

Working paper



**World Health
Organization**

An estimation of the economic impact of chronic noncommunicable diseases in selected countries

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2006**

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Introduction

The epidemiological burden of chronic diseases and their risk factors is increasing worldwide, especially in low and middle income countries where chronic diseases have been assumed to be less common. Projections indicate that 35 million of the 58 million worldwide expected deaths in 2005 were due to chronic, noncommunicable diseases. A projected 388 million people will die of chronic disease in the next ten years. The majority of these deaths will occur in the most productive age groups; 80% of the deaths will be in low and middle income countries.

Despite global successes, such as the WHO Framework Convention on Tobacco Control, the first legal instrument designed to reduce tobacco-related deaths and disease around the world, chronic diseases have generally been neglected in international health and development work. Many countries do not have clear national policies for the prevention and treatment of chronic diseases. Low and middle income countries must also deal with the practical realities of limited resources and a double burden of infectious and chronic diseases.

Aside from the epidemiological evidence demonstrating the chronic disease burden, and a few cost of illness studies related to chronic diseases in a few countries, compelling evidence on the economic impact of chronic disease has been starkly lacking.

This paper attempts to fill the gap by presenting estimates of the economic impact of selected chronic diseases - heart disease, stroke and diabetes. These estimates were also presented in the recent World Health Organization publication *Preventing chronic diseases: a vital investment*. The primary objective of this analysis was to explore and demonstrate the economic impact (cost) of chronic diseases at the national level; to demonstrate how these cost would increase without intervention; and to demonstrate the potential economic benefit from interventions to control the burden of chronic diseases.

This paper is an account of the initial exploration in ongoing work on the economic impact of chronic disease. In this paper, we apply the economic growth model to explore the

macroeconomic consequences of premature mortality from selected chronic diseases on national income of countries. In addition, we estimate the potential economic gains given the achievement of the global goal for chronic disease prevention. An additional approach to exploring the economic impact of chronic disease using the full income model is reported in a separate paper.

The paper is divided into five main sections: 1. a description of links between disease and the economy, which are used to inform disease and economic growth models; 2. A review of the application of Solow's economic growth model to specific diseases, and how the approach adopted for the analysis in this paper was decided upon; 3. A presentation of the data and their sources, as well as variables applied to the model, including the approach to estimation; 4. A presentation of the results of the analysis; 5. The discussion of the results including a brief discussion on the sensitivity of the forecast to the assumptions in the model.

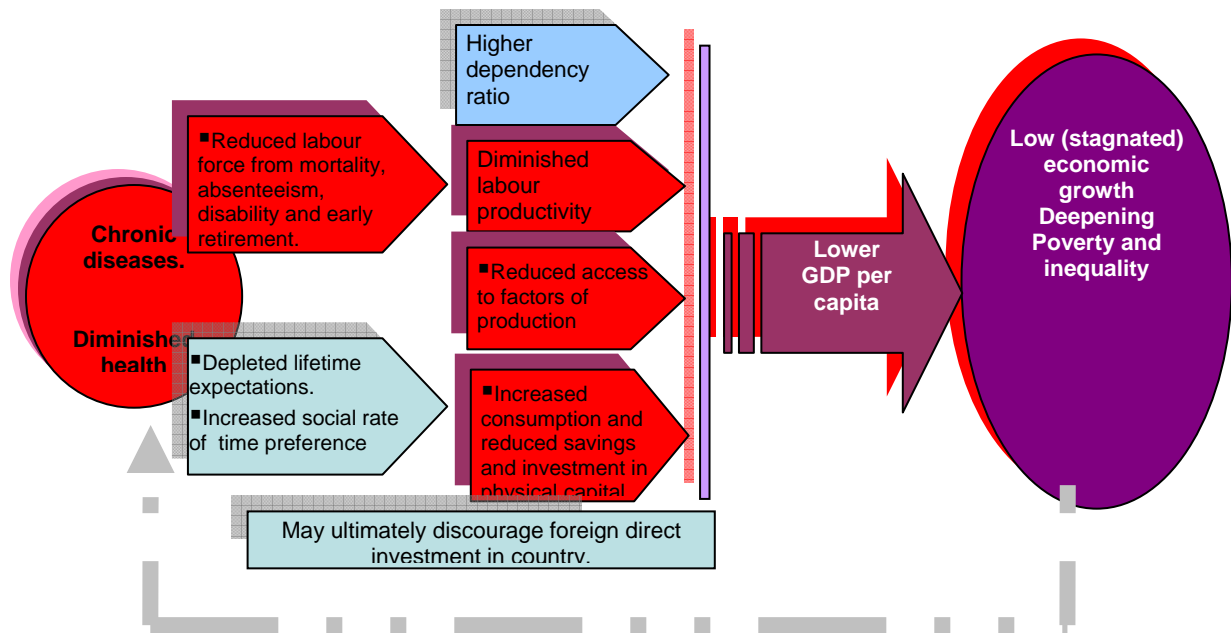
1. Linkages between disease and the economy

The various channels through which disease may impact on the economy are well-discussed in the growing literature on health and economic growth. Diseases in general, particularly chronic diseases, deprive individuals of their health and productive potential. The burden of chronic diseases may invariably challenge individual or household income and savings, and compete with investment activities. From countries' perspective, chronic diseases reduce life expectancy and ultimately economic productivity, thus depleting the quality and quantity of countries' labour force. This may result into lower national output in national income (GDP and GNI). There has been some description in the literature of how diseases reduce intergenerational skills and wealth transfer. Schooling of the children is affected, propagating the spiral of ill health and poverty. An extreme simplification of these channels and linkages is presented in figure 1 below.

In contrast, good health improves levels of human capital which may in turn, positively affect individual productivity and ultimately affect economic growth rates (*1*). Workforce productivity is increased by reducing incapacity, disability and workdays lost. Good health also increases individuals' economic opportunities and levels of education (schooling and

scholastic performance). Finally, good health frees resources, which would otherwise be used to pay for treatment, and as such reduces the likelihood of poverty(1).

Figure 1: Linkages between chronic disease and the economy: The poverty spiral



N.B. Channels indicated in red are those explored in this paper.

The channels through which chronic disease may impact on the economy interlink - directly or indirectly. It is well-recognized also that health positively influences economic wellbeing, growth and wealth. The reverse influence is also well-recognized. Countries would certainly be economically better-off in the absence of ill-health (morbidity and mortality) from epidemic diseases, such as chronic diseases. and to avoid the spiral of poor economic performance and poor health especially at individual and household levels if left unchecked.

The economic impact of chronic diseases can be estimated and projected by analysing specific channels through which chronic disease influences economies. However, income earnings (e.g. GDP) provide the ultimate link to the socioeconomic effects of chronic disease, hence are convenient outcome measures by which economic impact of chronic diseases may be estimated.

Two possible approaches to exploring the economic impact of chronic diseases are: 1. the cost perspective, that is, exploring the economic cost of failing to intervene; and 2. the benefit perspective, that is., exploring the accruable gains from timely interventions.

Approaches to estimating economic impact of chronic diseases in the literature fall into three main categories: (1) the cost of illness (COI) methods; (2) economic growth (growth accounting) models which estimates cost of chronic diseases focusing on the impact on human capital or on labour supply; and (3) through the full-income method which adds the value of health gains (health income or welfare) to national income. The majority of the studies on economic impact of chronic disease have employed the cost of illness approach even though these are relatively few in contrast to the magnitude of burden of chronic disease. To our knowledge, studies that used economic growth and the full-income models to explore the economic impact of chronic diseases are rare, despite the burden that they pose to countries and regions. The few studies that have explored the impact of health on the economy have focused on AIDS(2-6), malaria and other communicable diseases.

Nonetheless, a few studies provide anecdotal evidence of the impact of chronic diseases on economic growth. Empirical evidence from the Eastern Europe and Asia show that a per annum-increase in economic growth of between 0.3 to 0.4% is associated with a 10% increase in life expectancy (Report of CMH), which is mainly accounted for by the reduction in the burden of cardiovascular diseases. Expected life expectancy gains of as much as 7.75 additional years have been adduced to the control of cardiovascular disease in Europe and Central Asia(7). These are indications that control of chronic diseases could potentially yield economic dividends for countries.

2. Solow's Model

The neoclassical growth accounting model – the Solow-Swan's growth model is applied for the estimations in this paper. The classical model combines the Cobb-Douglas function (equation 1) with the capital accumulation function (equation 2) to estimate the long-run impact of chronic diseases (CD) on economic growth for the countries. We have applied these models as follows:

$$Y_{it} = r A_{it} K_{it}^{\alpha} L_{it}^{1-\alpha} \quad (1)$$

Where:

Y = National (production) income – GDP pc

K = Capital accumulation

L = Labour inputs

α = Elasticity of Y with respect to K

$1 - \alpha$ = Elasticity of Y with respect to L

i = countries

t = time period

Note that $\alpha + (1 - \alpha) = \text{unity}$ i.e. constant returns to scale.

r = Adjustment factor (Cuddington et al 1992 (4))

$$K_{it} = sY_{it} - xC_{it} + (1 - \delta)K_{i(t-1)} \quad (2)$$

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

δ = depreciation

Several applications of and extensions to Solow's original models have occurred since 1956(8). These so called "*augmented*" models have tended to improve the definition of the model in explaining the empirical data on economic growth by the addition of the human capital component in addition to the labour input (9). Education capital was initially commonly added to explain the human capital impact of disease in the growth models until recently, when health capital seems to be assuming stronger importance (10) (8). The straightforward (not augmented) model above is adopted for the estimation in this paper, partly because of limitations in the quality the limited human capital data specific to chronic disease.

3. Methods

Data were obtained from a number of sources for this analysis. GDP data projected to 2015 was obtained from the World Bank and converted to GDP per worker (Y) as all other variable input. A worker was defined as everyone within working age of 15 to 64 years in the population in each country. For a number of reasons, the working age population was not adjusted for unemployment rates¹. Capital per worker (K) was obtained from: Easterly, W. and Ross Levine (1999)(11). Impact of CD on labour (L) was obtained from the population and mortality projections from the Global Burden of Disease unit of the World Health Organization. Data on heart disease stroke and diabetes deaths were aggregated as proxy for chronic diseases. Medical costs of treating CD (C) were obtained from EIP and national health accounts of the WHO. Historical savings rates (s) and depreciation (δ) were obtained from the World Bank Development Index database.

The impact of direct medical expenditures on growth was captured through the assumption that certain proportion ($x\%$) would be met through savings. This was assumed to be 10% varying between 0% and 25% for the base estimates. Region or country specific elasticity of Y with respect to capital (K) – *alpha* (α) was obtained from Senhadji 1999(12). There was difficulty in obtaining data for capital accumulation data for the Russia Federation; as a result, it was set to the average of countries. All assumptions with regard to these variables were tested in a detailed sensitivity analysis. Gross domestic savings as percentage of GDP were obtained from World Bank data available online:

<http://www.worldbank.org/research/growth/GDNdata.htm>

¹ No such adjustments have been made in many of the economic growth models in the literature, from which some of the parameters for this model were taken. Further, the relative effects of unemployment in the countries have been captured from the historical GDPs, which formed the basis for the projections used in our estimates.

Table 1: Data and data sources.

Data item	Source(s)
GDP per capita	World Bank estimates
Population data	WHO/GBD projections
Working population data	WHO/GBD projections
Disease specific deaths	WHO/GBD projections
Capital stock per worker	Projected from Easterly, W. and Ross Levine (1999)(11).
Depreciation rates	Estimations (0.04) following Senhaji(12) and Steve Knowles suggestions.
Savings rate: Gross Domestic savings as % GDP	World Bank data obtained online: http://www.worldbank.org/research/growth/GDNdata.htm
Medical expenditures	WHO – CHOICE data base
Alpha (α)	Senhaji’s regions specific alpha range include country specific alpha where available(12).
Proportion of Medical cost funded from savings	Assumed 10% for base case, ranging from 0% to 25%.

The adjustment factor (r) in equation 1 is a constant scale factor adjusted in order to fit the *actual* projected data. This factor was obtained as the fraction of the estimates of output computed by the model and the GBD projected estimates. The impact on the estimates is subtracted out of the estimates of lost income.

Model assumptions

The characteristic model assumptions for the simple Cobb-Douglas model are: essentiality of inputs; $F(0, 0) = 0$; and homogeneity of degree one ($a + [1 - a]$) are given for our estimates. In addition to these, other assumptions were made to fix the model:

Base case assumptions.

Due to data limitations, working age population was used as proxy for labour input forcing the assumptions of: uniform labour efficiency units within and between countries; and full labour force participation.

Assumptions for sensitivity analysis

It was important to specify plausible distributional forms for the variables employed in the estimates for the purpose of the sensitivity analysis. These specifications were

made based on available insight into the probability distribution and the characteristic of the variables. This process is also assisted by the standard deviation or standard error statistics obtained for much of the variables. A uniform distribution was assumed for the share (x) of savings (s) that funds medical expenditure and the lognormal distribution was assumed for a . Some data were obtained that helped the correlating alpha (α) and total factor productivity (TFP) (1β) for the Monte Carlo analysis. We did not find data useful for correlating other variables beyond the functional relationship that obtained in the model.

Approach to estimation

All three possible main approaches to elucidating the model: (1) econometric estimation and projections; (2) econometric estimation and calibration; and (3) straightforward calibration using data and information on variable form various sources were considered in exploring the model. The calibration (third) approach was adopted for this initial phase of work because of data availability, quality and time constraints that made options one and two unfeasible. In the longer-term, these two other options may be preferable and will be explored as continuing work and follow-up to this report.

Model programming and elucidation

We capitalized upon the programmable properties of Microsoft Excel® worksheets to programme the yearly recursive function between the Cobb-Douglas and capital accumulation equations (1&2); starting from 2002 although the analysis window was from 2005 projecting to 2015. This was necessary to allow the model to move towards steady state. The model was programmed to compute output (GDP) per worker if there were no deaths from chronic disease (the counterfactual), against output given the projected deaths from chronic disease on annual basis. This procedure was then repeated for estimating the global goal for preventing chronic diseases - that is assuming it were possible to reduce chronic disease death rates by an additional 2% annually, over and above projected trends, until 2015. The assumptions and variables were subjected to *univariate* and *multivariate* analysis (Monte Carlo) using Crystal ball software.

The model was implemented on data from nine countries: Brazil, Canada, China, India, Nigeria, Pakistan, Russian Federation, the United Kingdom and the United Republic of Tanzania. The estimations were deliberately conservative for a number of reasons: (1) Estimations primarily projected the economic impact to a 2015 horizon, which avoided exaggerated estimates; (2) the model took a narrow view of economic impact of chronic diseases, in that it mainly explored the impact of disease on the economy through change in labour supply, or the opportunity cost of one unit of labour, and through the impact of the cost of treating chronic disease on savings; (3) The effect of chronic disease morbidity is unaccounted for in the model; and (4) Attempting to completely estimate all possible economic impacts of chronic might likely result in an unwieldy and implausible model.

4. Results

Impact of deaths from Heart disease, stroke and diabetes on national income. (Table 2, Figure 2)

The base estimates show that countries will potentially lose substantial amounts in national income as a result of the impact of deaths from chronic disease on labour supplies and savings. In 2005, the estimated loss in national income from heart disease, stroke and diabetes are \$18 billion dollars in China, \$11 billion dollars in the Russian Federation, \$9 billion dollars in India, and \$ 2.7 billion dollars in Brazil. Similarly, the losses for UK, Pakistan, Canada, Nigeria and the United Republic of Tanzania are \$1.6 billion, \$1.2 billion, \$ 0.53 billion \$0.4 billion and \$0.1 billion respectively².

These losses accumulate over time because each year, more people die. Estimates for 2015 for the same countries are between 3 and 7 times those of 2005. The cumulative and average loss over the entire period is summarized in table 2. The dollar values of the losses are obviously higher in the larger countries like China, India and the Russian Federation, and are as high as \$556 million dollars in China. By the same estimation, Brazil, Pakistan and the United Kingdom stand to lose between \$30 billion and \$49 billion over the same period. Nigeria and the United Republic of Tanzania are predicted to stand to lose a cumulated \$7.6 billion and \$2.5 billion in national income between 2005 and 2015.

Countries like China, India and the Russian Federation stand to lose on average between \$23billion and \$53 billion annually in forgone national income due to deaths from heart disease, stroke and diabetes over 10 years between 2005 and 2015. These annual losses are compared to Canada (\$0.9 billion) , the United Kingdom (\$3.4 billion), Pakistan (\$3.5 billion) and Brazil (\$5.1 billion) (See table 2 and figure 2)

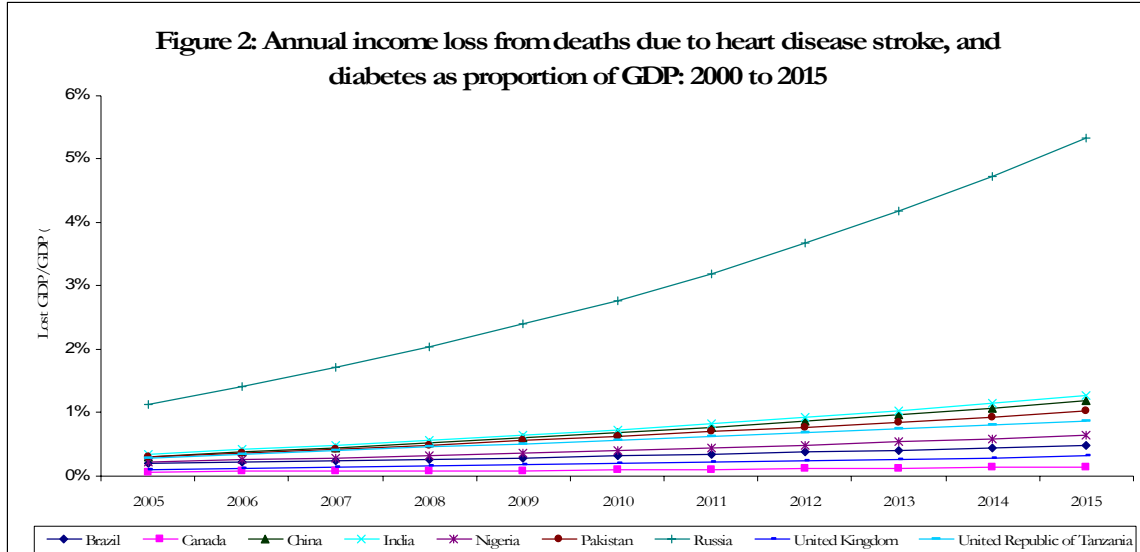
²All figures are reported in international dollars to account for differences in purchasing power between countries.

Table 2: Estimates of effect of Heart disease, stroke and diabetes on the economy.

	Brazil	Canada	China	India	Nigeria	Pakistan	Russia	United Kingdom	United Republic of Tanzania
	<i>(\$'000,000,000) constant 1998 international \$</i>								
Estimated income loss in 2005	-2.7	-0.5	-18.0	-8.7	-0.4	-1.2	-11.0	-1.6	-0.1
Estimated income loss in 2015	-9.3	-1.5	-13.0	-54.0	-1.5	-6.7	-6.6	-6.4	-0.5
Accumulated loss in 2005's value	-\$49.2	-\$8.5	-\$555.7	-\$236.6	-\$7.6	-\$30.7	-\$303.2	-\$32.8	-\$2.5
Average annual loss in income.	-\$5.1	-\$0.9	-\$53.3	-\$23.0	-\$0.8	-\$3.0	-\$29.8	-\$3.4	-\$0.2

These losses can be translated into percentage reductions in the GDP by comparing what GDP would have been in the absence of chronic diseases with GDP in their presence. (Figure 2). In 2005, diseases are estimated to reduce GDP by less than 0.5% in most countries and by 1% in the Russian Federation. By 2015, the percentage reduction in GDP would be over 5% in the Russian Federation and around 1% in the other countries. The absolute loss in dollar terms would be highest in the most populous countries, not unexpectedly India and China. However, the greatest percentage loss would be in the Russian Federation, where the incidence of and case fatality rates from cardiovascular disease is much greater than in the other countries.

The results indicate that the burden of chronic disease poses appreciably greater constraints to economic performance in low and middle income countries. For instance, the average annual foregone contribution to national income due to chronic diseases as percentage of GDP is projected to be higher in China, India, Pakistan and the United Republic of Tanzania than in Canada and the United Kingdom (See table 3).



The general trend for all countries is a gradual increase to 2015 in the share of income loss in GDP due to these three chronic diseases. This increase is steeper for the Russian Federation and for Brazil, China, India, Nigeria, Pakistan and the United Republic of Tanzania than for Canada and the United Kingdom. These differences might be because high income countries have generally stable population growth rates and higher GDP per capita compared to low and middle income countries; in addition, many high countries have appreciably minimized the impact of the burden of chronic diseases on their respective economies. On the other hand, the share of chronic disease medical care cost to GDP is likely to be higher for low income countries.

Table 3: Projected chronic disease-attributable income loss as percentage of GDP: 2005 and 2015.

	Year	Brazil	Canada	China	India	Nigeria	Pakistan	Russia	United Kingdom	United Republic of Tanzania
<i>Estimated loss in GDP/ Projected GDP (%)</i>										
NCD deaths	2005	0.19%	0.07%	0.31%	0.35%	0.23%	0.30%	1.13%	0.10%	0.29%
	2015	0.48%	0.15%	1.18%	1.27%	0.65%	1.02%	5.34%	0.32%	0.86%
	<i>Mean</i>	<i>0.3%</i>	<i>0.1%</i>	<i>0.7%</i>	<i>0.7%</i>	<i>0.4%</i>	<i>0.6%</i>	<i>2.7%</i>	<i>0.2%</i>	<i>0.5%</i>
All-cause deaths	2005	0.92%	0.38%	1.08%	1.27%	1.11%	0.84%	2.73%	1.11%	1.57%
	2015	3.21%	0.64%	3.94%	5.04%	3.07%	3.08%	12.35%	5.18%	4.19%
	<i>Mean</i>	<i>1.4%</i>	<i>0.4%</i>	<i>1.6%</i>	<i>2.0%</i>	<i>1.6%</i>	<i>1.3%</i>	<i>4.5%</i>	<i>1.8%</i>	<i>2.2%</i>

5. Discussion

Chronic disease, economic growth and development

Two major factors account for these grim forecasts on the economic impact of chronic diseases: the labour units lost on account of deaths from chronic disease and; expenditure to treat chronic disease (in direct medical costs). Evidence from the United States, Japan and other countries that have appreciably controlled the burden of chronic disease indicate that these expenditures continue to increase annually. As indicated in this model, medical expenses are initially covered by current earnings, then by savings and eventually from accumulated capital assets. This, in addition to lost labour units, may constrain growth and development given business as usual scenario. Further analysis will indicate that the results from this model are primarily sensitive to the share of physical capital in real output (value of *a*) and secondarily, the proportion of healthcare funded from savings underscoring the importance of medical expenditure on chronic disease to economic growth.

Chronic diseases are responsible for larger share of the foregone income of all deaths in countries.

The estimates from the production model discussed above are for heart disease, stroke, and diabetes only, and do not include cancer, chronic respiratory diseases and many other chronic diseases. In addition, the estimates did not include the life-time cost of morbidity,

disabilities, and foregone expected lifetime earnings of individuals. If costs were estimated for all chronic diseases, they would have been disproportionately much more than for these three chronic diseases and even more so if the other omitted costs were included in the estimation. Estimates of foregone national income from labour supply losses due deaths from stroke heart disease and diabetes only, account for about 42%, 34% 29% and 25% of estimates for all-cause deaths for the Russian Federation, Pakistan, China and India respectively (See bottom row in table 3). Values for low and middle income countries where chronic diseases have been assumed to be less prevalent are comparable (e.g. Nigeria; 21%, United Republic of Tanzania; 20%). This is an indication that chronic diseases may exact the majority of impact on countries' economy compared to other groups of disease. This not surprisingly, may be related to the fact that chronic disease affects mainly the productive age group of any population.

Potential economic gains from achieving the global goal in countries

The global goal proposes a target of an additional 2% annual reduction in projected chronic disease death rates between 2005 and 2015. This corresponds to preventing 36 million premature deaths over the next 10 years, 17 million of which will be in people under 70 years of age.

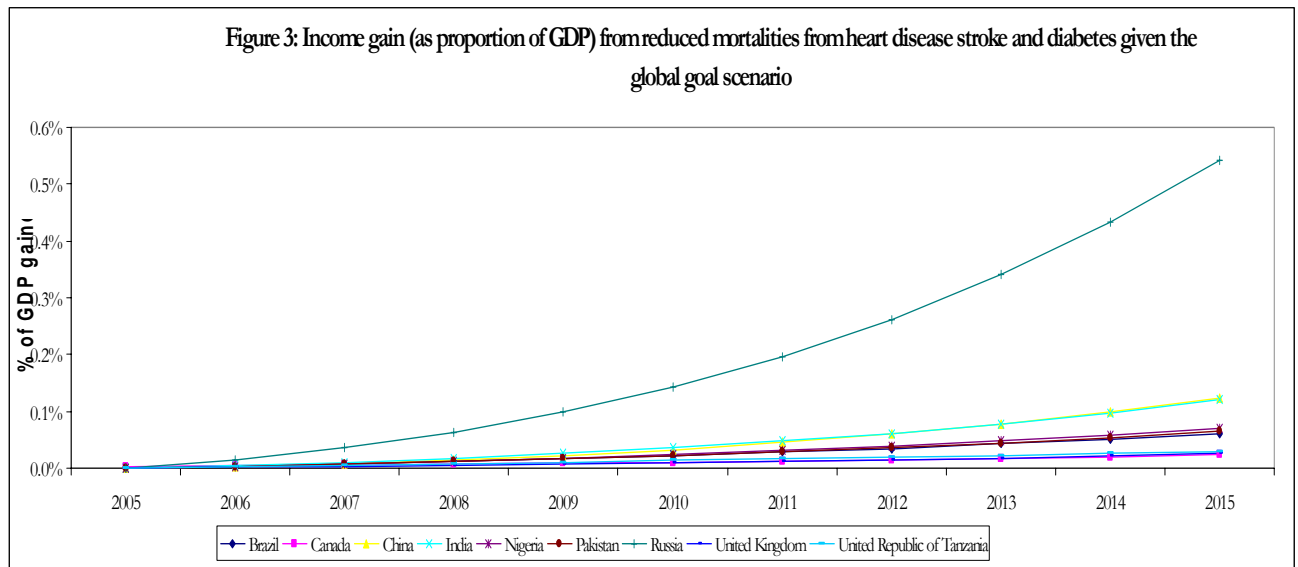
Comparing the loss in national income given the global goal scenario with the loss that would have occurred given business-as-usual situation, our results indicate that averted deaths would translate into substantial labour supply gains in all countries. This in turn will translate to an accumulated gain in income of over 36 billion dollars in China, 15 billion dollars in India and 20 billion dollars in the Russia Federation over the next 10 years. These estimates can be regarded as income which will otherwise be lost to chronic diseases if the global goal were not achieved.

As shown in table 4 and figure 3, comparing these estimates of gains in income given the global goal situation, indicate that the Russian Federation stand to appropriate as much as 0.19% to its projected GDP, similarly for India, 0.05% and China 0.04%. Gains in other countries range between 0.01% and 0.03% of GDP over ten years. In general, those countries experiencing relatively greater burden of chronic diseases and those whose

economies suffer most from the burden of chronic disease stand to gain more from the mortality reduction. For instance, China, India and the Russian Federation stand to gain more than other countries from achieving the global goal, especially compared to Canada and the United Kingdom. The potential gains from the global goal scenario also increase gradually to 2015 in all countries.

Table 4: Annual gain in income as percentage of GDP given the global goal scenario: Average between 2005 and 2015.

Average annual income gain as % of GDP	Brazil	Canada	China	India	Nigeria	Pakistan	Russia	United Kingdom	United Republic of Tanzania
	0.03%	0.01%	0.04%	0.05%	0.03%	0.03%	0.19%	0.01%	0.01%



How robust are these estimates from the calibration model and the economic parameters employed?

The sensitivity of the model to many of the assumptions was tested, focusing on two main types of sensitivity: model sensitivity to the assumptions, and the uncertainty in the assumptions. The sensitivity of the forecasts from model to a total of 79 assumptions (variables) was examined to finally focus on the 10 most influential variables.

The general trend is that in 2005 forecasts, lost GDPs are disproportionately sensitive to either the share of capital on output (a) or the percentage of medical treatment funded from savings (s). The initial sensitivity to these variables reduces rapidly as the forecasts gradually become sensitive to additional variables and evening out towards 2015. For example, a accounted for 87% of the variability in Brazil's forecast lost GDP in 2005 while proportion of medical cost funded from savings accounted for 7.7% of the variability. These contributions evened out to 39% variability due to s and 33% due to a . Sensitivity to capital per worker increased from 2.2% to 15% and sensitivity to savings rate increased from 1% in 2005 to 9% in 2015. This pattern held in the eight other countries only with slight variation. In addition to this pattern, the variances of the forecasts increased to 2015. See Annex II. The estimates for Russian Federation were not sensitive to capital per worker.

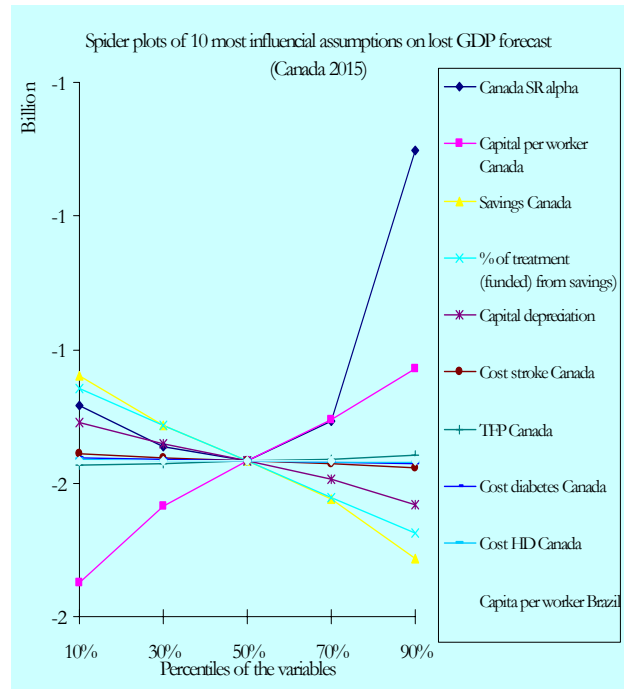
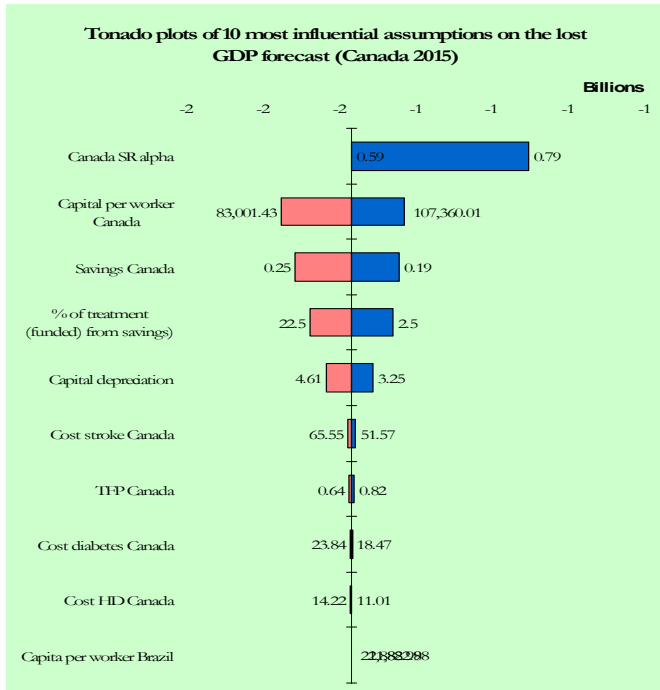
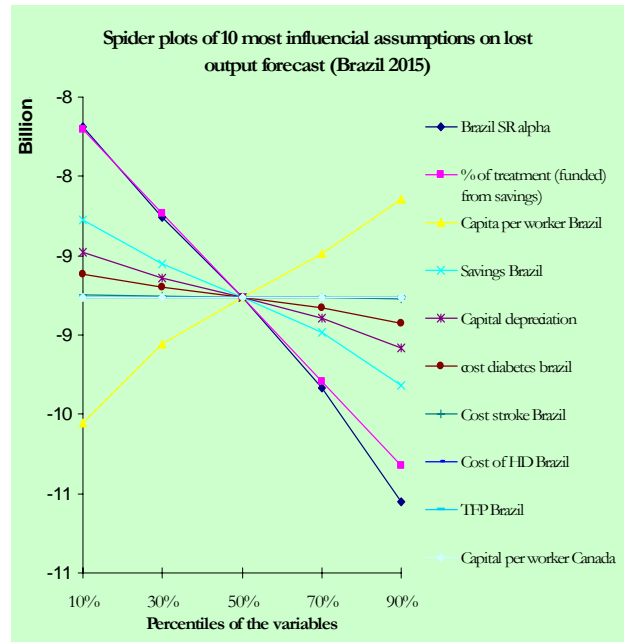
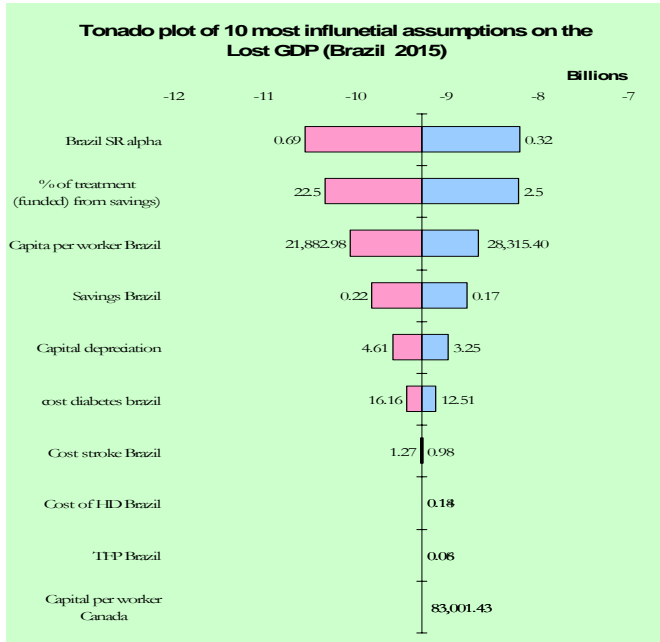
As expected, the model was most sensitive to the share of physical capital in real output (a) followed by the proportion of healthcare funded from savings in all countries (See Tornado and Spider plots in Annex II). The finding that many of the variables contributed little to the variations in the forecasts is sufficient indication of model sensitivity rather than the sensitivity to the assumptions on the variables. The results were robust to even large changes in the majority of the assumptions, including the costs of treatment, suggesting that the impact on chronic diseases on the countries' economy is not equivalent to what they cost the countries (as is often computed in the COI studies), but rather, the extent to which these costs competes with savings, other investments and capital growth.

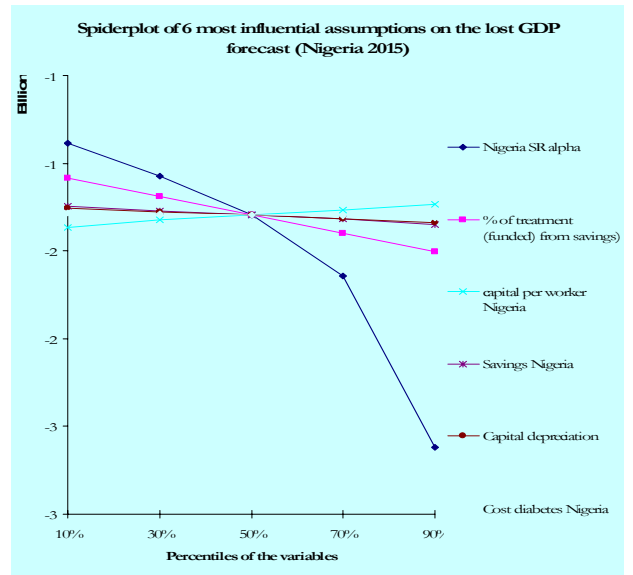
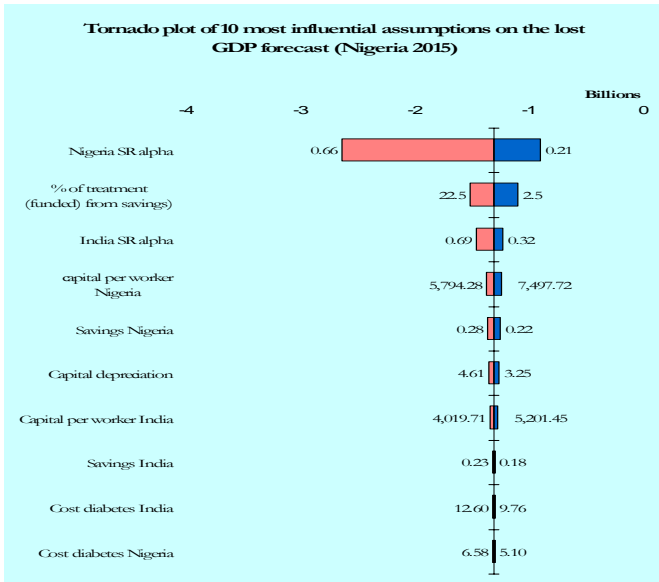
Annexes

Annex 1 Estimates of loss out in 2005 relative to 2005 and proportion on output loss from heart disease stroke and diabetes compared to loss from all causes.

	Brazil	Canada	China	India	Nigeria	Pakistan	Russia	United Kingdom	United Republic of Tanzania
Estimates of 2015 relative to 2005	3.5	2.9	7	6	3.7	5.8	6	3.9	5
Proportion of losses from HD, Stroke and Diabetes on all-cause losses	16.0%	20.4%	29.1%	25.1%	21.2%	33.5%	41.9%	6.7%	20.4%

Annex II: Results of Sensitivity Analysis.





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