# Estimating the cost and burden of chronic diseases: A review on the methods and the evidence in LAC

*By Jorge I. Ugaz*

## Introduction

During the past few decades, the developed world experienced an epidemiologic and demographic transition in which the mortality rates for most chronic diseases decreased dramatically, coupled with sustained increases in life expectancy and quality of life, and drastic decreases in fertility rates, as well as in child and maternal mortality. While the overall burden of chronic diseases continues to increase, age-adjusted death rates for most of these causes are declining, which also suggests the success of preventive interventions.

Unfortunately, the developing world – particularly Latin America – has not shared these successes, or experienced the same transition. Long periods of economic stability and moderate economic growth have ushered in changes in lifestyle, eating habits and frequency of physical activity. In combination with persistent unequal access to health services and greater prevalence of risk factors, these changes have seriously depressed the average health status of the population in this region. Thus, in contrast to the developed world, mortality rates for major chronic diseases in Latin America have not declined.

As the main causes of mortality and morbidity, these chronic conditions are crucial to understanding the challenge ahead, especially since their prevalence is expected to increase along with an increase in life expectancy of the population. The root of this challenge is that chronic diseases predominantly attack the labor force's most productive age groups, reducing their productivity and competitiveness, and threatening the sustainability of the region's recent macroeconomic achievements.

In the particular case of diabetes, for example, the disease primarily attacks those already of retirement age in developed countries, but those between 35 and 64 years of age in developing countries, which represents the most productive years of their lives.

# 1. <u>Objectives and concerns</u>

This paper presents a review of the methods and evidence in the literature regarding the cost and impact of the four main chronic diseases affecting Latin American and the Caribbean: cancer, diabetes, heart disease and hypertension (the latter two are jointly classified as cardiovascular diseases). It should be noted that despite there is no single, universally accepted methodology to obtain these estimates, there is increasing agreement on the benefits and caveats of each method, as well as on the urgency of the matter.

The main objective is to present a clear review of the more common estimation methods used to estimate the economic burden of chronic diseases, as well as its specificities, with a particular emphasis on the evidence relevant to Latin America and the Caribbean, the United States and Canada. There is a firm belief that only through the dissemination of this knowledge can we obtain more accurate estimates of the benefits of potential interventions.

While there is a growing body of literature addressing the cost-effectiveness of programs to prevent, treat and fight chronic diseases, this paper will not focus on this. A more decisive government intervention is needed to address the growing burden of chronic diseases. By increasing awareness of the true economic burden of chronic diseases, it will be possible to work more closely with policymakers on how to solve this problem, minimizing its long-term impact.

To be clear: if governments in the region do not intervene and adopt a more active role in the prevention of and fight against these chronic diseases, the region will lose its newly obtained competitiveness, resulting in a weakened labor force and significant productivity losses. It is indeed worrying that many countries in the region do not have clear policies regarding the prevention and treatment of chronic diseases. Addressing this challenge demands the active involvement of not only Ministries of Health but also Ministries of Economics and Finance. As previously noted, while the prevention and treatment of chronic diseases almost always falls

within the realm of the Ministries of Health, the economic burden will be felt most acutely in the finance, fiscal and labor fields, especially due to the magnitude of productivity losses.

However, some study results presented in this paper have been received with skepticism by policymakers and particularly by macroeconomists, who have expressed their doubts and concerns about some of the assumptions made and measurements proposed to estimate the economic burden of chronic diseases. This will remain a significant obstacle in convincing them of the urgency of this threat to competitiveness and productivity.

The paucity of literature on the economic burden of chronic diseases in developing countries can be explained by the relative newness and diverse roots of the problem, as well as by the limitations imposed by available data. Some countries have datasets that allow estimating the direct and indirect costs without problems regarding the accuracy or representativeness of the data. In the United States, for example, studies tend to rely on the Medical Expenditure Panel Survey (MEPS) for direct costs, and on the National Health Interview Survey (NHIS) for indirect costs[1]. Surveys and panel data with similar quality are rarely available in low-income and poor Latin America countries.

However, to actively engage relevant institutions and policymakers outside the health sector, rigorous studies on the economic impact of chronic diseases will be essential.


## 2.  <u>Methods for estimating the true burden of chronic diseases</u>

The two most common perspectives on the problem of chronic diseases are the cost perspective, which focuses on the economic burden of the disease, and the benefits perspective, which focuses on the potential benefits of interventions.

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[1] See, for example, Devol & Bedroussian, 2007.

This paper will explore the cost perspective. Within this perspective, the estimation of the economic burden of a disease can be divided in three broad approaches: (i) The cost-of-illness method, which estimates the *direct costs* of the illness for a particular population in a specific period, plus the *indirect costs* of the illness. These indirect costs are considered part of the human capital approach, which focuses on the years of labor lost due to the disease in a country[2]. The cost-of-illness methodology was essentially established by Rice et.al.[3] and has since been used as the starting point for the estimation of the burden of any type of disease; (ii) Economic growth models, which assess the impact of chronic diseases on the gross domestic product of a country through changes in the model's inputs (e.g., savings rate, labor supply, etc)[4]; and (iii) The full-income approach, which estimates the societal value of welfare losses or gains associated with poor health, early death, or increases in life expectancy in monetary terms.[5]

Devol and Bedroussian (2007) provide a good example of the economic growth model approach. Using a standard economic model of the relationship between inputs like labor, capital, and skills, and economic output, they estimated how poor health conditions affect investments in human capital and, in turn, the rate of economic growth. Through simulation procedures, the study concluded that moderate reductions in chronic disease would help the United States avoid losing almost $2 trillion of economic output by the year 2030.

Although this paper will examine a few additional studies that used the economic growth model approach, it will mainly review the methods and evidence from the cost-of-illness approach, which estimates the direct and indirect costs of chronic diseases.

**Direct and indirect costs under the cost-of-illness approach**

a) **Direct Costs**

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[2] There is no clear consensus on this approach; some studies include indirect costs as part of the cost-of-illness methods, and some studies do not consider indirect costs as part of a cost-of-illness approach.

[3] Rice et.al. (1985)

[4] Abegunde (2006) and Devol and Bedroussian (2007) represent good examples of this second approach.

[5] Becker, Philipson & Soares (2003).

Direct costs are composed of the monetary resources needed to cover the medical services offered to all the patients suffering from a particular disease. These include, but are not limited to, hospitalization services (from hospital outpatient visits, inpatient days, and emergency room visits), physician and nurse services, long-term care, prescription drugs, medical supplies and laboratory tests. Although harder to estimate, out-of-pocket expenditures are usually included as well.

Direct costs are usually estimated from expenditure surveys, which provide disease-specific data on cost per hospital day, combined with some data on the average hospital days related to each disease.

Sometimes, the estimation of these direct costs is different from other cost-of-illness approaches, which are usually based on aggregated data of utilization of services and spending. Analyses based on aggregated data have become less common recently, and tend to underestimate the true cost of a disease, due to the exclusion of out-of-pocket expenditures. This is especially relevant when comparing the burden of different diseases; for example, people with diabetes and hypertension tend to have greater levels of out-of-pocket expenditures than people with cancer or heart diseases (partially due to differences in insurance coverage)[6]. Estimation of the direct costs increasingly relies on national surveys that provide information on health care use, insurance coverage, individual and household spending, etc.

## b) **Indirect Costs**

Indirect costs are much harder to quantify, not only because of the more limited availability of data but also due to conceptual concerns and disagreements. Economists and policy analysts have increasingly employed the human capital approach, with a few studies using the willingness-to-pay approach. Our primary focus will be on the former.

- *The willingness-to-pay (WTP) approach.*

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[6] Druss, 2001.

Under this approach, indirect costs consist of how much a person would be willing to pay in order to reduce the probability of morbidity or mortality from a certain disease. Due to data limitations, as well as myriad types of response bias that may arise in its estimation, few studies have adopted this approach to estimate the indirect costs of chronic diseases.

Yabroff et.al.[7] is one of the most recent examples that used the WTP approach to estimate the value of life lost from a chronic disease: cancer deaths by tumor site in the United States. The authors used the value of a year of life published in two recent documents that measured the impact of the tobacco settlements and increased longevity in the United States.[8] [9] The average value of life (which was used as the proxy for the willingness to pay for an additional year of life) was $150,000 for men and women in all age groups. The final estimates produced in this study were between 5 and 10 times the total estimates obtained using the human capital approach.

- *The human capital approach*

In general terms, indirect costs represent the cost incurred by a society due to an individual being unable to work, either due to an illness or premature death from an illness.

Under this approach, economic value is imputed in years of life lost (YLL) due to premature death by a certain disease by assigning average age-specific and gender-specific earnings to those lost years. In a minority of cases, it also includes the value of household work for individuals who left the labor force to care for relatives. At the same time, economic value is also imputed in years lived with disability (YLD), whether disability was temporary or permanent. Thus, the total burden of disease is quantified in terms of DALYs, or disability-adjusted life-years, which consists of the sum of YLLs (to account for premature mortality) and YLDs (to account for lives lived with disabilities). Conceptually, one DALY represents the value of the

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[7] Robin Yabroff et.al., (2008).

[8] Cutler et.al. (2008).

[9] Lichtenberg (2008).

gap between the current health status of a population and the ideal situation in which everyone in that population lives to old age in *full* or perfect health.[10]

In this sense, indirect costs consist of mortality costs and morbidity costs, which are represented by the loss of a population's productive potential, due to permanent disability (for the time the person is sick) or due to premature mortality (in case the person died from the illness)[11]. A widely used proxy for lost productivity is the current and projected earnings stream of the individual. The validity of using earnings as a proxy for productivity has been questioned, particularly in highly unequal societies such as the ones in some Latin American countries.

Within the human capital approach, a variety of costs are used to estimate the total indirect costs of an illness:

- Annual morbidity costs, or cost for prevalent cases. Using the particular incidence in a cohort of patients in a year, this method estimates the cost for prevalent cases in a particular period, usually one year, regardless of the time of disease onset. This method is quite unproblematic to estimate, which explains why it has been widely used in the recent literature.

- Lifetime cost for incident cases. This incidence-based method estimates the costs starting at the disease onset until either the person is cured or the person dies. Thus, for people suffering from a particular disease, indirect costs would represent the monetary value of the number of days, months, or years of work of the person's productive years in the labor market that she will miss due to being sick until she is cured or until she dies. This is used to estimate the number of discounted years of productive life lost (or YLL).[12]

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[10] Mathers, et.al. 206.

[11] A common critique of this approach of that it adds costs based on prevalence measures (costs occurring in the current year; direct costs and morbidity costs) with costs based on incidence measures (costs that accrue to an incidence case from diagnosis to death; mortality costs).

[12] A common criticism of this approach is that a day lost due to illness does not necessarily represent lost income or a loss to the economic output of a company or a country.

If the person is cured, the indirect costs are considered costs of temporarily disabled patients[13] ; if the person is never cured, the indirect costs are considered costs of permanently disabled patients. If the person dies (called "premature mortality" if the person dies due to the disease before reaching retirement age), indirect costs would also include the monetary value of the estimated number of additional years that person would have worked had she not suffered from the disease. Some studies assign average age-specific, gender-specific earnings to the lost years. There is little consensus on how to quantify the lost productivity (or value of household work) for people who were not formally employed in the labor force. The predominance of informal labor arrangements in the region increases the likelihood that a person will stop working if she becomes ill, since there are no health insurance or retirement plans to function as incentives to stay in the market.

This method is not as simple as the annual morbidity costs methods, since it relies on the availability of data on the natural history of the disease, including duration and survival rates, intensity of the illness, how different stages of the disease affect the likelihood of not working, and how they affect the demand for more or fewer medical and hospital services. However, it is more useful to estimate the benefits of reducing morbidity or mortality rates through specific interventions.

An additional layer of indirect costs under the human capital approach is the productivity loss from relatives of the patient who drop out from either school or the labor force to become de facto caregivers. In this case, the main source of income in the household has left the workforce, or is working substantially fewer hours[14]. According to the survey "Caregiving in the U.S.", 21% of the American population (or 44.4 million people) over 18 years of age are involved in some type of unpaid care giving activities, with around 10% of that population devoting more than 40

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[13] For a good summary on the use and applications of DALYs and QALYs, see Sassi (2006).
[14] See Bradley, et.al. (2008).

hours per week of care.[15] As the prevalence of chronic diseases in people in their most productive years increases, the future of the labor force in the region is threatened.[16]

Also included in the estimate of indirect costs should be the loss of productive potential due to children permanently dropping out of school in order to take care of a sick parent or a relative. Yet, the authors do not know of any major study that has tried to estimate this productivity lost as a consequence of chronic diseases in members of the family.

Finally, in theory, these estimations should also consider frictional costs, defined as those costs that are associated with replacing, temporary or permanently, a disabled worker. This includes search and training costs, as well as reduced productivity during the first months of work. However, to the authors' knowledge, no study has considered this in any estimation of the burden of chronic diseases.

3. **Methodological Issues and common critiques on the estimation of the economic burden of chronic diseases**

Although several recent studies estimated the economic burden of chronic diseases in the world, direct comparisons of their results, across and within countries, are often impossible because even small differences in assumptions can produce great differences in final estimates.

The existence of co-morbidity is particularly problematic. For example, it was estimated that approximately 25% of the US population suffers from more than one chronic disease[17], with hypertension being the most prevalent condition (10.2%), and diabetes and ischemic heart disease having the highest rates of co-morbidity. In the case of hypertension, for example, the prevalence and persistence of the disease in an individual is highly correlated with an increased probability of suffering from other conditions, such as aneurysm, heart failure, kidney failure,

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[15] NAC and AARP, 2004.
[16] Gaziano, 2007.
[17] Druss, 2001.

etc. The same is true of diabetes, which is associated with increased risk of hypertension, mental illnesses, heart failures and eye complications. Thus, to estimate the total costs associated with hypertension, one must determine the proportion of individuals suffering from that illness, as well as the associated morbidity and mortality that is only attributable to hypertension.

Including versus excluding these co-morbid conditions usually results in substantial differences in the estimated impact of the diseases. When co-morbid conditions are included, there is a risk of double counting or overstating the true burden from a particular disease; when co-morbid conditions are excluded, there is a risk is of understating the true dimensions of the problem.

Estimating the size of the population suffering from the disease.

The most accurate estimates are found in country-specific studies, which most often produce estimates based on previous prevalence rates, adjusted for a number of factors, including growth rate of the population, age structure, rising prevalence of associated illnesses (for co-morbidities), reduced mortality from the disease, and improvements in early detection, among others. However, some other studies also rely on metadata and aggregated data, failing to account for these particularities[18]. Although the latter type of study provides a general sense of the dimension of particular diseases in different countries, their estimates tend to be less reliable and are therefore viewed with skepticism.

A particular issue is the underreporting of diseases. For example, a study by the American Diabetes Association using the NHANES estimated that 2.2% of the non-institutionalized population of the US has undiagnosed diabetes[19]. In another study, Zhang estimated that around 6.3 million Americans have undiagnosed diabetes, with an estimated cost of $18 billion just from complications due to the lack of proper diagnosis.[20] Although that could be easily included as a final adjustment, more research is needed to establish how resource use differs among those with undiagnosed diabetes, with diagnosed diabetes and those without diabetes.  In the ADA paper

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[18] King, 1998.
[19] ADA, 2007.
[20] Zhang, 2009.

discussed above, Zhang employs population etiological fractions to answer this question, concluding that undiagnosed patients use more resources because of preventable complications from the disease.

This is an even more serious problem in Latin America. In the early 1990s, it was estimated that 42% of people under 40 years of age who were diabetic were not diagnosed, with rates in Brazil and Argentina around 45% and 50% respectively.[21]

Extrapolating for lifecycle cost estimates

Current prevalence rates by age, gender and race, for example, are bad proxies for future prevalence rates. Prevalence rates have different dynamic paths by race and gender. Adjustments are needed in order to use them as inputs to predict future costs.

Estimating costs due to disability and premature mortality

Studies that rely on survey data can estimate the costs of temporary disability by using the previous wages of the person suffering from the disease. However, this strategy does not work for people who have already died, or who have been permanently disabled for certain period of time. In these cases, a possible proxy is the total number of years of productive life lost, multiplied by the GDP per capita[22]. However, this runs the risk of overestimating or underestimating the total cost of the disease, depending on the distribution of patients by level of education, or income. Another approach to estimate the years of lost productivity due to early mortality is computing the net present value of future productivity, by gender and by age.[23]

There is another complication that stems from estimating the lost productivity for people outside of the labor force. A possible solution is to use the minimum wage as a proxy, but that might underestimate the productivity of those who are retired or who simply opted out of the labor market (for example, highly educated mothers). On the other hand, using minimum wage as a

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[21] Andrade, 2009.

[22] See, for example, Arredondo & Zuniga, 2006.
[23] See, for example, American Diabetes Association, 2008.

proxy might inflate the final estimate, since those outside the labor market tend to have lower education levels. Some adjustments can be made to control for those issues.[24]

Another methodological issue is that estimates tend to omit the value of productivity loss that results in reduced earning potential without causing individuals to stop working altogether. In other words, people with certain illnesses stay in the labor force, but their productivity is diminished by the disease so that, even though they are working, their wages and salaries are smaller compared to individuals with same characteristics who do not have the disease.

A recent study by Loeppke[25] tried to address this by looking at data on self-reported employee productivity and health information. The study used the impact of diabetes on employees' productivity (though not on wages or salaries) to compare the magnitude of lost productivity (indirect costs) with medical and pharmacy costs (direct costs), concluding that the former was more than four times greater than the second.

Estimating which resources can be attributed to each disease

Each of these four chronic diseases has a long list of (potential) co-morbidities. This presents a serious problem because if the estimates do not control for factors that increase the risk and severity of the disease, the final results will overestimate the health resources attributed to it. There is no clear empirical strategy to solve this, and most of the methods available depend on the existence of highly disaggregated data.

Determining the true cause of death.

Underreporting exists not only in incidence rates for chronic diseases, but also in chronic diseases as the cause of death, since a person may die from complications of the disease. For example, a person who suffers from diabetes may die of kidney, heart, or brain complications, and very rarely is diabetes recorded as the main cause of death. This may not be a relevant issue for estimates of the burden of cancer or some heart diseases, but it certainly is relevant for diabetes and hypertension.

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[24] Op.cit.
[25] Loeppke, et.al., 2009.

Forecasting the expected number of cases of the disease

Predictive models employing time series data analysis have been used to predict the expected number of cases of a disease. Issues to consider include the evolution of the incidence rates by age group, gender, and expected levels of success or failure of current prevention and treatment programs. Arredondo & Zuniga, for example, used Box-Jenkins method to estimate epidemiological changes in their estimate of expected cases of hypertension in Mexico[26]. Levels of co-morbidity should also be considered, especially since they are not constant across either time or different population groups.

The quality covariate

It often makes sense to include the quality of life for those people who continue working or living with the disease: they may work the same number of hours as they did when they were not sick, but their productivity or on-the-job-performance may be severely impaired and their levels of happiness and quality of life at home may be diminished.

Although it is beyond the scope of this paper, we should briefly note that there are two broad approaches to this issue.[27] The first approach produces healthy life expectancy (HLE) measures, through which the life expectancy of an individual is adjusted based on epidemiological information on the amount and kind of morbidity that is expected for those remaining years (a variation of this is QALYs, or quality-adjusted life years). A second approach (explained earlier in this paper, to estimate indirect costs under the human capital approach) is DALYs, or Disability Adjusted Life Years, which integrates the concepts of permanent or temporary morbidity and premature mortality into a single measure.[28] Thus, DALYs are a combination of Years of Lost Life (YLL) and Years lived with disability (YLD).

The unavoidable link to the obesity epidemic

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[26] The Box-Jenkins is a method that applies ARMA or ARIMA models to find the best fit of time series of past information in order to make predictions.
[27] National Center on Health Statistics, 2000.
[28] Brown et.al. (2001).

No estimate will be accurate if it does not consider the impact of the obesity epidemic on the number of sufferers of diabetes, cardiovascular diseases (in particular hypertension) and cancer. This is critical not only because obesity rates continue to increase, but also because the presence of obesity increases the likelihood of co-morbidity in a patient. Although it is difficult to accurately measure the impact of obesity on productivity in the household or labor market, it is feasible to estimate the impact of being obese on the likelihood of developing one or more chronic conditions.

In this sense, recent evidence has shown that the obese population today may enjoy increased longevity compared to earlier generations due to improvements in cardiovascular health, but paradoxically may experience more disability[29]. In other words, we expect increasing obese population to live longer but also report many more days of disability due to obesity-related complications across their lifespan.

In a widely cited paper, Manson et.al.[30]suggested potential biases in studying the impact of obesity and weight gain on mortality rates, especially when researchers adjust for the presence of hyperglycemia or hypertension, since those conditions, through increasing BMI, are the ones affecting health risks in the individual. For an alternative perspective on the channels through which obesity is related to premature mortality, see Katzmarzyk et.al.[31]

## A fiscal impact from chronic diseases

The recent discussion of the impact of these chronic diseases has not addressed the fiscal implications of both the direct and indirect costs. This lack of interest, however, should not be interpreted as a lack of urgency. From the federal government's perspective, the increasing mortality and morbidity rates from these diseases will cause an increase in the proportion of welfare transfers to ill individuals who may not be able to return to the labor force. On the other hand, a labor force that is diminished and more prone to illnesses will generate fewer federal or local taxes than a healthier one. Again, this is more relevant in Latin American countries than in

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[29] Alley & Chang, 2007.
[30] Manson et.al. (2008).
[31] Katzmarxyk et. al.(2003)

developed countries, since diseases like diabetes and hypertension are more likely to affect individuals in their most productive years.

## 4. <u>A general overview of the evidence</u>

As previously noted, due to the wide range of methods, assumptions and data sources employed to estimate the economic burden of chronic diseases in particular countries, any comparison should be interpreted carefully. In fact, in this paper, we caution against any sort of comparison of final estimates because methods of health goods and services delivery vary a great deal between societies. Nevertheless, any compilation of available results can provide a useful approximation of the true dimensions of the problem, serving as an input for policy or budget priority changes. Additionally, this sort of review is valuable since it provides evidence of the deficit of country-studies with good estimates of the cost of chronic diseases.

Table 1 presents estimates of the economic burden of chronic diseases from several studies written in the last few years, some of which have been mentioned earlier in the paper. The table includes estimates mainly from papers that presented single-country studies, and only a couple of studies that presented estimates for more than one country based on aggregated data. In addition, this document does not include papers that presented evidence only on specific types of the disease (e.g., prostate cancer, breast cancer).

Table 1 includes a column with the ratio between indirect costs and direct costs as a way to show the magnitude of indirect costs compared to direct costs. Any estimate of the economic burden of a chronic disease that does not include indirect costs will grossly understate the true dimensions of the problem that chronic diseases represent. That column is intended to act as a reminder that the true threat presented by chronic diseases is not in the ever-increasing magnitude of medical costs, but rather in the serious impact on the labor force and investments in human capital.

In general, direct costs tend to be higher in developed countries than in developing countries, not only because of the higher relative cost and quality of medical services, but also because of greater access to treatment. Also, as previously mentioned, diseases like diabetes or hypertension are more likely to go untreated and undiagnosed in developing countries. While the lack of proper diagnosis affects the estimation of both direct and indirect costs, the lack of treatment aggravates the productivity losses indicated in the indirect costs, but also produces a smaller estimate of direct costs than would be expected with greater access to health services.

## 5.  <u>Conclusions</u>

Most Latin American countries face a serious threat to their future economic success due to the increasing presence of chronic diseases among their most productive population groups. The epidemiological transition of the last couple of decades has brought some benefits, but it has also deteriorated the health profile of the average person in the labor force, and this is only likely to worsen considerably. Whether this situation can be reversed or improved depends on convincing the macroeconomic institutions in each country, not only of the true dimension of the problem, but also to be part of the team that will fight against the growing incidence of chronic diseases in the region.

Obtaining accurate and solid diagnoses of the economic burden of chronic diseases for each country is essential to reduce the skepticism found in some academic and policy-making circles. This study has tried to show how there is more than one way to estimate costs, and different methodologies generate different responses and different concerns. In this sense, we welcome the new but growing interest in the estimation of the impact from those diseases. It is time to figure out how to replicate some of the best studies presented in this paper in other countries and in a more systematic way. Data limitations will surely be an issue, but not one that cannot be overcome.

## References

Abegunde D, Stanciole A. 2006. An estimation of the economic impact of chronic noncommunicable diseases in selected countries. World Health Organization Department of Chronic Diseases and Health Promotion (CHP).

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

Alley DE, Chang VW. 2007. The changing relationship of obesity and disability, 1988–2004. Journal of the American Medical Association; 298(17): 2020–7.

American Diabetes Association. 2008. Economic costs of diabetes in the US in 2007. Diabetes Care; 31(3): 596–615.

Andrade F. 2009. Estimating diabetes and diabetes-free life expectancy in Mexico and seven major cities in Latin America and the Caribbean. Revista Panamericana de Salud Pública [online]. Vol.26, n.1, pp. 9-16. ISSN 1020-4989.

Arredondo A, Zúñiga A. 2004. Economic consequences of epidemiological changes in diabetes in middle-income countries: the Mexican case. Diabetes Care 2004; 27(1): 104–9.

Arredondo A, Zúñiga A. 2006. Epidemiologic changes and economic burden of hypertension in Latin America: evidence from Mexico. American Journal of Hypertension; 19(6): 553–9.

Azambuja M, Foppa M, Fernando de Camargo M, Achutti A. 2008. Economic Burden of Severe Cardiovascular Diseases in Brazil: an Estimate Based on Secondary Data. Porto Alegre, RS. Brazil.

Barcelo A, Aedo C, Rajpathak S. et al. 2003. The Cost of Diabetes in Latin American and the Caribbean (includes Brazil, Chile, Colombia, and Mexico). Bulletin of the World Health Organization; 81:19–27.

Becker G, Philipson T, and Soares R. 2003. "The Quantity and Quality of Life and the Evolution of World Inequality." NBER Working Paper 9765, National Bureau of Economic Research, Cambridge, MA.

Boutayeb A, Boutayeb S. 2005. The burden of non communicable diseases in developing countries. International Journal for Equity in Health, 4: 2.

Bradley C, Yabroff KR, Dahman  B, Feuer EJ, Mariotto A, Brown M. 2008. Productivity Costs of Cancer Mortality in the United States: 2000 – 2020. Journal of National Cancer Institute; 100: 1763 – 1770.

Brown ML, Fintor L. 1995. The economic burden of cancer. In: Cancer prevention and control, ed. P. Greenwald, BS Kramer, DL Weed, pp.69-81. New York: Marcel Dekker.

Brown ML, Lipscomb J, Snyder C. 2001. The burden of illness of cancer: economic cost and quality of life. Annual Review of Public Health; 22: 91–113.

Cutler DM, Gruber J, Hartman RS, Landrum MB, Newhouse JP, Rosenthal MB. 2008. The Economic Impacts of the Tobacco Settlement .NBER Working Paper No. W7760. http://ssrn.com/abstract=235716 . Accessed October 31, 2009.

Dawson KG, Gomes D, Gerstein H, Blanchard JF, Kahler KH. 2000. The economic cost of diabetes in Canada. Diabetes Care; 25: 1303-7.

Devol R, and Bedroussian A. 2007. An Unhealthy America: The Economic Burden of Chronic Disease. Milken Institute, October.

Druss BG, Marcus SC, Olfson M, Tanielian T, Elinson L, and Pincus HA. 2001. Comparing the National Economic Burden of Five Chronic Conditions. Health Affairs, November - December.

Gaziano TA. 2007. Reducing the Growing Burden of Cardiovascular Disease in the Developing World. Health Affairs; 26(1): 13–24.

Javitt J, & Chiang Y. 1995. Economic Impact of Diabetes. <u>In</u>: Diabetes in America, 2nd edition, Chapter 30. U.S. National Diabetes Data Group, National Institutes of Health, Bethesda, MD.

Katzmarzyk PT, Janssen I, Ardern CI. 2003. Physical inactivity, excess adiposity and premature mortality. Obesity Reviews; 4: 257–290

King H, Aubert RE, Herman WH. 1998. Global burden of diabetes, 1995-2025: prevalence, numerical estimates, and projections. Diabetes Care, Volume 21, Number 9, September.

Lichtenberg FR. 2008. Sources of U.S. Longevity Increase, 1960–1997 (December 2000). CESifo Working Paper Series No. 405. http://ssrn.com/abstract=263113 . Accessed October 31, 2009.

Lim SS, Gaziano TA, Gakidou E. et al. 2007. Prevention of cardiovascular disease in high-risk individuals in low-income and middle-income countries: health effects and costs. The Lancet; 370(9604): 2054–62.

Loeppke R, Taitel M, Richling D, Parry T, Kessler R, Hymel P, and Konicki D. 2007. "Health and Productivity as a Business Strategy," Journal of Occupational and Environmental Medicine 49, No. 7.

Lopez AD, Mathers CD, Ezzati M, Jamison DT, Murray CJL. 2006. Global and regional burden of disease and risk factors, 2001: systematic analysis of population health data. Lancet; 367: 1747–57.

Manson JE, Stampfer MJ, Hennekens C, Willet WC. 1987. Body-weight and longevity – a reassesment. JAMA; 257:187–193.

Mathers CD, Lopez AD, Murray CJL. 2006. The burden of disease and mortality by condition: data, methods and results for 2001. In: Lopez AD, Mathers CD, Ezzati M, Murray CJL, Jamison DT, eds. Global burden of disease and risk factors. New York: Oxford University Press: 45–240.

National Alliance for Caregiving and AARP, 2004. Caregiving in the US.

National Center on Health Statistics. 2000. Developing an Index of Health: Approaches, Current Developmental Activities, and Implications. A Report to the Senate Committee on Appropriations. Atlanta, GA: Natl. Cent. Health Stat, Center for Disease Control and Prevention.

Popkin BM, Kim S, Rusev ER, Du S, and Zizza C. 2006. Measuring the full economic costs of diet, physical activity and obesity-related chronic diseases. Obesity Reviews, 7, 271–293.

Pramparo P, Mendoza C, Barceló A. et.al. 2006. Cardiovascular diseases in Latin America and the Caribbean: The present situation. Prevention and Control; 2(3): 149–157.

Rice DP, Hodgson TA, Kopstein AN. 1985. The economic costs of illness: a replication and update. Health care Financing Review 7: 61-70.

Runge CF. 2007. Economic consequences of the obese. Diabetes; 56(11): 2668–72.

Sassi F. 2006. How to do (or not to do)… Calculating QALYs, comparing QALY and DALY calculations. The London School of Hygiene and Tropical Medicine.

Vijan S, Hayward RA, Langa KM. 2004. The impact of diabetes on workforce participation: results from a national survey. Health Services Research; 39(6): 1653–69.

Villareal E, Mathew-Quiroz A, et.al. 2002. Costo de la atención de la hipertensión arterial y su impacto en el gasto en salud en México. Salud Pública de México; 44: 7-13.

Villarreal-Ríos E, Salinas-Martínez AM, Medina-Jáuregui A. 2000. The cost of diabetes mellitus and its impact on health spending in Mexico. Archives of Medical Research; 31(5): 511–4.

Yabroff KR, Bradley CJ, Mariotto AB et al.. 2008. Estimates and Projections of Value of Life Lost From Cancer Deaths in the United States. Journal of the National Cancer Institute; 100: 1755-1762.

Zhang Y, Dall TM, Mann SE, Chen Y, Martin J, Moore V, Baldwin A, Reidel VA, Quick VW. 2009. Population Health Management. April, 12(2): 95-101. doi:10.1089/pop.2009.12202.

| Table 1: Economic burden by chronic disease, in the Pan-American region (US$ millions) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Country | Disease | Total | Direct costs | Indirect costs | Indirect / Direct | Year estimated | Source | Key information |
| United States | Cancer | | | 115,800 | | 2000 | Bradley, et.al (2008) | Does not include productivity lost due to morbidity or disability. |
| | | | | 232,400 | | 2000 | Bradley, et.al (2008) | Includes earnings lost due to caregiving and household activity. |
| | | | | | | | | Does not include productivity lost due to morbidity or disability. |
| | | | | 960,600 | | | Yabroff (2008) | Used the Willingness to Pay Approach |
| | | 96,126 | 27,458 | 68,668 | 2.50 | 1990 | Brown & Fintor (1995) | |
| | | 319,000 | 48,000 | 271,000 | 5.65 | 2003 | Devol & Bedroussian (2007) | |
| | Diabetes | 132,000 | 27,000 | 105,000 | 3.89 | 2003 | " " | |
| | Hypertension | 313,000 | 33,000 | 280,000 | 8.48 | 2003 | " " | |
| | Heart disease | 170,000 | 65,000 | 105,000 | 1.62 | 2003 | " " | |
| | Diabetes | 174,000 | 116,000 | 58,000 | 0.50 | 2007 | American Diabetes Assoc. (2008) | |
| | | 153,000 | 116,000 | 37,000 | 0.32 | 2002, in 2007 | " " | |
| Canada | Diabetes | 4,756 | 3,478 | 1,277 | 0.37 | 1998 | Dawson (1998) | Indirect costs include estimated costs for undiagnosed diabetes, but it does not include costs on disability (only mortality costs). |
| Brazil | CVD | 10,512 | 4,709 | 5,803 | 1.23 | 2004 | Reinert Azambuja et.al.(2008) | Considers only severe cases of CVD |
| Mexico | Diabetes | | 2,618 | | | 1998 | Villareal-Rios, et.al. (2000) | |
| | | 15,118 | 1,974 | 13,144 | 6.66 | 2000 | Barceló, et.al. | See footnote 1 |
| | Hypertension | 2,486 | 1,179 | 1,307 | 1.11 | 2007 | Arredondo & Zuniga (2006) | Only public institutions |
| | | 4,479 | 1,963 | 2,516 | 1.28 | 2001 | Villareal (2002) | |
| Cuba | Diabetes | 1,347 | 722 | 624 | 0.86 | 2000 | Barceló, et.al. | See footnote 1 |
| Dominican R. | | 625 | 226 | 399 | 1.77 | | | |
| Haiti | | 79 | 48 | 31 | 0.64 | | | |
| Bahamas | | 149 | 11 | 138 | 12.91 | | | |
| Barbados | | 151 | 13 | 138 | 10.81 | | | |
| Guyana | | 36 | 20 | 16 | 0.78 | | | |
| Jamaica | | 410 | 136 | 273 | 2.01 | | | |
| Trinidad/Tobago | | 285 | 38 | 247 | 6.49 | | | |
| Costa Rica | | 473 | 97 | 377 | 3.90 | | | |
| El Salvador | | 500 | 137 | 362 | 2.64 | | | |
| Guatemala | | 841 | 291 | 550 | 1.89 | | | |
| Honduras | | 240 | 114 | 126 | 1.11 | | | |
| Nicaragua | | 129 | 85 | 44 | 0.52 | | | |
| Panama | | 435 | 104 | 330 | 3.16 | | | |
| Argentina | | 10,935 | 747 | 10,188 | 13.64 | | | |
| Bolivia | | 228 | 86 | 142 | 1.66 | | | |
| Brazil | | 22,604 | 3,952 | 18,652 | 4.72 | | | |
| Chile | | 2,418 | 295 | 2,123 | 7.20 | | | |
| Colombia | | 2,587 | 415 | 2,172 | 5.23 | | | |
| Ecuador | | 599 | 233 | 365 | 1.56 | | | |
| Paraguay | | 218 | 72 | 146 | 2.03 | | | |
| Peru | | 1,844 | 502 | 1,342 | 2.67 | | | |
| Uruguay | | 775 | 95 | 680 | 7.19 | | | |
| Venezuela | | 2,194 | 308 | 1,886 | 6.13 | | | |

1/ Some variables in the estimation were obtained from a single country, and then extrapolated to other countries with similar levels of GDP per capita. Thus, some variables are constant across countries. Possible underestimation of direct costs.