Chronic Diseases: Chronic Diseases and Development 3

Tackling of unhealthy diets, physical inactivity, and obesity: health effects and cost-effectiveness

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The obesity epidemic is spreading to low-income and middle-income countries as a result of new dietary habits and sedentary ways of life, fuelling chronic diseases and premature mortality. In this report we present an assessment of public health strategies designed to tackle behavioural risk factors for chronic diseases that are closely linked with obesity, including aspects of diet and physical inactivity, in Brazil, China, India, Mexico, Russia, and South Africa. England was included for comparative purposes. Several population-based prevention policies can be expected to generate substantial health gains while entirely or largely paying for themselves through future reductions of health-care expenditures. These strategies include health information and communication strategies that improve population awareness about the benefits of healthy eating and physical activity; fiscal measures that increase the price of unhealthy food content or reduce the cost of healthy foods rich in fibre; and regulatory measures that improve nutritional information or restrict the marketing of unhealthy foods to children. A package of measures for the prevention of chronic diseases would deliver substantial health gains, with a very favourable cost-effectiveness profile.

Lancet 2010; 376: 1775–84

Published Online November 11, 2010 DOI:10.1016/S0140-6736(10)61514-0

See Comment *Lancet* 2010; **376:** 1619–21

See Online/Comment DOI:10.1016/S0140-6736(10)61856-9, and DOI:10.1016/S0140-6736(10)61891-0

This is the third in a Series of five papers about chronic diseases

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Introduction

The action plan devised by WHO as part of the global strategy for the prevention and control of non-communicable diseases[1] focuses on four chronic diseases that account for 60% of deaths worldwide: cardiovascular disease, cancer, diabetes, and respiratory disorders. Prominent yet largely preventable behavioural risk factors associated with these diseases—either directly or indirectly via risk factors such as increased blood pressure or cholesterol concentrations—include tobacco, harmful alcohol use, unhealthy diets, physical inactivity, and obesity.

Underpinned by the forces of globalisation—including increased amounts of international trade, travel, and shared communication—the obesity epidemic is rapidly becoming a worldwide problem.[2] Before 1980, obesity rates were generally much lower than 10%. Since then, rates have doubled or tripled in many countries, and in more than half of countries of the Organisation for Economic Co-operation and Development (OECD), 50% or more of the population is overweight. Mexico's population is one of the most affected. Between 2000 and 2006, the prevalence of overweight (body-mass index [BMI] ≥25 kg/m²) increased from 62·1% to 69·9%, and the prevalence of obesity from 23·7% to 30·4%.[3] In China, where rapid changes in dietary habits are exacting a large toll,[4] overweight rates doubled from 13·5% to 26·7% between 1991 and 2006, and the number of people who are obese tripled from 1·1% to 3·2%.[5] The prevalence of diabetes in China is estimated to be as high as that in the USA, with more than 92 million cases.[6] In Brazil, obesity rates tripled in men and almost doubled in women between 1975 and 2003.[7] Smaller increases in overweight were recorded in India (rates for women rose from 10·6% to 12·6% between 1998–99 and 2005–06), but increases were steepest in urban areas in the west of the continent, where rates approached 40% in the early 2000s, almost doubling in less than 10 years.[8] Overweight and obesity are now the prominent features of malnutrition in South Africa,[9] where a third of women and a tenth of men are obese,[10] with highest rates in black women and white men. After the political and economic transition, rates of obesity rose also in Russia, where one in four women and one in ten men are now obese, and rates are projected to grow fast in the coming years.[10]

Key messages

- Cost-effective interventions aimed at tackling obesity by improving diets and increasing physical activity could usefully be added to a package of measures designed to deal with chronic diseases in low-income and middle-income countries.
- Price interventions and regulation can produce the largest health gains in the shortest timeframe. Interventions in primary care can be very effective in countries with less capacity constraints.
- A strategy of several interventions would generate substantially larger health gains than would individual interventions, often with a favourable cost-effectiveness profile.
- Health gains from interventions targeting children occur in the long term. Regulation of food advertising to children can be more effective and efficient than can school-based health promotion.
- Private-sector initiatives might contribute to tackling some risk factors while alleviating the burden on public-sector budgets, but more evidence of their effectiveness is needed.

The gap between available and required resources to tackle the global burden of obesity and chronic diseases is already very large and, on present trends, is set to grow further. In addition to making new resources available to address chronic diseases on a large scale—eg, via tobacco or alcohol tax levies—there is a consequent need to improve the use of existing resources to ensure adequate returns in terms of health, longevity, and economic progress. Cost-effectiveness information, together with strong financial and budgetary analysis, has a key part to play in identification of core packages of chronic disease interventions that can be realistically scaled up in countries at different levels of income, thus contributing to the business case for large-scale investment and action. Much of the latest available economic evidence in support of interventions that tackle effectively key risk factors for non-communicable diseases was reviewed in a preceding Series on chronic disease in *The Lancet*.[11–13] In this third report in the Series about chronic diseases, we present new findings relating to the efficiency of interventions aimed at tackling the rapidly escalating obesity epidemic (via healthier dietary habits and increased amounts of physical activity), and set these findings in the context of latest available economic evidence for other risk-factor prevention strategies for non-communicable diseases.

Model of the health effects of diet, physical activity, and obesity

The OECD and WHO jointly developed a microsimulation model (chronic disease prevention [CDP] model) that implements a so-called causal web of lifestyle risk factors for selected chronic diseases. This model was initially applied to the European A WHO region, under the scrutiny of an expert group convened by the OECD.[14] A microsimulation approach is best suited to addressing questions that would be difficult or impossible to answer through empirical investigation. In the assessment of the long-term population-level effects and costs of preventive interventions that target a complex group of time-dependent and interacting risk factors, an empirical study would need many variables, a very large study population, and a very long follow-up to record results that in some cases are only realised over a lifetime.

Risk factors in the CDP model range from more distant exposures (so-called distal risk factors), which are several steps away from disease events in the chain of causation, to proximate exposures (so-called proximal risk factors), which are more immediately connected to disease events. Figure 1 shows the key relations between risk factors and chronic diseases that are addressed by the CDP model. In the causal web concept there are mutual interactions between risk factors, which therefore have both direct and indirect effects on chronic diseases. The model explicitly accounts for three groups of chronic diseases: stroke, ischaemic heart disease, and cancer (including lung, colorectal, and female breast cancer). Proximal risk factors, such as high blood pressure, cholesterol, and blood glucose, have a direct effect on the probability of developing these three chronic diseases, on the basis of established pathophysiological mechanisms. Conversely, distal risk factors such as low intake of fruit and vegetables, high fat intake, and insufficient physical activity have an indirect effect on chronic diseases, which was modelled on the basis of the existing empirical evidence. The indirect effect is mediated partly by BMI, which acts on proximal risk factors and directly on

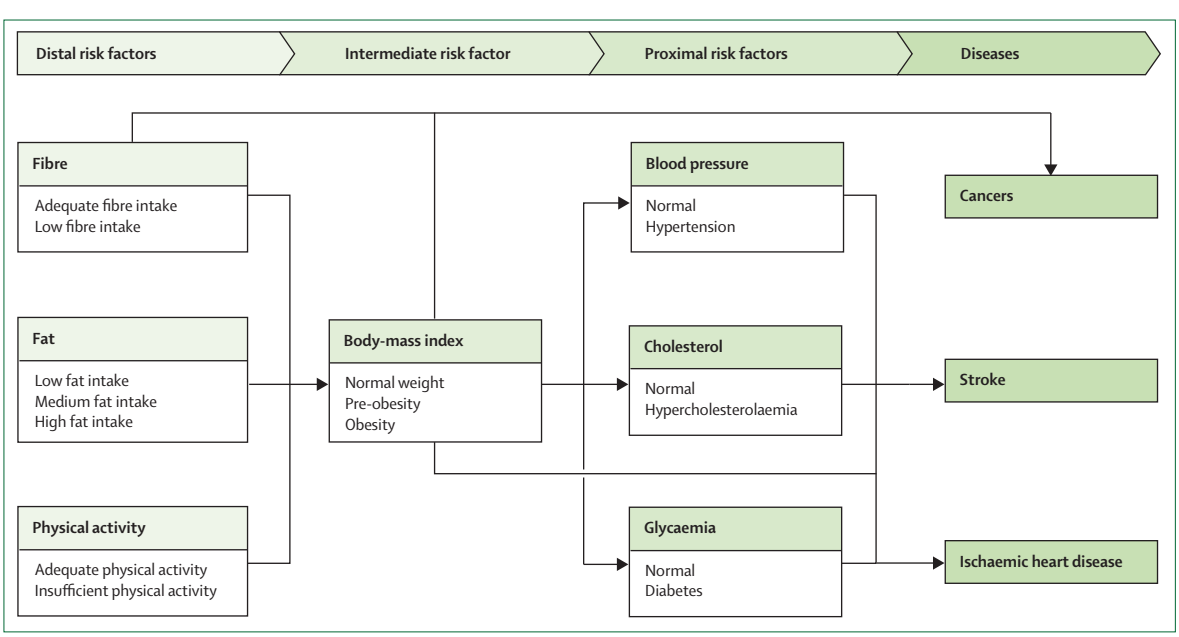

Figure 1: **Causal web for risk factors and disease events implemented in the chronic disease prevention model**

disease events. The model accounts for mortality from all causes of death and assumes that mortality rates associated with diseases that are not explicitly modelled remain stable at the rates recorded in the relevant populations. Incidence and prevalence of disease in the population of a specific country were matched to recorded (marginal) distributions of risk factors via a calibration procedure, which ensured that the observed distributions were mutually compatible and consistent. The model simulates the dynamics of a specific country or regional population over a lifetime (set at 100 years to capture the full effectiveness of all interventions, including those targeting young children), although effects can be assessed at any time.

The choice of different endpoints to present the effects of interventions in this report is meant to draw attention to the differences in cost-effectiveness over time. However, results should not be interpreted as future projections, since we made no attempt to account for factors potentially affecting disease dynamics other than policy-induced changes in risk factor distributions. Births, deaths, and the incidence and prevalence of risk factors and chronic diseases are modelled accordingly, on the basis of best existing epidemiological evidence for the relevant countries from a range of sources, including national health surveys, published studies, and datasets from WHO, the UN Food and Agriculture Organization, and the International Agency for Research on Cancer. Further details about the modelling approach are available elsewhere,[14] and webappendix pp 1–8 provides a list of input data sources. Webappendix pp 9–11 shows the age-distributions of selected relative risks.

Governments in countries at different levels of income have considered or implemented interventions to improve diets, increase physical activity, and tackle obesity.[15] Findings from a WHO review of the effectiveness of such interventions[16] showed that school-based interventions are most often assessed, whereas few studies focused on other public health interventions and hardly any were from low-income settings. On the basis of this WHO review and further studies published after its conclusion, or investigating interventions not covered in the review, we put together a small but important evidence base for the effect of several health interventions on individual health-related behaviours, obesity, and other risk factors for chronic diseases. The interventions assessed in the model-based analysis are those for which evidence of effectiveness is available. Interventions for which evidence is scarce were excluded, even if they were part of the public debate about chronic disease prevention. The interventions assessed were: school-based health promotion interventions, worksite health promotion interventions, mass media health promotion campaigns, counselling of individuals at risk in primary care, fiscal measures affecting the prices of fruit and vegetables and foods high in fat, regulation of food advertising to children, and compulsory food labelling.

Additionally, a prevention strategy including several of the above interventions (a mass media campaign, fiscal measures, food advertising regulation, and food labelling) was assessed on the basis of the assumption that the effects of the individual interventions, measured in terms of relative risks of risk factors or chronic diseases, would combine multiplicatively.

Table 1 summarises the main characteristics of these interventions in the relevant countries, as modelled in the analysis. These characteristics are indicative of those of the interventions assessed in existing experimental and observational studies, and not necessarily those of interventions which specific countries might have adopted or might contemplate to adopt. Whereas individual-level effectiveness is based mostly on studies from high-income settings (as discussed in webappendix pp 12–15), country-specific information was used to establish potential population coverage (eg, the proportion of the population working for large employers in worksite interventions) and to adapt effectiveness to the local population distribution of risk factors (eg, rates of television viewing by children in regulation of food advertising). Interventions were implemented in the CDP model by applying the effects on risk factors shown in table 1 to the relevant target age groups, taking into account the likely coverage of the same age groups. The effects would then progressively affect more proximal risk factors, older age groups, and new birth cohorts as the simulation develops.

See Online for webappendix

Costs of interventions were considered both at the level of personal use of health services—such as hospital or primary care visits, prescribed drugs, or diagnostic tests undertaken[17,18]—and at the programme level (which includes administration, training, mass media, and other activities taking place above the level of health-care facilities).[19,20] A standardised approach was used, requiring information about the quantities of physical inputs needed and their respective unit cost (ie, total costs are quantities of inputs multiplied by their unit costs). All costs are reported in US dollars, with 2005 the chosen base year, so as to provide results uniformly expressed in a currency that is widely used in trade and international aid. Future costs and future health effects were discounted at a 3% rate.

Analyses were undertaken for a set of six low-income and middle-income countries presenting a high burden of chronic diseases: Brazil, China, India, Mexico, Russia, and South Africa. These countries were selected because of their size and prominence in the relevant regions, and because of a greater availability of detailed input data than for other countries. Additionally, results are presented here for England to draw attention to similarities and differences between settings at different levels of income, presenting different distributions of risk factors, health-system characteristics, and costs.

Effect of diet and physical activity interventions on health outcomes and expenditures

Interventions to tackle obesity by improving diets and increasing physical activity have the potential to reduce the incidence of ischaemic heart disease and stroke and, to a lesser extent, the incidence of at least three types of cancer. The effect of interventions on morbidity, in terms of numbers of years lived without chronic diseases, is generally larger than their effect on mortality. Interventions tend to delay the onset of chronic diseases, rather than prevent them altogether, which means that effects on morbidity are best assessed by calculation of numbers of disability-adjusted life-years (DALYs) averted. The number of cases of chronic diseases will drop in some age groups, but they will probably rise at older ages, as the onset of diseases is postponed by preventive interventions, partly offsetting the initial decrease. For example, a multiple-intervention strategy will prevent one case of ischaemic heart disease for every 230 (Russia) to 2400 (South Africa) people over their life-course; one case of stroke for every 370 (China) to 2800 (India) people; and one case of lung, colorectal, or female breast cancer for every 2000 (Russia) to 22 700 (South Africa) people.

240 000–740 000 life-years can be gained every year in the seven countries through different interventions, relative to a situation in which no prevention policies were in place and no standard care was offered in the relevant settings to a proportion of people developing chronic diseases who have access to medical care. The sum of DALYs averted ranges from 240 000 to 920 000, with the least gains obtained through health-promotion campaigns delivered via the mass media and the largest gains through regulation of food advertising to children (figure 2). However, most of the gains generated by the regulation of food advertising are concentrated in the final years of the simulation. When health gains are appropriately discounted over time, most interventions show higher effectiveness than that for regulation of food advertising throughout most of the simulation period (figure 3 and table 2). Only in the final years does advertising regulation catch up with interventions that rank highest in terms of cumulative effectiveness, such as counselling in primary care and fiscal measures involving a combination of subsidies on fruit and vegetables and taxes on foods that are high in fat.

Interventions targeting adults start to generate health effects immediately after their implementation, and benefits are even faster for interventions that narrowly target high-risk individuals and age groups, such as primary-care-based counselling. Conversely, interventions targeting children, including regulation of food

	School-based intervention	Worksite interventions	Mass media campaigns	Fiscal measures	Physician counselling	Food advertising regulation	Food labelling
Target population							
Target group	School children	Large employers	..	..	BMI ≥25 kg/m² or high cholesterol/SBP, diabetes	..	Label users
Target age range (years)	8–9	18–65	≥18	≥0	22–65	2–18	≥0
Target as % of population	1·7–4·2%	3·4–15·7%	61·1–80·4%	100%	1·1–14·7%	19·3–36·5%	100%
Effect sizes							
Fibre consumption (g per day)	37·6	45·6	18·4	3·6–10·4	..	..	9·87
Fat (% total energy)	–1·64%	–2·2%	..	–0·4% to –0·6%	–1·6%	..	–0·36%
Physical activity (% of people who are active)	..	11·9%	2·4%	..	..	..	..
BMI (kg/m²)	–0·2	–0·5	..	..	–0·83	–0·03 to –0·78	–0·02
Cholesterol (mmol/L)	..	..	..	..	–0·12	..	..
SBP (mm Hg)	..	..	..	..	–2·3	..	..
Cost per head (2005 US$)							
Brazil	0·82	0·82	0·27	0·01	1·71	0·04	0·15
China	0·53	0·20	0·37	*	0·47	*	0·05
England	1·41	5·48	2·32	0·11	10·12	0·30	1·05
India	0·73	0·17	0·29	*	0·20	*	0·05
Mexico	1·22	1·70	0·45	0·02	4·40	0·09	0·23
Russia	0·51	0·86	0·80	0·02	2·70	0·13	0·22
South Africa	0·99	0·40	0·67	0·02	1·05	0·08	0·22

BMI=body-mass index. SBP=systolic blood pressure. *Cost per head is less than US$0·01.

Table 1: **Summary of coverage, main effects, and costs of selected preventive interventions**

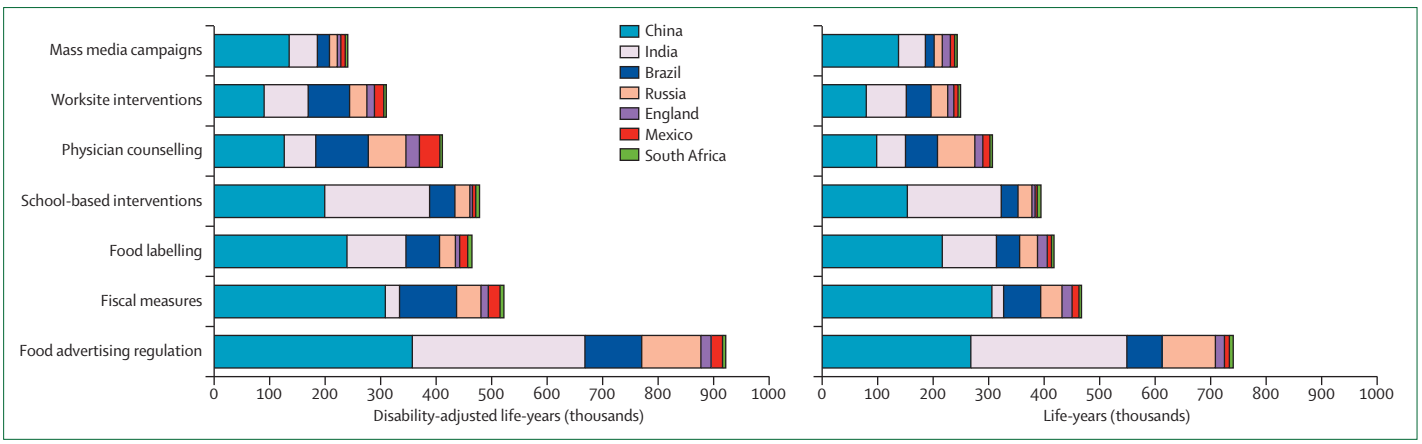

Figure 2: **Health outcomes at the population level (average effect per year)**

advertising and school-based health promotion, are unlikely to have any meaningful effects within populations for at least 40–50 years. However, provided that some of the behavioural changes produced by regulation of food advertising to children can be maintained over their life-course, the overall benefits of this intervention, in the end, will be as large as those of some of the most effective interventions targeting adults. School-based interventions are likely to have a modest, although not negligible, effect, at least on the basis of evidence about their effects on individual behaviours. A multiple-intervention strategy would generate health gains roughly twice as large as the most effective single intervention, apart from in Mexico and in Russia, where primary-care interventions (not included in the multiple-intervention strategy) can be especially effective.

The health effects of interventions vary between age groups. Health gains for people younger than 40 years are barely noticeable, whereas the largest benefits tend to be realised in people aged 40–80 years, or those aged 40–70 years in countries with a short life expectancy. In this older age group, interventions tend to delay the onset of chronic diseases more than they reduce mortality from these diseases. This pattern is indicative of larger numbers of DALYs averted than life-years gained in the same age group. From the seventh or eighth decade of life, the primary effect of interventions is increased survival for those who benefited from a delayed onset of chronic diseases or had no disease. In this age group, the life-years gained through counselling in primary care in China are 7% more than the DALYs averted, and the difference is 24% for advertising regulation in Brazil. The effects of interventions on health-care expenditures are indicative of the patterns of effectiveness we describe in this report. Interventions have almost no effects on expenditure up to 40 years of age; they reduce health expenditures between ages 40 and 80 years, and they raise expenditure in later years of life because of enhanced survival and need

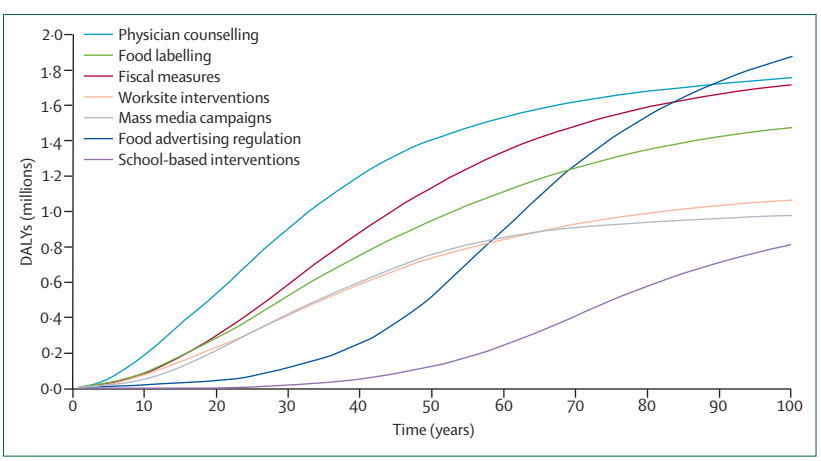

Figure 3: **Cumulative disability-adjusted life-years (DALYs) gained over time**

for medical care. The increase in health expenditure in the oldest age groups is in most cases directly proportional to the decrease in expenditure realised at earlier ages.

The costs associated with the delivery of interventions are substantially lower in low-income and middle-income than in high-income settings (table 1). Of the countries considered in this analysis, India has the lowest intervention costs. Costs are, on average, four times higher in Mexico than in India, and almost seven times higher in England, after accounting for differences in purchasing power between countries. These variations have important implications. Whereas in high-income settings intervention costs often exceed reductions in health-care expenditure by a large amount, in settings of low and middle income the opposite finding is often true for interventions such as fiscal measures and food labelling. Conversely, reductions in health-care expenditures cannot be expected to pay for interventions such as counselling in primary care and health promotion at school and in the workplace. Additionally, although investments in prevention need

	Brazil		China		England		India		Mexico		Russia		South Africa	
	DALYs	CE*	DALYs	CE*	DALYs	CE*	DALYs	CE*	DALYs	CE*	DALYs	CE*	DALYs	CE*
20 years														
School-based interventions	4	†	10	704 863	0	†	8	†	3	†	12	830 177	3	†
Worksite interventions	1187	8270	399	7785	1725	45 630	405	6151	644	37 912	1759	6187	254	25 409
Mass media campaigns	627	5074	688	7188	1361	25 897	246	15 552	533	6858	811	12 911	421	23 221
Fiscal measures	1642	CS	1027	CS	1496	CS	139	CS	509	CS	1696	CS	528	CS
Physician counselling	2805	8503	864	9390	5562	25 284	523	6155	2796	23 811	6988	5982	719	23 841
Food advertising regulation	38	CS	145	556	245	25 672	49	3186	112	11 151	288	5718	89	13 241
Food labelling	1030	9962	779	71	1134	12 577	495	952	358	3974	1176	396	389	7953
50 years														
School-based interventions	170	93 350	337	35 174	245	152 989	232	59 665	83	235 957	696	26 114	152	153 233
Worksite interventions	3323	3541	1383	3393	6078	20 506	939	4491	2175	16 932	5929	2926	739	14 561
Mass media campaigns	1803	1994	2500	3177	4025	13 796	670	8575	1530	2778	2914	5822	1047	15 211
Fiscal measures	5483	CS	3909	CS	6049	CS	355	CS	1978	CS	5898	CS	1725	CS
Physician counselling	7163	5156	2306	5718	14 776	15 731	1045	5553	7477	15 108	16 644	4331	1739	16 591
Food advertising regulation	988	CS	1314	CS	2179	4278	752	332	658	3415	5823	552	610	3352
Food labelling	3259	CS	2805	CS	4019	5268	1089	776	1304	CS	4099	CS	1157	3927
Cost-effectiveness threshold (US$/DALY)‡	..	15 000	..	5000	..	50 000‡	..	2500	..	20 000	..	15 000	..	15 000

DALYs=disability-adjusted life-years saved per million population. CE=cost-effectiveness. CS=cost-saving. *Cost-effectiveness ratios are expressed in US$ per DALY averted, and represent the net cost of gaining 1 additional year of healthy life, relative to a no prevention or treatment-only scenario. †Cost-effectiveness ratio is higher than US$1 000 000 per DALY. ‡For countries other than England, the guideline amount of three times gross domestic product per head (US$2005) is used as a cost-effectiveness threshold. In England, US$50 000 DALY is a threshold commonly adopted by the UK's National Institute for Health and Clinical Excellence to denote that an intervention is cost effective.

Table 2: **Effectiveness and cost-effectiveness of interventions after 20 years and 50 years**

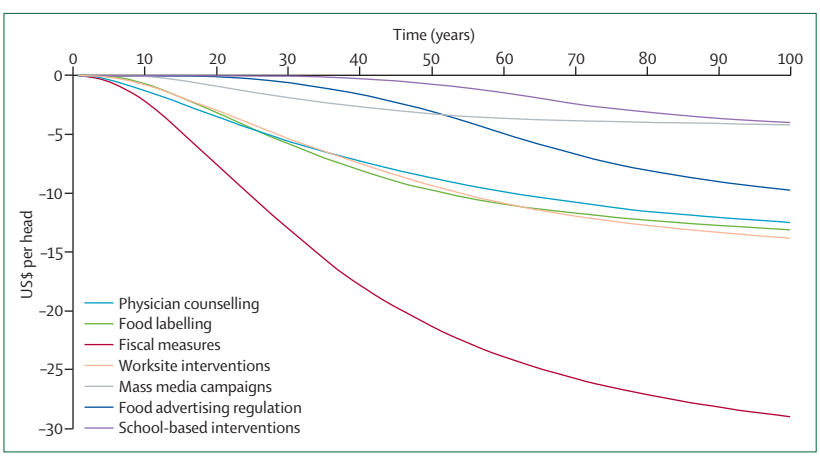

Figure 4: **Cumulative effect on health expenditure over time (US$ per head) in Brazil**

to be made available upfront, potential savings are usually deferred (figure 4).

Combination of the health and economic outcomes of interventions into incremental cost-effectiveness ratios (table 2) shows that, relative to a comparator situation of treatment only and no prevention, fiscal measures are consistently cost-saving in all the low-income and middle-income settings considered, and generate the largest (eg, in China) or second largest health effects in both 20 years and 50 years. The health effect of the fiscal measures modelled in this analysis is substantially lower in India than in other countries, because of a lower consumption of foods high in fat. Food labelling is also cost-saving in many settings, but with smaller health effects than for fiscal measures. Regulation of food advertising to children, and mass media health promotion campaigns, have very favourable cost-effectiveness ratios. In 50 years, regulation of food advertising is even cost-saving in several countries, although its health effect is still very small, compared with other interventions, in this timeframe. Worksite health-promotion initiatives have favourable cost-effectiveness, with quicker health returns than those for advertising regulation, although returns are lower in some countries over the entire simulation. Physician counselling of individuals at risk in primary care is one of the most effective interventions, but its health effect is greatest and cost-effectiveness best in countries where a larger proportion of the population has regular access to primary-care physicians and facilities. Finally, school-based health promotion interventions consistently have unfavourable cost-effectiveness ratios up to 50 years from their initial implementation. However, the cost-effectiveness of interventions targeting young children tends to improve substantially in a longer timeframe (greater than 50 years), as these interventions realise their full potential in improving health.

A multiple-intervention strategy would achieve substantially larger health gains than would individual interventions, often with an even more favourable cost-effectiveness profile. Such a strategy would be cost-saving in about half the countries examined, and in other

countries it would reach cost-effectiveness ratios less than the country-specific thresholds listed in table 2 after a maximum of 15 years (in South Africa).

Strengths and limitations of the model

The CDP model developed for this study has provided new insights into the complex reality that exists with respect to the effect of interventions on a range of inter-related risk factors and disease outcomes. Nevertheless, the model can only ever be a simplified representation, and is heavily constrained by the availability of national (or subnational) data for the many required input parameters. The model, for example, does not take into account the potential confounding effect of risk factors (eg, smoking) other than those explicitly addressed, mainly because of the absence of robust evidence of interactions between risk factors and, especially, of the effect of interventions on risk factors other than those they directly aim to modify. For a few factors (eg, age) the model takes into account the full distribution of risk factors, whereas broad categories of risk had to be used in other cases. The (restricted) availability of suitable evidence identified what intervention effects could be accounted for in the analysis. Interventions might well produce additional effects that have not been reliably measured in existing studies and therefore could not be included. In particular, information about the long-term effects of interventions is almost non-existent, so we had to assume that effects disappear once exposure to an intervention ends (apart from for interventions targeting children, which are assumed to have some effects on adult behaviours). The CDP model accounts for intergenerational effects to a small extent, by assuming that children who are born during the course of the simulation inherit health-related behaviours from their mothers (although they might change behaviours later in their lives). Social multiplier effects[21] (the clustering of risk factors within households and social networks) could not be accounted for. Nor was there sufficient data to investigate any differences between urban and rural settings with respect to risk factor exposure or intervention effect, even though this difference might affect the roll-out of prevention programmes within countries.

However, one of the key strengths of the modelling approach that we used is that it allows combination of multiple and heterogeneous sources of data, thus overcoming the limitations of individual sources. At the same time it offers ample opportunities to test the internal consistency of the input data used and the robustness of the results produced. A probabilistic uncertainty analysis was undertaken on the results produced by the CDP model, which is shown in webappendix pp 25–29. This analysis, which addresses uncertainty in relation to both intervention costs and effectiveness, shows the substantial variation that exists around point estimates of costs and effects but, despite these variations, it also confirms the cost-effectiveness of the most efficient interventions against country-specific thresholds for consideration of cost-effectiveness in the health sector.

Chronic disease prevention: from evidence to practice

Calls for renewed global action on chronic diseases need to be supported by further evidence of the effectiveness and cost-effectiveness of different policy measures that are capable of reducing a rising burden of disease. The analysis presented in this report is intended to address a notable gap in the international economic evidence base for chronic disease prevention—namely, the identification of public health strategies that are most cost effective to tackle unhealthy diets, physical inactivity, and obesity in the population. The analysis has drawn attention to, among other things, important limitations in the availability of evidence about the epidemiology of risk factors and chronic diseases and the effectiveness of potential interventions, on which economic assessment could be built. Low-income and middle-income countries need to establish or strengthen existing initiatives for the collection of data for the prevalence of key risk factors for chronic diseases, including behavioural risk factors, and for how these risk factors jointly contribute to fuelling of chronic diseases. Furthermore, countries at all levels of income should have a broader and stronger evidence base for the effectiveness of preventive interventions in a broad range of populations.

WHO's global strategy for diet, physical activity and health[22] was devised to respond to the challenges posed by rapid changes in nutrition coupled with increasingly sedentary lifestyles in many low-income and middle-income countries, especially in urban areas. Many such countries face a double burden of nutrition from the simultaneous presence of large underweight and overweight groups within national populations.[23] In at least three of the countries examined in this report—Brazil, China, and Russia—the two problems co-exist within 8–9% of households.[24]

Compared with the alternative strategy of treating only individuals who develop cardiovascular disease or cancer, our findings suggest that several population-based prevention policies can be expected to generate much-needed health gains while entirely or very largely paying for themselves through their reduction of future health-care costs. These policies include health information and communication strategies that improve population awareness and behaviour about the benefits of healthy eating and physical activity; fiscal measures that increase the price of unhealthy food content (fat) or reduce the price of healthy foods rich in fibre (fruits and vegetables); and regulatory measures that improve nutritional information content or restrict the marketing of unhealthy food products.

What sets these interventions apart from the other, more targeted strategies that were also assessed in this analysis (school-based or work-based interventions, and counselling in primary care for those at an increased risk of chronic disease) is their greater coverage in the population—ie, more people are exposed to their positive effects—and the fairly low cost of their implementation. These interventions might usefully be added to the inventory of feasible and affordable countermeasures that already exists for other risk factors for chronic diseases—in particular demand-reduction strategies for tobacco and alcohol (such as raised excise taxes, advertising bans, and improved labelling) and salt-reduction strategies (via mass media campaigns or increased regulation of the salt content in manufactured foods).[12,25] This analysis clearly shows that the strategic approaches that deliver best value for money to address unhealthy diets, physical inactivity, and obesity—improved awareness and information, appropriate fiscal measures, and enhanced regulatory mechanisms—closely match those for other key chronic disease risk factors (eg, tobacco and harmful alcohol use; high blood pressure and cholesterol).[11,25–28] For example, according to a World Bank report on the economics of tobacco control[26] tax-induced price increases were the most cost-effective intervention (<US$100 per year of healthy life gained in low-income and middle-income regions), relative to a package of non-price interventions or nicotine replacement therapy. Similarly, in a review of the effectiveness and cost-effectiveness of alcohol policy measures Anderson and colleagues[25] concluded that excise tax increases (of 20% or even 50%) represent the most cost-effective response in countries with a high prevalence of heavy drinking; regulatory measures such as advertising bans and restrictions on access and availability were also economically viable. For high blood pressure and cholesterol, Murray and colleagues[27] showed that population-based approaches such as salt reduction were marginally more cost-effective than was individual-based treatment for people most at risk for cardiovascular disease, although both strategies fall within the broad range of international US$100–1000 per year of healthy life gained.

Willett and co-workers[28] derived a similar range of cost-effectiveness for the replacement of trans fat with polyunsaturated fat; the most optimistic scenario suggested that such a change in dietary fat would not only be more effective but also reduce health-system costs. The combined and coordinated implementation of these public health measures across the full range of risk factors for chronic diseases would offer the best opportunities to address globally the rapidly escalating problem of chronic disease.

The present debate about improving diets, increasing physical activity, and tackling rising obesity in the countries examined in this report tends to focus on health promotion initiatives, especially within school or community settings, and on interventions channelled through health-care systems. Government policy in some of these countries follows the same direction—one example is the national programme on diabetes, cardiovascular diseases, and stroke[29] in India. Our analysis shows that interventions based in primary care can generate larger health gains than can other interventions, with favourable cost-effectiveness; however, interventions are successful only when large sectors of the population have regular access to doctors and facilities, which is not always the case in countries in which primary care is under severe pressure dealing with an increasing double burden of chronic and infectious diseases in large and often geographically dispersed populations. In such settings, a population-wide approach that does not rely only on the ability of the health system to deliver patient-level care seems to offer additional benefits in terms of implementation and scalability of the proposed interventions. For example, in addition to interventions for health education, the national strategy for the prevention and control of non-communicable diseases and injuries in Russia lends supports to tight regulation of the manufacture, packaging, and labelling of food, and of interventions for urban design and transportation policy.[30]

	Brazil	China	India	Mexico	Russia	South Africa
Tobacco use—excise tax increase, information and labelling, smoking restrictions, and advertising bans[12]	0·25	0·14	0·16	0·54	0·49	0·60
Harmful alcohol use—excise tax increase, advertising bans, and restricted access[25]	0·15	0·07	0·05	0·24	0·52	0·29
Unhealthy diet and physical inactivity—mass media campaigns, food taxes and subsidies, nutritional information/labelling, and marketing restrictions (this analysis)	0·48	0·43	0·35	0·79	1·18	0·99
High blood pressure and cholesterol						
Reduced dietary salt (mass media campaigns, regulation of food industry)[12]	0·12	0·05	0·06	0·22	0·16	0·15
Combination drug therapy for high-risk individuals[13]	1·89	1·02	0·90	2·74	1·73	1·85
Total cost per head of intervention set (excluding any cost synergies or future treatment cost savings)	2·89	1·72	1·52	4·53	4·08	3·88

Table 3: **Estimated yearly cost per head (in US$) of a chronic disease prevention package by intervention and country**

The food and beverage industry played an active part in negotiations for the development of WHO's global strategy. As part of the commitments they made in that framework, major companies are rolling out a programme of so-called pledges for a responsible marketing of food and beverages to children and several local health promotion activities, mostly based in school and recreational settings. The pledges started in North America, Europe, and Australia, and were progressively extended to low-income and middle-income countries, including Brazil, Mexico, Russia, and South Africa. Although the move obviously aims to pre-empt tight government regulation, similar initiatives have the potential to mobilise private-sector resources—an outcome that is especially welcome in low-income countries, although evidence of the effectiveness of initiatives led by the private sector in changing risky behaviours is still scarce.

In a previous Series in *The Lancet*, Abegunde and colleagues[31] showed that if nothing is done to reduce the risk of chronic diseases, heavy losses in terms of human life and economic production can be expected (for 23 low-income and middle-income countries alone, an estimated 250 million deaths and $84 billion of lost national output are expected in 2006–15). Other papers in that Series[12,13] showed that an investment of $1–2 per person in a small set of key intervention strategies (salt reduction, tobacco control, and combination drug therapy for people at risk of a cardiovascular disease event) could avert 32 million deaths and reduce losses in economic output by $8 billion over the same period. The implementation cost of an expanded set of preventive strategies that includes the most efficient fiscal, regulatory, and health-care measures to tackle the main risk factors for chronic diseases—but that excludes any future treatment cost savings resulting from these preventive measures—is estimated to range from $1·5 to $4·5 per head for the countries assessed in this report (table 3). Only a very small notional price for the value of a human life—a few thousand dollars, which is equivalent to the average income per person in many low-income countries—is needed for the averted deaths or health gains resulting from such an intervention package to outweigh the projected economic losses. If we applied the value of statistical life used in high-income countries, which amounts to around 100 times the average income per person, benefits would exceed implementation costs by a massive margin.

Economic evidence does not in itself provide a sufficient basis to establish priorities in health; other important concerns need to be taken into account, particularly the fairness with which available resources and health outcomes are distributed across different groups in the population. Although the CDP model was designed to assess the distributional effects of prevention strategies, we were unable to undertake such assessment in this analysis because of data limitations. In high-income settings, people who are less affluent can benefit disproportionately from the interventions examined here,[14] provided that interventions can generate the same changes in behaviour in individuals in different socioeconomic groups. Prediction of the distributional effects that would be seen in countries with a different distribution of risk factors (eg, obesity is more prevalent in high socioeconomic groups in many low-income and middle-income countries), and those with greater disparities in health literacy and risk perception across population groups, is difficult. Furthermore, the regressive financial implications of tax measures, which would not be offset entirely by the associated subsidies on fruit and vegetables in the intervention assessed in this report, might impose a heavy burden on the poorest households. Equity concerns need to be firmly on the policy agenda in the design of strategies for the prevention of chronic diseases to avoid exacerbation of existing inequalities.[32]

Contributors

MC contributed to the study design, did the analyses, and contributed to the interpretation of findings and drafting of the report. FS conceived the study, contributed to the design of the analyses and interpretation of the findings, and drafted the report. JAL contributed to the study design, programmed the CDP model, and contributed to the interpretation of findings and drafting of the report. YYL and VG-B contributed to the collection and elaboration of input data for the analyses, participated in the interpretation of findings, and reviewed draft versions of the report. DC contributed to the study design, cost analysis, interpretation of findings, and drafting of the report.

Conflicts of interest

We declare that we have no conflict of interest.

Acknowledgments

The authors gratefully acknowledge the contributions of Robert Beaglehole, University of Auckland, Auckland, New Zealand; Marion Devaux and Michael Borowitz, OECD Health Division, Paris, France; Maria Teresa Ledo, University of Valladolid, Valladolid, Spain; Sarah Barber, Tim Armstrong, and Godfrey Xuereb, WHO, Geneva, Switzerland; Patricio V Marquez, World Bank, Washington, DC, USA; Gustavo Rivera-Peña and Cristina Gutiérrez-Delgado, Economic Analysis Unit, Mexican Ministry of Health, Mexico City, Mexico; Peter Dick, Health Improvement Directorate, UK Ministry of Health, London, UK; Shah Ebrahim, London School of Hygiene and Tropical Medicine, London, UK; and Sylvie Desjardins, Public Health Agency of Canada, Ottawa, ON, Canada. Responsibility for the final report rests with the authors. The views expressed are those of the authors and not necessarily those of the World Health Organization, the OECD, or their member countries.

References

1 WHO. 2008–2013 Action Plan for the Global Strategy for the Prevention and Control of Non-communicable Diseases. Geneva: World Health Organization, 2008.

2 Prentice AM. The emerging epidemic of obesity in developing countries. *Int J Epidemiol* 2006; **35:** 93–99.

3 Olaiz-Fernandez G, Rivera-Dommarco J, Shamah-Levy T, et al. Encuesta Nacional de Salud y Nutrición 2006. Cuernavaca: Instituto Nacional de Salud Pública, 2006.

4 Baillie K. Health implications of transition from a planned to a free-market economy—an overview. *Obes Rev* 2008; **9** (suppl 1): 146–50.

5 Lu Y, Goldman D. The effects of relative food prices on obesity—evidence from China: 1991–2006 (February, 2010). NBER Working Paper Series, vol w15720, 2010. http://ssrn.com/abstract=1548778 (accessed April 20, 2010).

6 Yang W, Lu J, Weng J, Jia W, et al. Prevalence of diabetes among men and women in China. *N Engl J Med* 2010; **362:** 1090–101.

7 Monteiro CA, Conde WL, Popkin BM. Income-specific trends in obesity in Brazil: 1975-2003. *Am J Public Health* 2007; **97:** 1808–12.

8 Wang Y, Chen HJ, Shaikh S, Mathur P. Is obesity becoming a public health problem in India? Examine the shift from under- to overnutrition problems over time. *Obes Rev* 2009; **10:** 456–74.

9 Puoane T, Steyn K, Bradshaw D, et al. Obesity in South Africa: the South African demographic and health survey. *Obes Res* 2002; **10:** 1038–48.

10 WHO Infobase. Geneva: World Health Organization, 2010. http://www.who.int/infobase/ (accessed April 20, 2010).

11 Gaziano TA, Galea G, Reddy KS. Scaling up interventions for chronic disease prevention: the evidence. *Lancet* 2007; **370:** 1939–46.

12 Asaria P, Chisholm D, Mathers C, Ezzati M, Beaglehole R. Chronic disease prevention: health effects and financial costs of strategies to reduce salt intake and control tobacco use. *Lancet* 2007; **370:** 2044–53.

13 Lim SS, Gaziano TA, Gakidou E, et al. Prevention of cardiovascular disease in high-risk individuals in low-income and middle-income countries: health effects and costs. *Lancet* 2007; **370:** 2054–62.

14 Sassi F, Cecchini M, Lauer J, Chisholm D. Improving lifestyles, tackling obesity: the health and economic impact of prevention strategies. OECD Health working paper 48. Paris: OECD, 2009. http://www.who.int/choice/publications/d_OECD_prevention_report.pdf (accessed April 20, 2010).

15 WHO Regional Office for Europe. Nutrition policy database. Copenhagen: World Health Organization, 2010. http://data.euro.who.int/nutrition/ (accessed April 20, 2010).

16 WHO. Intervention on diet and physical activity: what works. Geneva: World Health Organization, 2009.

17 Adam T, Evans DB, Murray CJL. Econometric estimation of country-specific hospital costs. *Cost Eff Resour Alloc* 2003; **1:** 3.

18 Adam T, Evans DB. Determinants of variation in the cost of inpatient stays versus outpatient visits in hospitals: a multi-country analysis. *Soc Sci Med* 2006; **63:** 1700–10.

19 Johns B, Baltussen R, Hutubessy R. Programme costs in the economic evaluation of health interventions. *Cost Eff Resour Alloc* 2003; **1:** 1.

20 Johns B, Adam T, Evans DB. Enhancing the comparability of costing methods: cross-country variability in the prices of non-traded inputs to health programmes. *Cost Eff Resour Alloc* 2006; **4:** 8.

21 Sassi F. Obesity and the economics of prevention: fit not fat. Paris: OECD Publishing, 2010.

22 WHO. Global strategy on diet, physical activity and health. Geneva: World Health Organization, 2004. http://www.who.int/dietphysicalactivity/strategy/eb11344/strategy_english_web.pdf (accessed April 20, 2010).

23 FAO. The double burden of malnutrition—case studies from six developing countries. Rome: Food and Agriculture Organization, 2006.

24 Doak CM, Adair LS, Bentley M, Monteiro C, Popkin BM. The dual burden household and the nutrition transition paradox. *Int J Obes (Lond)* 2005; **29:** 129–36.

25 Anderson P, Chisholm D, Fuhr DC. Effectiveness and cost-effectiveness of policies and programmes to reduce the harm caused by alcohol. *Lancet* 2009; **373:** 2234–46.

26 Jha P, Chaloupka F, eds. Tobacco control in developing countries. Oxford: Oxford University Press, 2000.

27 Murray CJL, Lauer JA, Hutubessy RCW, et al. Effectiveness and costs of interventions to lower systolic blood pressure and cholesterol: a global and regional analysis on reduction of cardiovascular-disease risk. *Lancet* 2003; **361:** 717–25.

28 Willett WC, Koplan J, Nugent R, Puska P, Dusenbury C, Gaziano T. Prevention of chronic disease by diet and lifestyle changes. In: Jamison D, Breman K, Measham A, et al, eds. Disease control priorities in developing countries, 2nd edn. New York: Oxford University Press and World Bank, 2006: 869–85.

29 Government of India, Press Information Bureau. Pilot phase of the National Programme for Prevention and Control of Diabetes, Cardio-Vascular Diseases and Stroke launched. January, 2008. http://pib.nic.in/release/release.asp?relid=34389 (accessed Sept 29, 2010).

30 State Research Center for Preventive Medicine. Strategy for the prevention and control of noncommunicable diseases and injuries in the Russian Federation. Moscow: Ministry of Health and Social Development, 2008.

31 Abegunde DO, Mathers CD, Adam T, Ortegon M, Strong K. The burden and costs of chronic diseases in low-income and middle-income countries. *Lancet* 2007; **370:** 1929–38.

32 González-Pier E, Gutiérrez-Delgado C, Stevens G, et al. Priority setting for health interventions in Mexico's System of Social Protection in Health. *Lancet* 2006; **368:** 1608–18.