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Economic Burden of *Diabetes mellitus* in Brazil

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Abstract:

Background: Global economic burden of Diabetes mellitus will reach US$ 745 billion in 2030. The growing prevalence of the disease, mainly type 2, is related to the population aging, nutritional transition, and economic growth. Brazil is the fourth country in number of patients with diabetes and also follows the global trends, with continuous increase in prevalence. In this sense, a complete assessment of the economic burden of the disease in the country, considering all direct and indirect costs, is needed.

Methods: We use a cost-of-illness approach to calculate total economic burden of DM. We use recent and complete data referring to 2016.

Findings: We estimate the Brazilian economic burden of US$ 2.15 billion in 2016, of which 70.6% is indirect costs related to premature deaths, absenteeism, and early retirement. Interpretation: Our results are in accordance with the literature, that shows that indirect costs are more relevant to low- and middle-income countries due to weak health services and therefore higher mortality rates from chronic diseases.

Funding: This study was supported by Bloomberg Philanthropies through a sub-award agreement 5104695 between the University of North Carolina at Chapel Hill and Center for Epidemiological Studies in Nutrition and Health.

Keywords: Direct costs; Indirect costs; Diabetes mellitus; cost-of-illness approach.

JEL Codes: H51; I18; J30.

Economic Burden of *Diabetes mellitus* in Brazil

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1 Introduction

Diabetes mellitus (DM) is one of the main non-communicable diseases (NCDs) in the world and the third highest risk factor for premature mortality after high blood pressure and tobacco use.[10] The global prevalence of DM increased from 108 million adults (4.7% of the total population) in 1980 to 415 million in 2015 (8.8% of the total population) [26, 28] [1] The rapid growth of DM prevalence, especially of type 2, is mainly caused by population aging, nutritional transition (unhealthy habits and lifestyles that raise obesity levels), economic growth and unplanned urbanization. [11, 27]

In this sense, DM prevalence leads to relevant costs to health systems (disease and co-morbidity treatment), and therefore to society as a whole [3]. In 2010, the global economic burden of DM was estimated at US$ 500 billion and was forecast to reach US$ 745 billion in 2030.[10] The calculation of the total economic burden includes direct medical costs (medicines, health services, emergency rooms and hospitalization expenses), direct non-medical costs (expenses for diet products and patient transportation) and indirect costs (productivity effects, early retirement, absenteeism, premature mortality and lost quality of life.).[4, 12]

There are some important aspects related with DM. For example, 25% of people with diabetes represent 82.5% of total global costs.[10, 28] Furthermore, in developed countries, the medical costs are higher than non-medical and indirect costs [33, 19]: in the USA, the direct costs represented 71.8% of total costs (US$ 176 billion out of US$ 245 billion) in 2012. [4]. In low- and middle-income countries, on the other hand, the indirect costs of DM are more relevant, mainly due to higher DM mortality rates[1, 23, 21] and weaker health systems (insufficient and/or inefficient) [25, 16, 8, 9, 23].

Despite the efforts of Brazilian public health care system (SUS), Brazil is the fourth country in the world in number of adults with DM (6.2% of total adults[2])[6, 22]. The literature also shows that DM prevalence might be underestimated in the country [24][17]. DM prevalence has also been rising rapidly in the last decade. [14] [2]The first study with national coverage estimated that the prevalence of diabetes in the urban population aged 30 to 69 years was 7.6% at the end of the 1980s [24]. More recent studies calculate about 14.3 million[6] adults with DM in Brazil, in which the prevalence ranges from 6.3% to 13.5%, depending on the region and the diagnostic criteria adopted in each study.[18]. In 2015, 7% of all disability, with an annual loss of 4,049,510 DALYs[3], could be attributed to DM in Brazil[20], and women were more affected than men.[17]

Diabetes-related health expenditures in Brazil were estimated to be around US$ 22 billion in 2015.[6]. In 2007, the T2DM total annual economic burden in the Brazilian public health system was US$ 2,108 per patient, of which 63.3% was direct costs and 36.7% indirect costs.[7]. Another study estimated the T2DM costs in 2010 for the city of Sao Paulo. The authors found that T2DM costs US$ 1,844 per patient (55% direct costs and 45% indirect costs). [13, 15] A recent study, applying the attributable risk method, estimated an average total cost of US$845 per patient.[30]. Despite the fact that many studies have attempted to calculate the total economic burden of DM in Brazil, they do not consider all types of diabetes or all the opportunity costs involved in treatment and prevalence. Due to this lack of comprehensive nationwide estimates, we intend to fill the gap by estimating the total economic burden of DM (cost-of-illness method) in Brazil using recent data (2016) and a more complete set of data to assess the direct and indirect costs related to the disease. This is the main contribution of our study, as no other has considered as many data sources and types of costs as those examined here.

2 Materials and Methods

2.1 Study Design

The indirect costs (productivity losses) are normally disregarded by the literature. They can be measured as the value of economic output lost due to health conditions associated with DM (injury-related work

[1] The DM prevalence is expected to rise to nearly 642 million by 2040.[6]
[2] PNS 2013 - people who are 18 years old or older
[3] Disability adjusted life year

disability, premature retirement because of illness, or premature death before retirement).[4]

2.2 Data sources and analysis

2.2.1 Population size

The method we use to measure the economic burden of DM in Brazil is similar to previous studies of DM burden. Unless otherwise specified, we define an event caused by DM when it carries some code between E10 and E14 of the International Classification of Diseases (ICD 10). We exclude DM acquired during pregnancy [11][5].

To calculate all the economics costs associated with DM, it is also important to identify the relation between DM and the incidence of other relevant diseases caused by DM. We reviewed the medical literature involving the increase in risks of some illness due to DM ([4]) to understand this relation. Thus, the chronic diseases associated with DM we consider are: microvascular complications; macrovascular complications; respiratory and urinary tract infections; neurological; renal and eye diseases; and selected cancers (breast, liver, colorectal, endometrium and pancreas neoplasms).

The concept of Population Attributable Risk (PAR) is used to measure the relationship between DM and other diseases to assess this important second-order effect of DM prevalence. The PAR indicates the proportion of cases that would not occur if DM was absent. This concept depends on the prevalence of the risk factor and the risk of exposure (Relative Risk, RR) of the disease:

$$share_g = \frac{P_g \text{x}(RR_g - 1)}{[1 + P_g \text{x}(RR_g - 1)]} \tag{1}$$

The fraction is calculated using DM prevalence rate (P) and the relative ratio risk (RR) for each chronic complications of DM.[30] The subscript g refers to age-groups. The idea is to consider all the health issues from DM along with diseases related to DM. In this sense, PAR determines the share of health problems due to diseases commonly classified as morbidity of diabetes.

All the costs are disaggregated by gender (men and women) and age groups ($<$ 18, 18-34, 35-44, 45-54, 55-64, 65-74 and 75 $>$). Costs related to hospitalization and ambulatory procedures are also divided into cost incurred by the Brazilian public health system (SUS) and private costs, which include both out-of-pocket and insured medical services.

2.2.2 Direct costs

The economic costs of DM are calculated using the cost-of-illness (COI) approach, adding the medical and non-medical costs of DM and other diseases associated with DM for Brazil. Direct costs refer to health sector costs for prevention, diagnosis and treatment of disease. In this paper, the following expenditures are included: expenses for hospital care (hospital services and physicians/other healthcare professionals), medical services (outpatient), and pharmaceutical expenses.

Hospitalization cost: We collect hospitalization data from the Hospitalization System (SIHSUS) for the public health system, and from the Communication System of Hospital and Ambulatory Information (CIHA) for private health system costs. Both datasets are generated by DATASUS (Information Technology Department of the Public Health Care System), and contains 2016 data about the hospitalization date, length of stay, days in intensive care unit (ICU), gender, age, among others. It is noteworthy that only SIHSUS presents the average costs per hospitalization.[5]Therefore, we use SIHSUS costs as a lower-bound approximation for private average costs.

[4]Other indirect costs associated with DM, such as presenteeism (reduced work productivity while working), could not be estimated due to data unavailability.

[5]Costs in SIHSUS are disaggregated into expenses for healthcare professionals and materials and installations. We also know the cost of days spent in ICUs.

[5]Another possibility is to use hospitalization prices from DRG Brazil - a dataset composed of data from more than 200 hospitals in the country. In 2016, this dataset included 4,909 patients that were hospitalized due to DM or complications of DM.

Ambulatory Cost: We collected data from two sources: (i) Ambulatory Information System (SIASUS), which considers all outpatient procedures paid by the government; and (ii) CIHA, for the private health system. The former contains data for the public system and we perform the same average cost approximation for CIHA using data from SIASUS by age and gender.

For both hospitalization and ambulatory costs, we consider procedures whose main cause is DM and also morbidities related to DM, based on the PAR method explained in Section 2.1.[30] We consider adults older than 35 years old to calculate morbidities related to DM, since the literature rarely defines relative risk for younger people. The parameters are calculated based on the National Health Survey for 2013 (PNS-2013), stratified by gender and age groups.

Medication costs: We collect data from the Popular Pharmacy program (PP). It is a Brazilian government program that provides commonly used drugs at reduced price or free, including several free diabetes drugs. The entire population is eligible for the program, but purchases are controlled. The drugs can be purchased at any accredited private pharmacy or program pharmacy. Data were obtained by invoking the Brazilian Information Access Law. The pharmaceuticals include human insulin and oral medicines.

Other out-of-pocket costs for materials: We collected data from the last available National Household Budget Survey (POF) to calculate direct costs related to material for measuring the level of blood glucose. POF is conducted by the Brazilian Institute of Geography and Statistics (IBGE). Since the last data available refer to January 2009, we inflate the value by the National Consumer Price Index (IPCA-e) between 02/2009 and 12/2016.[6]

2.2.3 Indirect costs

We considered the following indirect costs in this analysis.

Absenteeism: Denotes the lost productivity due to sickness requiring absence from work. We calculate this using the number of workdays missed per year per person due to the disease (WDM). The measure corresponds to the WDM multiplied by the daily average minimum wage. In our data, absenteeism is a direct implication of hospitalization, even for children and elderly, since they may require accompaniment of some adult (possibly of working age). In addition, children and adolescents up to 18 years old and elderly (above 60 years) have the right to have one companion in the hospital while hospitalized.

We use the minimum monthly salary of US$441.10 (in 2016) to evaluate a missed day for people aged between 18 and 64. For the younger and older, we attribute the average salary of those aged between 18 and 64.

Premature death (PD): Denotes the economic losses due to labor decreases as a result of terminal conditions. We calculate PD losses from the present value of the labor market outcomes lost prior to retirement on the basis of age. According to the Brazilian pension system (in 2016), private-sector employees are entitled to retire if they meet one of two conditions: (i) retirement on the basis of age - 65 for men and 60 for women with a minimum length of contribution of at least 15 years, and (ii) retirement based on length of contribution - 35 years for men and 30 years for women:

$$PD_{ij} = \sum_{t=1}^{T} \frac{N_{ij} w}{(1+r)^t} \tag{2}$$

In which N_{ij} is the number of deaths per year of individuals of gender i and age j, w_{ij} is the minimum salary established in January 2016, r is the real interest rate in Brazil (average between 2012 and 2016).[7] $T = (L_{ij} - AR_i)$ is the difference between the age of mortality, L_{ij}, and age of retirement of the gender, AR_i, for those above the minimum legal age (18 years old).

To calculate YLL, we use data on premature deaths from the Mortality Information System (SIM) in 2016. The dataset is disclosed annually and contains information about all deaths occurred in Brazil. We attribute a minimum value to the lost years of life in terms of productivity. In this calculation, we consider

[6] We did not use the cost of Popular Pharmacy Program to measure medicine expenditures to avoid double counting, since the PP was still incipient when the last household survey was conducted. Today, the program is universal.

[7] The rate is calculated by subtracting the average Brazilian benchmark interest rate (*SELIC rate*, disclosed by the Brazilian Central Bank) by the accumulated inflation for the year (National Consumer Price Index - IPCA).

deaths of which DM was the main cause. We restrict the data to 60 years for women and 65 years for men, as those are the legal ages for retirement. We also exclude deaths of those below 18 years old. As mentioned, we use minimum wage to represent the productivity loss in the labor market and the Brazilian average real interest rate to calculate net present values for 2016.

Disability or early retirement (DIS): Represents the value of interruption of employment due to sickness related to DM. The cost is estimated using the average amount paid by the government to new retirees and sickness aid due to DM in 2015. The number of beneficiaries is determined as the number of people retiring early due to disability related to severe diabetes.

Finally, to calculate the cost due to early retirement related to DM complications, we proxy the number of beneficiaries by people under legal age of retirement who have DM in PNS 2013, as well as morbidities[8]in which DM limits activities. As for the monthly value of benefits, we use data from the National Social Security Institute (INSS).[9]We restrict data to benefits related to DM according to ICD-10[10]. As the most recent data are for 2015, we bring the values to 2016 using the price consumer index and the real interest rate. We only consider men until 65 years and women until 60 years, as these are the legal ages for retirement in Brazil.

2.2.4 Economic burden projection

We project future costs to 2030 based on two scenarios. The first is a conservative scenario in which we consider that the DM prevalence will remain the same from our last statistics calculated from PNS-2013. In the second approach, which we judge more realistic, we consider that prevalence will grow from 2016 to 2030 at the same annual rate it grew between 2003 and 2013 (calculated using the PNAD 2003 and PNS 2013 surveys). In both situations we consider the prevalence by age group. We do not consider people under 18 years old, since there is no information for them in those surveys. In this situation, the diabetes prevalence in Brazil is a weighted average of the groups' prevalence. On the cost side, we use our estimate of diabetes cost, maintaining it constant over time.

Finally, the number of people with diabetes is calculated by multiplying the estimated prevalence of diabetes in 2030 by the projected population in 2030 according to IBGE. The future cost is given by the product of the cost per person calculated in this study and the estimated number of diabetics in 2030.

3 Results

We estimate total costs of US$ 2,153.05 million: US$ 633.03 million (29.4%) in direct costs and US$ 1,520.02 million (70.6%) in indirect costs.[11]The next subsections describe the costs by type (direct and indirect) and demographic groups (gender/age).

3.1 Direct costs

In 2016, the total direct costs related to DM are US$633 million.[12] Table 1 shows all components of the direct costs. When it comes to hospitalizations, we estimate total expenses of US$232.8 million, mainly public expenses (81.4% of the total).[13]When accounting for DM expenses and its complications, women's hospitalization expenses are US$108.6 million (46.7%), while the expense for men are US$124.1 million (53.3%). Direct costs of hospitalizations, only related to DM, represent US$50.2 million for the public health system and US$8 million for the private system. On the other hand, morbidities related to DM summed US$139.7 million at the public system, and US$35 million at the private.

[8]The morbidities considered are heart attack, stroke, kidney problems, vision problems, and foot ulcers/wounds.

[9]We consider data of new disability benefits granted, which include retirement for disability due to injury and sickness.

[10]Since the ICD-10 is not in the most disaggregated level in this dataset, we cannot separate diabetes acquired during the pregnancy and pregnant women who already had diabetes

[11]When using DRG prices, the total costs estimated are US$ 2,342.7 million: US$ 822.7 million in direct costs (35.12%), and US$1,520.01 million in indirect costs (64.9%).

[12]Total direct costs using DRG prices in hospitalization costs are US$ 823 million**??**.

[13]Total costs of hospitalization using DRG prices are US$ 422.5 million.

The total costs of hospitalization attributed to DM (US$174.7 million) were three times higher than DM hospitalization costs as the main cause of hospitalization (US$ 58 million).

In regard to outpatient costs, we calculate a total of US$ 86 million in 2016 (95% of those costs were incurred by the government), and women represent 57% of such costs (US$ 49 million), while men's total is US$ 37 million (43%). The total costs of outpatient care attributed to DM (US$ 82.1 million) was 21 times higher than total DM outpatient costs when DM is the main cause (US$ 3.9 million).

The same results of Table 1 are also disaggregated by age groups in Table 2. DM as a main cause contains 7 age groups, while costs attributed to DM has 5 age groups. In both cases we observe some heterogeneity. The age groups 55-64, 65-74 and 75 years and older are responsible for 80.7% of total hospitalization costs and 86% of ambulatory costs.

Finally, the total direct costs include drugs (US$304 million), and materials to measure diabetes and special needles (US$10 million). Due to data limitation, these total direct costs cannot be divided by gender or age-group.

3.2 Indirect costs

Total indirect costs are calculated by the sum of economic losses due to absenteeism, premature deaths, and early retirement caused by DM and its complications. In 2016, we estimate that they represent US 1.52 billion.

We use hospitalization data to calculate absenteeism (Table 3, which has a small share of total indirect costs (2.6%), amounting to US$ 39.8 million (US$ 20.1 million for men, 50.4%, and US$ 19.1 million, for women, 49.6%). The results are homogeneous by gender, but not by age group. The groups above 55 years old are responsible for more than 75% of total absenteeism costs.

The indirect costs due to premature deaths (Table 4) are US$ 1.18 billion (77.9% of total indirect costs): US$408.8 million for women and US$ 774.7 million for men. To obtain conservative estimates, we do not estimate indirect costs of premature death for chronic complications of DM and related diseases.

Likewise, the total indirect costs of early retirement are estimated only for those whose main diagnosis is DM due to lack of more information. The total costs of early retirement were US$ 296.7 million (19.5%), of which US$186.4 million (7.3%) is for women and US$ 110.4 (12.3%) for men.

3.3 Economic burden of DM per patient

We estimate that the prevalence of DM in Brazil in 2016 was 9,631,664 people (prevalence rate of 6.4% according to the National Health Survey for 2013). Therefore, Table 5 shows that the total cost per patient diagnosed with DM is US$ 223.54: US$67.72 of direct costs (or 29.40% of the total), and US$157.81 of indirect costs (or 70.60% of the total).[14]

When we calculate those costs for the Brazilian population, the total costs per capita represent US$10.49: US$3.09 as direct costs per capita, and US$7.41 as indirect costs.[15]

3.4 Projection of the economic burden in 2030

We project our estimates to 2030 by assuming two different scenarios, as Table 6 shows. In the first scenario, where total DM patients changes only due to population aging, the average prevalence rate increases from 6.42% in 2016 to 7.9% in 2030. The total economic burden increases from US$2.34 billion to US$3.33 billion in 2030 (a real increase of 42.2%, or 2.6% per year). In the second scenario, which we believe is more realistic, the prevalence rate increases to 12.96% in 2030. In this scenario, the total economic burden increases to US$5.47 billion (133.4%, or 6.24% per year).

[14] Direct costs per patient when using DRG prices are US$85.42 (35.12%) and the total costs are US$243.23.

[15] We consider the Brazilian adults (older than 18 years), or 205,156,589 people according to the most recent census figures from IBGE.

4 Discussion

We calculate that the Brazilian burden of diabetes in 2016 was US$ 2.15 billion, or 0.12% of the country's GDP. Most of the burden is attributed to indirect costs (70.6%), as other studies in Brazil also indicate ([7]). Our results are consistent with the literature on middle- and low-income countries, in which the health system weaknesses increase the participation of mortality and opportunity costs of the disease.

We contribute to the literature of DM costs in Brazil by using recent data (2016) and a more complete dataset to assess the direct and indirect costs related to the disease (we make use of dozens of publicly available data). Moreover, many of those studies do not consider detailed assumptions about the cost estimates, and do not consider all types of diabetes or all the opportunity costs involved in diabetes treatment and prevalence ([7, 13, 15]).

Another differential of our analysis is that we disaggregate the results by gender and age group. In this case, we are able to evaluate the heterogeneity of the results, such as the analysis of hospitalization and ambulatory costs. For those direct costs, DM is the main diagnosis across seven groups and costs attributed to DM with five groups. In both cases there is heterogeneity. The elderly (above 65 years) are responsible for 40% to 70% of total hospitalization and ambulatory costs. This result is similar to the literature, which also brings evidence that individuals older than 65 years are responsible for a much larger proportion of hospital resources (hospitalization and ambulatory). [30][4]

The analysis of gender costs provides interesting results. We find that ambulatory costs are more relevant among women, probably due to the greater attention that women give to their health, especially when they have DM, in comparison with men ([32], [31]). The same argument explains the larger premature death costs we find for men.

One important limitation of our analysis is the lack of price information of the medical services provided by the private sector. We assume that the service prices are the same as those paid by the government, which is a very conservative hypothesis that probably underestimates the direct cost estimates. In this sense, we assess the DRG price estimates (see Appendix) to improve the analysis. The average price of medical services of DRG is 30% higher than that paid by the government. However, since the DRG prices lack statistical representativeness, we opt to use the conservative estimates based on public prices to have lower-bound estimates.

Another limitation of our analysis is that we do not consider negative externalities of DM in Brazil. Negative externalities might occur when the health system does not absorb the increased demand for DM patients, generating spillovers among other patients.

As the Brazilian government offers free access to treatment of DM, we believe that undiagnosed diabetes is not a relevant limitation of our study.

Finally, there might exist judicialization costs of diabetes drugs. The list of medicines available from SUS is limited, not including those such as insulin analogues and new oral drugs. So some patients file lawsuits to assert their constitutional right to obtain access to the drugs indicated for their treatment at no cost. There are no data for Brazil as a whole, but in the state of So Paulo, 25% of all lawsuits of this type involve DM drugs.[29]

5 Conclusion

We calculated the total economic burden of *Diabetes mellitus* in Brazil using a cost-of-illness approach and dozens of data sources. We found that the cost of the disease represented 0.12% of the country's GDP in 2016, with a potential to more than double in the next 14 years. The indirect costs, despite the conservative analysis, accounted for the highest proportion of total DM costs.

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Tables and Figures

	Total	**DM as main cause**	**Morbidities related to DM**
Hospitalizations	232.8	58.1	174.7
Women	108.6	30.4	78.2
Men	124.1	27.7	96.4
Public	189.8	50.2	139.7
Private	43.0	8.0	35.0
Ambulatory	86.0	3.9	82.1
Women	49.0	1.9	47.1
Men	37.0	1.9	35.1
Public	82.5	3.5	79.0
Private	3.5	0.4	3.1
Popular Pharmacy	304.2		
Out-of-pocket Expenses	10.0		
Total	**633.0**		

Table 1: Direct costs estimates, in 2016 million US$.

	DM as main cause		**Attributed to DM**		**Total**	
Hospitalizations	58.1		174.7		232.8	
below 18 years old	3.5	6.0%			**3.5**	**1.5%**
18-34 years old	7.7	13.3%			**7.7**	**3.3%**
35-44 years old	6.3	10.8%	3.8	2.2%	**10.1**	**4.3%**
45-54 years old	7.6	13.1%	16.2	9.3%	**23.8**	**10.2%**
55-64 years old	11.5	19.7%	48.7	27.9%	**60.2**	**25.8%**
65-74 years old	11.6	19.9%	60.6	34.7%	**72.2**	**31.0%**
75 years old and above	10.0	17.3%	45.4	26.0%	**55.4**	**23.8%**
Ambulatory	3.9		82.1		86.0	
below 18 years old	0.04	1%			**0.04**	**0.05%**
18-34 years old	0.2	4%			**0.2**	**0.2%**
35-44 years old	0.3	7%	2.1	2.6%	**2.4**	**2.8%**
45-54 years old	0.7	19%	8.1	9.9%	**8.8**	**10.3%**
55-64 years old	1.3	34%	23.5	28.6%	**24.8**	**28.8%**
65-74 years old	0.9	24%	31.4	38.3%	**32.3**	**37.6%**
75 years old and above	0.4	12%	17.0	20.7%	**17.4**	**20.3%**

Table 2: Hospitalization and ambulatory costs by age groups, in 2016 million US$.

		DM as main cause		Attributed to DM	
	Total	**Women**	**Men**	**Women**	**Men**
Absenteeism (in million)	39.80	10.20	9.59	9.52	10.49
below 18 years old	2.53%	5.69%	4.44%		
18-34 years old	4.62%	13.17%	5.18%		
35-44 years old	5.37%	9.69%	7.63%	2.02%	2.15%
45-54 years old	11.43%	11.92%	17.34%	7.70%	8.95%
55-64 years old	23.42%	18.91%	26.12%	21.48%	27.12%
75 years old and above	27.29%	20.48%	23.29%	30.21%	34.92%

Table 3: Indirect costs estimates, absenteeism, in 2016 US$ million and % of total.

	DM as main cause		
	Total	**Women**	**Men**
Premature Death (in million)	1,183	409	775
18-34 years old	14.38%	20.07%	11.38%
35-44 years old	20.10%	25.29%	17.37%
45-54 years old	38.53%	40.98%	37.24%
55-64 years old	26.99%	13.66%	34.02%

Table 4: Indirect costs estimates, premature death, in 2016 US$ million and % of total.

	Direct Costs	**Indirect Costs**	**Total**
Total Economic Burden (in million US$)	633	1,520	2,153
% of the total	29.40%	70.60%	
Economic Burden *per capita* (in US$)	3.09	7.41	10.49
Economic Burden per patient (in US$)	65.72	157.81	223.54

Table 5: Economic burden of DM per patient and *per capita*, in 2016 values.

	DM prevalence	**DM patients**	**Total EB**	**% of EB**	**% Annual EB**
	%	**N**	**U$ Million**	**%**	**%**
2016 values	6.42%	9,631,664	2,153.05		
2030 optimist[1]	7.90%	13,695,390	3,061.45	42.19%	2.55%
2030 realist[2]	12.96%	22,479,515	5,025.05	133.39%	6.24%

Notes:

[1] We consider that DM prevalence changes only due to population aging.

[2] We consider that DM prevalence changes both with population aging and at the same pace it increased from 2003 and 2013.

Table 6: Total economic burden (EB) of DM, current (2016) and projected (2030), in 2016 million US$.

Appendix A - Costs attributed to DM - hospitalization and ambulatory

The main complications attributed to DM are disaggregated into five groups of diseases: cardiovascular; renal; ophthalmic; neoplasm; and others. The most relevant diseases, in terms of total costs, are cardiovascular diseases due to DM. They accounted for 42.5% (US$ 109 million) of total hospitalization and ambulatory costs. The second most important are renal diseases, which represented 19.7% of the direct costs from diseases related to DM, or US$ 50.6 million. Ophthalmic diseases are also very relevant, with costs of US$ 39.8 million (15.5%). Neoplasm diseases due to DM, on the other hand, accounted for 9.5% (US$ 24.4 million) of those total direct costs. Finally, other diseases represented 12.8% (os US$ 32.8 million) of total hospitalization and ambulatory costs attributed to DM.

Appendix B - Direct Costs - DM and Morbidities

Table 7: Total direct costs using DRG prices for private services, in 2016 US$.

	Diabetes				Morbidities			
	SUS		Non-SUS		SUS		Non-SUS	
	Female	Male	Female	Male	Female	Male	Female	Male
Hospitalization cost								
Groups								
below 18 years old	1,839,116.90	1,188,866.06	248,501.30	185,734.81				
18-34 years old	4,870,428.80	1,993,511.07	605,046.69	246,067.96				
35-44 years old	2,695,680.60	2,769,575.10	585,911.13	219,284.76	1,519,300.70	1,747,173.00	235,194.33	281,316.92
45-54 years old	2,964,576.89	3,851,663.76	326,524.08	482,653.05	5,937,992.83	7,996,699.14	893,408.86	1,333,386.49
55-64 years old	4,571,851.72	5,578,708.47	515,400.04	800,715.57	16,742,800.15	24,402,537.45	2,869,079.96	4,670,614.53
65-74 years old	4,876,710.41	4,998,014.04	675,786.12	1,006,577.87	20,975,948.98	28,068,575.63	4,529,913.32	7,072,699.18
75 years old and above	4,511,282.42	3,455,800.05	1,122,727.09	939,295.89	17,120,949.64	15,146,979.69	7,405,410.69	5,713,332.97
Total hospitalizations	26,329,647.74	23,836,138.56	4,086,896.44	3,880,329.91	62,296,992.30	77,361,964.90	15,933,007.16	19,071,350.08
Ambulatory cost								
Groups								
below 18 years old	17,955.97	17,962.22	2,850.77	2,977.77				
18-34 years old	71,891.82	65,147.47	8,077.29	10,052.20				
35-44 years old	162,365.00	87,366.18	12,883.31	11,524.28	1,228,194.71	809,162.43	35,567.17	23,688.19
45-54 years old	278,178.88	374,373.72	22,690.77	41,619.61	4,580,599.44	3,316,093.62	138,798.80	96,475.35
55-64 years old	558,638.73	627,134.11	49,432.86	61,203.15	12,771,904.99	9,949,917.66	440,094.42	342,830.44
65-74 years old	386,944.93	449,877.46	42,570.08	50,534.39	17,117,502.79	13,078,640.43	698,549.31	522,242.21
75 years old and above	259,865.19	122,594.29	40,118.78	21,389.76	9,561,726.33	6,608,834.26	501,177.85	306,007.15
Total ambulatory	1,735,840.51	1,744,455.45	178,623.86	199,301.16	45,259,928.25	33,762,648.40	1,814,187.55	1,291,243.34
Popular Pharmacy	304,234,400.00							
POF (material)	10,016,764.00							
TOTAL	**633,033,719.62**							

Notes: DRG Brazil collects data from more than 200 hospitals in the country and 4,909 patients hospitalized due to DM or complications from the disease (2016).

Table 8: Total indirect costs using DRG prices for private services, in 2016 US$.

	Diabetes		Morbidities	
	Female	Male	Female	Male
Absenteeism cost				
Groups				
below 18 years old	580,508.81	425,327.28		
18-34 years old	1,343,757.75	496,369.97		
35-44 years old	988,542.75	731,137.94	192,166.86	225,476.36
45-54 years old	1,216,245.63	1,662,624.50	733,241.75	938,137.88
55-64 years old	1,928,707.50	2,504,171.75	2,045,643.75	2,843,334.75
65-74 years old	2,089,243.75	2,233,472.25	2,876,845.50	3,661,182.50
75 years old and above	2,052,454.63	1,535,072.00	3,675,572.75	2,817,755.25
Total absenteeism	10,199,460.81	9,588,175.69	9,523,470.61	10,485,886.73
Early death cost				
Groups				
18-34 years old	82,067,216.67	88,152,875.19		
35-44 years old	103,376,179.91	134,543,304.55		
45-54 years old	167,510,805.92	288,475,875.30		
55-64 years old	55,849,680.96	263,518,382.08		
Total early death	408,803,883.47	774,690,437.12		
INSS	186,363,308.25	110,364,389.00		
TOTAL		**1,520,019,011.69**		

Notes: DRG Brazil collects data from more than 200 hospitals in the country and 4,909 patients hospitalized due to DM or complications from the disease (2016).

	SUS	**non-SUS**	**Total**
Diabetes	137,094	13,377	150,471
Attributed to DM	124,588	24,551	149,139
Total	261,682	37,928	299,610

Table 9: Economic burden of DM per patient and *per capita*, in 2016 values.