Preventing
CHRONIC DISEASES
a vital investment
ANNEXES
WHO has prepared updated projections of trends for mortality and burden of disease between 2002 and 2015 using methods similar to those used in the original Global Burden of Disease (GBD) study (1). A set of relatively simple models was used to project future health trends under various scenarios, based largely on projections of economic and social development, and using the historically observed relationships of these to cause-specific mortality rates. The data inputs for the projection models have been updated to take account of the greater number of countries reporting death registration data to WHO, particularly developing countries, and to take into account other recently developed projection models on HIV/AIDS and other conditions where appropriate, as well as tobacco epidemics.

A BRIEF OVERVIEW OF THE METHODS AND ASSUMPTIONS

Rather than attempt to model the effects of the many separate direct determinants or risk factors for disease from the limited data that are available, the GBD methodology considered a limited number of socioeconomic variables: average income per capita, measured as gross domestic product (GDP) per capita; average number of years of schooling in adults, referred to as “human capital”; and time, a proxy measure for the impact of technological change on health status. This latter variable captures the effects of accumulating knowledge and technological development, allowing the implementation of more cost-effective health interventions, both preventive and curative, at constant levels of income and human capital (2).

These socioeconomic variables show clear historical relationships with mortality rates, and may be regarded as indirect, or distal, determinants of health. In addition, a fourth variable, tobacco use, was included in the projections for cancers, cardiovascular diseases and chronic respiratory diseases, because of its overwhelming importance in determining trends for these causes. Tobacco use was measured in terms of “smoking intensity” – that component of observed lung cancer mortality that is attributable to tobacco smoking (3).

For the projections reported here, death rates for all major causes excluding HIV/AIDS were related to these four variables using historical death registration data for 107 countries between 1950 and 2002 (4). Death rates were then projected using World Bank projections of GDP per capita, WHO projections of human capital, and smoking intensity projections based on historical patterns of tobacco use and further adjusted for recent regional trends in tobacco consumption where appropriate.

Separate projections for HIV/AIDS mortality were prepared by UNAIDS and WHO, under a scenario in which coverage with antiretroviral drugs reaches 80% by 2012, remaining constant beyond that year, and in which there are no changes to current transmission rates due to increased prevention efforts. Projected tuberculosis mortality rates were modified in regions with high HIV prevalence, owing
to the expected interaction of tuberculosis and HIV. Because a substantial proportion of diabetes mortality is attributable to overweight and obesity (5), a separate projection model for diabetes mortality was developed using WHO projection of trends in body mass index distributions from 2000 to 2010. Similarly, projections of mortality for chronic respiratory diseases were adjusted for projected changes in smoking intensity.

The original GBD projections assumed that the changes in death rates associated with income growth and time in countries with death registration data, mostly medium and high income countries, would also apply in low income countries. The new projections for low income countries were based on the observed relationships for a data set consisting of 3468 country-years of observation where income per capita was less than $10 000 per year. Additionally, observed regional trends in child mortality from 1990 to 2002 were compared with those predicted by the projection model for low income countries. As a result, the regression coefficient for time was set to zero for sub-Saharan Africa, and to 25% of its original value for other low income countries.

The WHO projections of mortality rates to 2015, together with UN medium variant assumptions for fertility rates and migration rates (6), were also used to prepare consistent population projections for all regions. The projected global population in 2015 was 7.1 billion compared to the UN medium variant projection of 7.2 billion, reflecting somewhat higher adult death rates in the WHO mortality projections.

PROJECTIONS FOR COUNTRIES

Projections were carried out at country level, but aggregated into regional or income groups for presentation of results, apart from the projections for nine selected countries included in this report. Baseline estimates at country level for 2002 were derived from the GBD analyses published in The World Health Report 2004 (7). Mortality estimates were based on analysis of latest available national information on levels of mortality and cause distributions as at late 2003. Incidence, prevalence, duration and severity estimates for conditions were based on the GBD analyses for the relevant epidemiological subregion, together with national and sub-national level information available to WHO. These baseline estimates represent the best estimates of WHO, based on the evidence available in mid-2004, rather than the official estimates of Member States, and have been computed using standard categories and methods to maximize cross-national comparability.

Initial WHO estimates and technical explanations were sent to Member States for comment in 2003, and comments or additional information incorporated where possible. Country-specific projections were shared with relevant WHO country offices and Member States in advance of publication.

LIMITATIONS

By their very nature, projections of the future are highly uncertain and need to be interpreted with caution. Three limitations are briefly discussed: uncertainties in the baseline data on levels and trends in cause-specific mortality, the “business as usual” assumptions, and the use of a relatively simple model based largely on projections of economic and social development.

For regions with limited death registration data, such as the Eastern Mediterranean Region, sub-Saharan Africa and parts of Asia and the Pacific, there is considerable uncertainty in estimates of deaths by cause associated with the use of partial information on levels of mortality from sources such as the Demographic and Health Surveys, and from the use of cause-specific mortality estimates for causes such as HIV/AIDS, malaria, tuberculosis and vaccine-preventable diseases (8). The GBD analyses have attempted to use all available sources of information, together with an explicit emphasis on internal consistency, to develop consistent and comprehensive estimates of deaths and disease burden by cause, age, sex and region.

The projections of burden are not intended as forecasts of what will happen in the future but as projections of current and past trends, based on certain explicit assumptions and on observed historical relationships between development and mortality levels and patterns. The methods used base the disease burden projections largely on broad mortality projections driven to a large extent by World Bank projections of future growth in income per capita in different regions of the world. As a result, it is important to interpret the projections with a degree of caution commensurate with their uncertainty, and to remember that they represent a view of the future explicitly resulting from the baseline data, choice of models, and the assumptions made. Uncertainty in
projections has been addressed not through an attempt to estimate uncertainty ranges, but through preparation of pessimistic and optimistic projections under alternate sets of input assumptions.

The results depend strongly on the assumption that future mortality trends in poor countries will have the same relationship to economic and social development as has occurred in higher income countries in the recent past. If this assumption is not correct, then the projections for low income countries will be over-optimistic in the rate of decline of communicable and noncommunicable diseases. The projections have also not taken explicit account of trends in major risk factors apart from tobacco smoking, and, to a limited extent, overweight and obesity. If broad trends in risk factors are for worsening of risk exposures with development, rather than the improvements observed in recent decades in many high income countries, then again the projections for low and middle income countries presented here will be too optimistic.

THE GLOBAL GOAL

The global goal for chronic diseases, proposed in this report, was modelled in terms of an additional 2% annual decline in chronic disease death rates from 2006 to 2015. Annual rates of change in age and sex specific death rates for all chronic disease causes were calculated for the mortality projections from 2005 to 2015 and then adjusted by subtraction of an additional 2% per annum. Death rates for the years 2006 to 2015 were then recomputed using the adjusted annual trends for age/sex-specific rates. Note that the final death rates for chronic diseases in 2015 under the bold goal scenario will be substantially lower than the base projections, since the additional 2% annual declines are cumulative.

FURTHER INFORMATION

Interested readers can visit the WHO web site at http://www.who.int/evidence/bod, where the following information is available:

- mortality and burden of disease estimates for 2002 for WHO regions and for countries grouped by income level;
- downloadable working papers on the data sources, methodology and tools used in assessment of mortality and burden of disease for 2002;
- a downloadable technical paper giving a detailed description of the data inputs, methods and results for the projections of mortality and burden of disease;
- links to other publications and results relating to the WHO projections.

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For operational and analytical purposes, the World Bank's main criterion for classifying economies is gross national income (GNI) per capita. Based on its GNI per capita, every economy is classified as low income, middle income (subdivided into lower middle and upper middle), or high income.

Categories for this report were based on the income groupings published in *World development indicators 2003*, Washington, DC, World Bank, 2003. Economies were divided according to 2001 GNI per capita, calculated using the World Bank Atlas method. The groups are: low income, US$ 745 or less; lower middle income, US$ 746–2975; upper middle income, US$ 2976–9205; and high income, US$ 9206 or more.

### COUNTRIES, AREAS AND TERRITORIES

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Annex 3. World Bank income groupings
Economic analysis methods

For the economic analyses of this report, three approaches were adopted:

1. systematic review on chronic disease costs of illness;
2. elucidation of the human capital impact of chronic diseases through their impact on labour supply – the Solow growth model using the Cobb-Douglas function;
3. elucidation of the impact of chronic diseases on and growth in economic welfare – the full-income approach.

Estimation of the economic impact was based on projections to 2015 for nine countries: Brazil, Canada, China, India, Nigeria, Pakistan, the Russian Federation, the United Kingdom and the United Republic of Tanzania. The focus was on heart disease, stroke and diabetes.

THE GROWTH (COBB-DOUGLAS) MODEL
The Cobb-Douglas function (equation 1) was combined with the capital accumulation function (equation 2) to estimate the long-run impact of chronic diseases on economic growth for these countries.

\[
Y_{it} = r A_{it} K_{it}^\alpha L_{it}^{1-\alpha}
\]  
\[
K_{it} = sY_{it} - xC_{it} + (1 - \delta)K_{i(t-1)}
\]

Where:
\( Y \), \( K \), \( i \) and \( t \) are as defined in above
\( s \) = savings rate
\( C \) = cost of treating illness
\( x \) = proportion of \( C \) funded from savings
\( \delta \) = depreciation

APPROACH TO ELUCIDATION
Three main approaches were initially considered: (1) econometric estimation and projections; (2) econometric estimation and calibration; and (3) straightforward calibration using information on variables from various sources. The third approach was adopted for this phase of work because of data availability issues and time constraints. However, options 1 and 2 will be pursued as part of the ongoing work in this area, and as a follow-up to the report.

DATA AND DATA SOURCES
Projected gross domestic product (GDP) data were obtained from the World Bank and converted to GDP per worker as all other variable input. Capital per worker was obtained from Easterly & Levine (7). Information on the impact of chronic diseases on labour supply was obtained from the population and mortality projections of the Global Burden of Disease Unit of WHO. Costs of treating chronic diseases were obtained from WHO sources. Historical savings rates, depreciation, were obtained from the World Bank Development Index database.

For the base case estimated, proportion of cost of treating illness funded from savings was set at 10%. Region-specific elasticities of \( Y \) with respect to \( K \) were obtained from Senhadji (2). There was difficulty in obtaining data for capital accumulation in the Russian Federation; this was then set to the average of countries. All these variables were then subjected to sensitivity analysis.
THE FULL-INCOME MODEL
The full-income (FI) approach captures the value of changes in population health in the assessment of “economic welfare” (3, 4). The welfare value of deaths or changes in life expectancy from disease, estimated through the Value of Statistical Life (VSL) (Value of a Life Year (VLY)) nexus is added to changes in annual GDP per capita. For example, if $\Delta p =$ change in the probability of dying within a given period say 2005–2015, and VSL = 100 times GDP per capita the welfare loss from mortality = ($\Delta p \times 100$) X GDP per capita X (proportion of adults in the population). Suppose $\Delta p = 0.4\%$ and proportion of adults in pop = 50%, then welfare loss = 0.4 X GDP X 0.5 = 20% of GDP per capita. That is, GDP per capita would have been 20% of the actual GDP per capita. This would correspond to a rate of decrease in economic welfare due to mortality increase of 2% per annum. This approach, which may seem more complete than the previous approaches, does not account for the total value of the changes in health. It is, however, useful in that it demonstrates fuller returns to investment in health compared to the above approaches. Estimation should be of interest to country development strategists and policy-makers in the health and finance sectors, and also useful for international comparison.

MODEL PROGRAMMING AND ELUCIDATION
Microsoft Excel was used to programme the relationships in the equations from 2002 to 2015. The model was programmed to compute output if there were no deaths due to chronic disease (the counterfactual) against output given the projected deaths from chronic disease on an annual basis. This procedure was then repeated for estimating the global goal of an additional 2% annual reduction in chronic disease death rates over and above baseline projections, over 10 years from 2006 to 2015.

All the variables in the Cobb-Douglas model were subjected to univariate and multivariate analysis (Monte Carlo) using Crystal Ball software.

The CHOICE (CHOosing Interventions that are Cost-Effective) project was developed by WHO in 1998. The objective is to provide policy-makers with evidence on which to base decisions regarding interventions and programmes, given the need to provide the best health gains possible with available resources. WHO-CHOICE reports the costs and effects of a wide range of health interventions in 14 epidemiological sub-regions (world divisions made based on geographical location and epidemiological profiles). The results of these cost–effectiveness analyses are assembled in regional databases, which policy-makers can adapt to their specific country setting.

According to the cost–effectiveness results, interventions can be grouped into three categories:

<table>
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<tr>
<th>COST–EFFECTIVENESS CATEGORY</th>
<th>DEFINITION</th>
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<tbody>
<tr>
<td>Very cost-effective</td>
<td>Interventions that avert each DALY at a cost less than gross domestic product per head.</td>
</tr>
<tr>
<td>Cost-effective</td>
<td>Interventions that avert each DALY at a cost between one and three times gross domestic product per head.</td>
</tr>
<tr>
<td>Not cost-effective</td>
<td>Interventions that avert each DALY at a cost higher than three times gross domestic product per head.</td>
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</table>

Interested readers can visit the WHO CHOICE web site at http://www.who.int/choice where the following information is available:

» cost–effectiveness results of the interventions evaluated for the 14 world sub-regions;
» a list of countries in the 14 sub-regions used for the WHO-CHOICE analysis;
» downloadable background papers on the methodology and tools used in conducting the WHO-CHOICE cost–effectiveness analyses;
» detailed region-specific demographic data and list of input variables, including prices and quantities, exchange rates, price multipliers and other key reference material for conducting cost–effectiveness analyses;
» a brief description on the WHO guide to cost–effectiveness analysis (1), the theoretical and practical compendium on CHOICE methodology.

Preventing chronic diseases: a vital investment was produced with the input, guidance and assistance of many colleagues. Valuable material, help and advice were received from policy advisers to the Director-General and many technical staff at WHO headquarters, regional directors and members of their staff, WHO country representatives and country office staff. These contributions have been vital to the project, both in creating and enriching the report.

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Over 40 people with, or affected by, chronic disease were photographed and interviewed by a photojournalist in early 2005. Overall, this set of photographs and stories from five diverse countries demonstrates that chronic diseases are widespread in low and middle income countries and are an underappreciated source of poverty, requiring comprehensive and coordinated responses.
We would like to thank all those people who were willing to tell their story, and have their photo taken, for inclusion in this report and on the WHO website: http://www.who.int/

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Projected global deaths by cause, all ages, 2005

35 000 000 people will die from chronic diseases in 2005

80% of chronic disease deaths occur in low and middle income countries