to HIV, other STDs may receive less attention. For instance, congenital syphilis for which tools of prevention have been available for decades is still endemic in many developing countries, contributing significantly to

the global burden in spite of the possibilities of cost-effective screening. In 1999, it was estimated that there were 4 million cases of syphilis among adults in sub-Saharan Africa, 3 million in Latin America and the Caribbean, and 4 million in South and Southeast Asia. WHO estimates that, each year maternal syphilis is responsible for 460 000 abortions or stillbirths, 270 000 cases of congenital syphilis and the birth of 270 000 low birthweight or premature babies. A special WHO bulletin was recently devoted to different aspects of syphilis. Hundreds of papers were reviewed to discuss economic and pragmatic aspects (Schmid, 2003), antenatal control (Hawkes et al., 2003), prevention and management (Saloojee et al., 2003), pathophysiology and treatment (Berman, 2003), and an overview of diagnostic tools for prevention and management (Peeling and Ye, 2003).

Although they lead to fewer deaths, CDs like lymphatic filariasis, influenza and sleeping sickness are causing millions of DALYs in developing countries (WHO, 2003c). Almost half the people in the developing world have one or more of the main diseases or infections associated with inadequate water supply and sanitation: diarrhoea, schistosomiasis, intestinal helminth infections, and trachoma (Bartram et al., 2005). According to the Scientific Working Group on Dengue (TDR, 2000), dengue disease will be one of the great emerging health challenges, recognized in over 100 countries, causing an estimated 50—100 million infections annually among the more than 2.5 billion people at risk.

4. Communicable and non-communicable diseases: the overlap

In studies of impact and burden of disease, it is not always easy to distinguish between CDs and NCDs. More generally, evaluation of disease burden is complicated by overlapping between different diseases and conditions. It is estimated that 26% of cancers in developing countries can be attributed to infectious agents. Liver, cervical, bladder and stomach cancers are particularly linked to infections (Mathers et al., 1999). For diabetes, it is well known that infections affect its management and conversely, uncontrolled diabetic people are more exposed to infectious diseases. Infections of eyes and feet are likely to increase the burden of diabetes especially at the stage of complications. Around 13 million people are co-infected with HIV and TB, making them many times more likely to develop active TB because of the deficiency of their immune systems. More generally, a multitude of diseases may contribute separately or jointly to physical and mental disability (Boutayeb and Chetouani, 2003).

5. Risk factors: the enemies to combat

Globally, many of the risk factors for heart disease, diabetes, cancer and pulmonary diseases are due to lifestyle and can be prevented. Physical inactivity, Western diet and smoking are prominent causes (Table 6).

- Tobacco is enemy number one (WHO, 2000). It is the most important established cause of cancer but also responsible in CVDs and chronic respiratory disease. In the twentieth century, approximately 100 million people died worldwide from tobacco-associated diseases such as cancer, chronic lung disease, diabetes and CVDs. Half of the 5 million deaths attributed to smoking in 2000 occurred in developing countries where smoking prevalence among men is nearly 50%.

Table 6 Burden of disease and risk factors worldwide in 1990 and 2001 (in millions)

Risk factor	DALYs (1990)	% of total DALY	DALYs (2001)	% of total DALY
Underweight	220	15.9	138	9.5
Poor water, hygiene, sanitation	93	6.8	54	3.7
Unsafe sex	49	3.5	92	6.3
Alcohol	48	3.5	58	4.0
Occupation	38	2.7	23	1.6
Tobacco	36	2.6	59	4.1
Blood pressure	19	1.4	64	4.5
Physical inactivity	14	1.0	27	1.9
Illicit drugs	8	0.6	11	0.7
Air pollution	7	0.5	19	1.3

DALY: disability adjusted life year.
Sources: Burden of Disease Unit, 1990; Mathers et al., 2003; WHO, 2003a.

Today, 80% of the 1.2 billion smokers in the world live in poorer countries and, while tobacco consumption is falling in most developed countries, it is increasing in developing countries by about 3.4% per annum. However, albeit these striking facts, the majority of developing countries which signed the Framework Convention on Tobacco Control (FCTC) (Joossens, 2000) remain passive about the control of smoking.

- Obesity and dietary habits represent potential risk factors for CVDs (Kenchaiah et al., 2002), type 2 diabetes (Drewnowski and Specter, 2004), and some types of cancer (Key, 2002), especially in absence of physical activity (Derouich and Boutayeb, 2002; WHO, 2003b). Recent studies reported that regular fish consumption is associated with a reduced risk of death from all causes as well as CVD mortality (Stampfer, 2000). Unfortunately, fish consumption is very low, even in a country like Morocco, known for its large stock spread along a coast of 350 000 km but consuming only 8 kg/inhabitant/year. Similarly, intake of an adequate quantity of fresh fruit and vegetables is recommended to help reduce the risk of coronary disease, stroke and high blood pressure (WHO, 2002). But, once more, this is thwarted by the Western lifestyle invading developing countries, joined with the fact that governments in developing countries tend to export fruit and vegetables in exchange for foreign currency.
- Alcohol causes more than 2 million deaths every year in the world. It is particularly associated with liver disease and oesophageal cancer. The increase in alcohol consumption in developing countries will add other hazards caused by violence and road accidents to the burden of disease.
- For CDs, potential risk factors are malnutrition, unsafe sexual contacts, environmental conditions and precariousness of sanitation and hygiene. Common childhood infections kill more than 10 million annually (Black et al., 2003), with malnutrition associated with at least half of the preventable childhood deaths. According to the Helsinki Track Report (Chen, 2004), most of these infectious diseases are preventable as well as the 3 million deaths caused annually by TB and malaria.

6. Development, poverty reduction, and health: a high correlation

In developing countries, until recently, it was widely believed that economic development was a necessary prerequisite for improving a population's health status, and health was often classified as a non-productive sector. But, recent evidence showed that improved health is more than a consequence of development. It is a central input into economic and social development and poverty reduction. Special attention is being devoted to this relationship between development and health (Ezzati et al., 2005; Freedman et al., 2005). More and more publications are dealing with health of the poor (Sanchez and Swaminathan, 2005), health equity and health as a cornerstone of sustainable development (Boutayeb, 2004). According to the authors of Dying for Growth (Kim et al., 2000), economic growth, far from being a panacea, often accelerates the suffering of poor and marginalized people. The authors highlight the 'deadly synergy between poverty and AIDS' and relate other experiences concerning TB, malaria and other diseases under the economic structural adjustment policies. In another publication (McMichael and Kjellstrom, 2002), recalling the principles of the Rio Declaration stating that humans are at the centre of concerns for sustainable development and the need to eradicate poverty, the authors state that human population health becomes more than either a determinant or an incidental consequence of economic development, it becomes a central criterion. In the same direction, health innovation is expected to be the best solution for dealing with diseases of the poor in developing countries (Mashelkar, 2005). Empirical evidence on how investing in health can achieve economic development and poverty reduction was given in the report published by the Commission on Macroeconomics and Health in 2001. It was suggested that added investments in health could save at least 8 million lives each year by the end of the decade, resulting in economic benefits adding up to more than US$ 360 per year by 2015 (Brundtland, 2002).

7. Health and the Millennium Development Goals

Reducing child mortality by two-thirds relative to 1990, improving maternal health, including reducing maternal mortality by three-quarters, and preventing the spread of HIV/AIDS, malaria, and other diseases, were three goals amongst eight fixed in the Millennium Development Goals (MDG), and adopted by the UN Millennium Summit in 2000 (Sachs and McArthur, 2005), in order to address extreme poverty in its many dimensions, while promoting education, gender equality, environmental

sustainability and global partnership for development.

A recent cost-benefit analysis by WHO showed that achieving the global MDG target in water and sanitation would bring substantial economic gain in both health and other benefits (consequences of reduction in diarrhoeal episodes): each $1 invested would yield an economic return between $3 and $34 depending on region. The health-related costs avoided would reach $7.3 billion per year, and the annual value of adult working days gained as a result of less illness would be almost $750 million. More generally, tens of thousands of deaths can be avoided and billions of dollars saved by achieving the MDGs in developing countries. Unfortunately, at the 5-year juncture, many regions of the world, most notably in sub-Saharan Africa, but also in Latin America, the Middle East and North Africa, have made little headway in reducing the rates of extreme poverty and making progress in the MDGs targeted for 2015 (Sachs and McArthur, 2005). However, as indicated by the series of papers devoted to the Millennium Project and published recently by *The Lancet* in Volume 365, the goals can still be achieved if urgent action is taken to deal with the problems encountered, namely: poor governance in middle- and low-income countries, pervasive problems of the poverty trap, lack and absence of human capacity, and policy neglect, where policy makers are unaware of what to do, or neglectful of core public issues (Juma and Yee-Cheong, 2005).

8. Conclusions

There is an urgent need to develop efficient preventative strategies to halt the growing trend of CDs and NCDs through the control of risk factors like smoking, alcohol, obesity, diet and inactivity, sexual contacts and environmental factors in general. Considering the level of poverty and the cost of prevention and management of chronic diseases, the most affected countries are unable to cope with the burden of disease. For health strategies to be successful, international solidarity and public-private partnerships are needed to tackle the problems of shortage and lack of treatments, resistance, and the need for new drugs, vaccines and diagnostic procedures. Several programmes dealing with HIV/AIDS, TB, malaria and others, have already been launched. However, this global strategy is insufficient without national and local involvement. Health decision makers, non-governmental organizations, research institutions, community groups and individuals must co-ordinate their efforts in order to attenuate the incidence of specific diseases, control the spread of epidemics and development of complications, and optimize the health management of human and material resources.

Conflicts of interest statement

The author has no conflicts of interest concerning the work reported in this paper.

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References

Ait-Khaled, N., Enarson, D., Bousquet, J., 2001. Chronic respiratory diseases in developing countries: the burden and strategies for prevention and management. Bull. World Health Organ. 79, 971—979.

Alwan, A., 1997. Non-communicable diseases: a major challenge to public health in the region. East Mediterr. Health J. 3, 6—16.

Bartram, J., Lewis, K., Lenton, R., Wright, A., 2005. Focusing on improved water and sanitation for health. Lancet 365, 810—812.

Berman, S.M., 2003. Maternal syphilis: pathophysiology and treatment. Bull. World Health Organ. 82, 433—438.

Black, R.E., Morris, S.S., Bryce, J., 2003. Where and why are 10 million children dying every year? Lancet 361, 2226—2234.

Borgdorff, M.W., Floyd, K., Broekmans, J.F., 2002. Interventions to reduce tuberculosis mortality and transmission in low- and middle-income countries. Bull. World Health Organ. 80, 217—227.

Boutayeb, A., 2004. Sustainable development and diseases in developing countries, in: Boutayeb, A., Chetouani, A., Maamri, A. (Eds), Proceedings of the International Symposium on Health and Biomedical Research Interaction. HILAL Press, Oujda, pp. 109—121.

Boutayeb, A., Boutayeb, S., 2005. The burden of non communicable diseases in developing countries. Int. J. Equity Health 4, 2.

Boutayeb, A., Chetouani, A., 2003. Dynamics of a disabled population in Morocco. Biomed. Eng. Online 2:2. www.biomedical-engineering-online.com/content/2/1/2.

Boutayeb, A., Twizell, E.H., 2004. An age structured model for complications of diabetes mellitus in Morocco. Simul. Model. Pract. Th. 12, 77—87.

Boutayeb, A., Twizell, E.H., Achouyab, K., Chetouani, A., 2004. A mathematical model for the burden of diabetes and its complications. Biomed. Eng. Online 3:20. www.biomedical-engineering-online.com/content/3/1/20.

Brundtland, G.H., 2002. Health and development: A sustainable approach. Canadian J. Policy Res. 3, 37—42, Also available from www.isuma.net/v03n02/index_e.shtml.

Burden of Disease Unit, 1990. The Global Burden of Disease in 1990. Harvard University Press, Cambridge, MA.

Chen, L., 2004. Health as a Human Priority for the 21st Century. Helsinki Process Track Report, Paper for Human Security Track III.

Derouich, M., Boutayeb, A., 2002. The effect of physical exercise on the dynamics of glucose and insulin. J. Biomech. 35, 911—917.

Drewnowski, A., Specter, S.E., 2004. Poverty and obesity: The role of energy density and energy costs. Am. J. Clin. Nutr. 79, 6—16.

Dye, C., 1999. Tuberculosis 2000—2010: control but not elimination. Int. J. Tuberc. Lung Dis. 4 (Suppl. 2), S146—S152.

Dye, C., Scheele, S., Dolin, P., Pathania, V., Raviglione, M.C., 1999. Consensus statement. Global burden of tuberculosis: estimated incidence, prevalence, and mortality by country. WHO Global Surveillance and Monitoring Project. JAMA 282, 677—686.

Ezzati, M., Hoorn, S.V., Lawes, C.M.M., Leach, R., James, W.P.T., Lopez, A.D., Rodgers, A., Murray, C.J.L., 2005. Rethinking the 'Diseases of Affluence' Paradigm: Global Patterns of Nutritional Risks in Relation to Economic Development. PloS Med 2, e133 [online].

Freedman, L.P., Waldman, R.J., de Pinho, H., Wirth, M.E., Chowdhury, A.M.R., Rosenfield, A., 2005. Transforming health systems to improve the lives of women and children. Lancet 365, 997—1000.

Hawkes, S., Miller, S., Rechenbach, L., Nayyar, A., Buse, K., 2003. Antenatal syphilis control: people, programmes, policies and politics. Bull. World Health Organ. 82, 417—423.

IDF, 2003. Action Now: A joint initiative WHO and IDF. International Diabetes Federation. www.idf.org/home/index.cfm?node=1079.

James, P.T., Leach, R., Kalamara, E., Shayeghi, M., 2001. The worldwide obesity epidemic. Obes. Res. 9 (Suppl. 4), S228—S233.

Jones, G., Steketee, R.W., Black, R.E., Bhutta, Z.A., Morris, S.S., Bellagio Child Survival Study Group, 2003. How many child deaths can we prevent this year? Lancet 362, 159—164.

Joossens, L., 2000. From public health to international law: possible protocols for inclusion in The Framework Convention on Tobacco Control. Bull. World Health Organ. 78, 930—937.

Juma, C., Yee-Cheong, L., 2005. Reinventing global health: the role of science, technology, and innovation. Lancet 365, 1105—1107.

Kenchaiah, S., Evans, J.C., Levy, D., Wilson, P.M., Benjamin, E.J., Larson, M.G., Kannel, W.B., Vasan, R.S., 2002. Obesity and the risk of heart failure. N. Engl. J. Med. 347, 305—313.

Key, T.J., 2002. The effect of diet on risk of cancer. Lancet 360, 861—868.

Kim, J.K., Mullen, J.V., Irwin, A., Gershman, J. (Eds), 2000. Dying for Growth: Global Inequality and the Health of the Poor. Common Courage Press, Monroe, Maine.

Lenfant, C., 2001. Can we prevent cardiovascular diseases in low- and middle-income countries? Bull. World Health Organ. 79, 980—987.

Mashelkar, R.A., 2005. Nation building through science and technology: A developing world perspective. 10th Zuckerman Lecture. Innov. Strat. Today 1, 16—32.

Mathers, C.D., Bernard, C., Iburg, K.M., Inoue, M., Fat, D.M., Shibuya, K., Stein, C., Parkin, D.M., Pisani, P., Ferlay, J., 1999. Global Cancer Statistics. CA Cancer J. Clin. 49, 33—64.

Mathers, C.D., Bernard, C., Iburg, K.M., Inoue, M., Fat, D.M., Shibuya, K., Stein, C., Tomijima, J., Xu, H., 2003. Global Burden of Disease in 2002: data sources, methods and results. World Health Organization, Geneva, Global Programme on Evidence for Health Policy Discussion Paper No. 54.

McMichael, A.J., Kjellstrom, T., 2002. Sustainable Development. Global Environmental Change and Public Health. Canadian J Polic Res 3, 43—50, Also available from www.isuma.net/v03n02/index_e.shtml.

Murray, C.J.L., Lopez, A.D., 1996. The global burden of disease: a comprehensive assessment of mortality and disability from diseases, injuries and risk factors in 1990 and projected to 2020. Harvard School of Public Health, Cambridge, MA.

Peeling, R.W., Ye, H., 2003. Diagnostic tools for preventing and managing maternal and congenital syphilis: an overview. Bull. World Health Organ. 82, 439—446.

Reddy, K.S., 2002. Cardiovascular diseases in the developing countries: dimensions, determinants, dynamics and directions for public health action. Public Health Nutr. 5, 231—237.

Reddy, K.S., Yusuf, S., 1998. Emerging epidemic of cardiovascular diseases in developing countries. Circulation 97, 596—601.

Ruxin, J., Paluzzi, J.E., Wilson, P.A., Tozan, Y., Kruk, M., Teklehaimanot, A., 2005. Emerging consensus in HIV/AIDS, malaria, tuberculosis, and access to essential medicines. Lancet 365, 618—621.

Sachs, J.D., McArthur, J.W., 2005. The Millennium Project: a plan for meeting the Millennium Development Goals. Lancet 365, 347—353.

Saloojee, H., Velaphi, S., Goga, Y., Afadapa, N., Steen, R., Lincetto, O., 2003. The Prevention and management of congenital syphilis: an overview and recommendations. Bull. World Health Organ. 82, 424—430.

Sanchez, P., Swaminathan, M.S., 2005. Hunger in Africa: the link between unhealthy people and unhealthy soils. Lancet 365, 442—444.

Schmid, G., 2003. Economic and programmatic aspects of congenital syphilis prevention. Bull. World Health Organ. 82, 402—409.

Shibuya, K., Mathers, C.D., Boshi-Pinto, C., Lopez, A.D., Murray, C.J.L., 2002. Global and regional estimates of cancer mortality and incidence by site: II. Results for the global burden of disease 2000. BMC Cancer 2:37. Also available from www.biomedcentral.com/1471-2407/2/37.

Stampfer, M.J., 2000. Primary prevention of coronary heart disease in women through diet and life style. N. Engl. J. Med. 343, 16—22.

Tazi, M., Abirkhalil, S., Chaouki, N., Cherkaoui, S., Lahmouz, F., Srairi, J., Mahjour, J., 2003. Prevalence of the main cardiovascular risk factors in Morocco: results of a national survey in 2000. J. Hypertens. 21, 897—903.

TDR, 2000. Recommendations of the Scientific Working Group on Dengue. Meeting Report. UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases, Geneva, TDR/DEN/SWG/00.1.

UN, 2004. The impact of AIDS. United Nations Department of Economic and Social Affairs/Population Division, Geneva, World Population Prospects.

WHO, 2000. This month's special theme: Tobacco. Bull. World Health Organ. 78, part 7.

WHO, 2002. Reducing Risk: Promoting Health Life. World Health Organization, Geneva, Annual Report.

WHO, 2003a. Today's challenges. World Health Organization, Geneva, Annual Report.
WHO, 2003b. Diet, Nutrition and the prevention of Chronic Diseases. World Health Organization, Geneva, Technical Report Series No. 916.
WHO, 2003c. Global defence against the infectious diseases threat. World Health Organization, Geneva, WHO/CDS/2003.15.
WHO, 2004. Changing history. World Health Organization, Geneva, Annual Report.
WHO, 2005. Make every mother and child count. World Health Organization, Geneva, Annual Report.
Yusuf, S., Reddy, K.S., Ounpu, S., Anand, S., 2001. Global burden of cardiovascular diseases: Part I: General considerations, the epidemiological transition, risk factors, and impact of urbanization. Circulation 104, 2746—2753.