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IDF Diabetes Atlas estimates of 2014 global health expenditures on diabetes

Joao da Rocha Fernandes [a], Katherine Ogurtsova [a], Ute Linnenkamp [a], Leonor Guariguata [a], Till Seuring [a], Ping Zhang [b], David Cavan [a], Lydia E. Makaroff [a,*]

[a] International Diabetes Federation, Brussels, Belgium
[b] Division of Diabetes Translation, Centers for Disease Control and Prevention, Atlanta, GA, USA

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ABSTRACT

Aims: To estimate health expenditures due to diabetes in 2014 for the world and its regions.
Methods: Diabetes-attributable health expenditures were estimated using an attributable fraction method. Data were sourced from International Diabetes Federation (IDF) estimates of diabetes prevalence, UN population projections, WHO annual health expenditure reports, and estimates of the cost ratio of people with and without diabetes. Health expenditures were calculated in both US dollars (USD) and international dollars (ID).
Results: The average health expenditure per person with diabetes worldwide in 2014 was estimated to range from USD 1583 (ID 1742) to USD 2842 (ID 3110). The estimated annual global health expenditure attributable to diabetes ranged from USD 612 billion (ID 673 billion) to USD 1099 billion (ID 1202 billion). Together, the North America and Caribbean Region and the Europe Region were responsible for over 69% of the costs, and less than 10% of the costs were from the Africa Region, South East Asia Region, and Middle East and North Africa Region combined. The North America and Caribbean Region had the highest annual spending per person with diabetes (USD 7984 [ID 8040.39]), while the South East Asia Region had the lowest annual spending per person with diabetes (USD 92 [ID 234]).
Conclusions: Diabetes imposes a large economic burden on health care systems across the world, yet varies across world regions. Diabetes prevention and effective management of diabetes should be a public health priority to reduce the financial burden.

1. Introduction

Diabetes mellitus imposes high human, social and economic costs worldwide. Since the publication of the first International Diabetes Federation (IDF) Diabetes Atlas in 2000, successive editions have provided consistent evidence of the continuing growth of diabetes incidence and prevalence rates.

In 2014, the IDF estimated that 8.2% of adults aged 20–79 (387 million people) were living with diabetes; this compares with 382 million people in 2013, and the number of people with the disease was projected to rise beyond 592 million in 2035 [1]. Yet, with an estimated 46% of cases currently undiagnosed, millions of people are unaware of their increased risk for developing diabetes-related complications [2]. An

* *Corresponding author.*
E-mail addresses: joao.fernandes@idf.org (J. da Rocha Fernandes), katherine.ogurtsova@idf.org (K. Ogurtsova), ute_linnenkamp@gmx.de (U. Linnenkamp), leonor.guariguata@gmail.com (L. Guariguata), till.seuring@gmail.com (T. Seuring), paz2@cdc.gov (P. Zhang), david.cavan@idf.org (D. Cavan), lydia.makaroff@idf.org (L.E. Makaroff).
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estimated 47% of people with diabetes were aged between 40 and 59, with 77% living in low- and middle-income countries. Diabetes was responsible for the deaths of an estimated 4.9 million people worldwide in 2014 [2].

Together with the health burden, diabetes also imposes an enormous financial burden on national health care systems. As part of the 2014 update of the IDF Diabetes Atlas 6th edition, the estimate on health expenditures due to diabetes was updated for the world and IDF regions based on 194 countries and territories.

2. Materials and methods

The methodology for estimating global health expenditure due to diabetes was described in detail by Zhang et al. [3]. The global health expenditure was the sum of health expenditure of 194 counties and territories. The diabetes expenditure for each of the seven IDF regions was the sum of the countrys'/territories' expenditure in that region.

2.1. Country health expenditure estimates

Briefly, the total health expenditure in 2014 for diabetes for each country/territory (D) was calculated from the combination of four inputs (Fig. 1):

- The prevalence of diabetes in each country, for each age and sex subgroup (P_{as})
- The total population, for each age and sex subgroup (N_{as})
- The annual health expenditures per person, for each age and sex subgroup (C_{as})
- Ratios of health care expenditures for people with diabetes to people without diabetes, for each age and sex subgroup (R_{as})

These inputs were entered into the formula below:

$$D = \sum_{S=1}^{2}\sum_{a=1}^{6}\left\langle \frac{N_{as}C_{as}P_{as}(R_{as}-1)}{P_{as}(R_{as}-1)+1} \right\rangle$$

S: sex (male and female), *a*: age (10 year age-groups).

2.1.1. Diabetes prevalence (P)

The prevalence of diabetes in each country by age and sex sub-group in 2014 (P_{as}) was derived from the 2014 Update of the IDF Diabetes Atlas 6th edition (1), based on the methodology published by Guariguata and colleagues [4]. The diabetes prevalence estimates utilized country level data from national health statistics reports, peer reviewed studies, and commissioned studies on diabetes prevalence. These data were used to generate estimates based on logistic regression taking in consideration adjustments for urbanization rates and age structure. If no specific studies for a particular country could be found, extrapolations were calculated based on countries with a similar geographical location and gross national income per capita.

For each country or territory, the diabetes prevalence rate was estimated for both sexes separately, and for six age groups (from 20 to 79 years old). Countries and territories were grouped by IDF geographic region and World Bank income level.

2.1.2. Total population structure (N)

The total population for each age and sex subgroup for a country/territory in 2014 (N_{as}) was derived from the *World Urbanization Prospects: 2014 Revision* provided by the United Nations [5].

2.1.3. Annual health expenditures (C)

The annual health expenditures per person, in each age and sex subgroup (C_{as}), were expressed in United States dollars (USD) and international dollars (ID). These data were sourced from the World Health Organization (WHO) Global Expenditure Database [6]. Figures from 2012 were used as this was the most recent year for which the data were available. These expenditures cover the provision of health services (preventive and curative), family planning activities, nutrition activities, and emergency aid designated for health, but do not include provision of water and sanitation. They include both public and private health expenditures [7].

The WHO only reported the overall per capita health expenditure. The following five steps were undertaken to break down the overall per capita expenditure into age and sex specific health expenditures.

(1) The total health expenditure was divided into two categories: It was assumed that 80% of the total expenditures were for health expenditures positively associated with death rates, and 20% of the total expenditures were independent from death rates, for all the age and sex subgroups [3]. The mortality rates per age and sex group used for each of the 194 countries were derived from the WHO Burden of Disease Project [8].
(2) Death-related expenditures were estimated by first transforming mortality data using a logarithmic function, ln(3 + mortality rate), and multiplying it by WHO annual expenditure per person. After that, these expenditures were adjusted for age and sex to account for the different levels of medical expenditure associated with different age groups. Each cost per death was multiplied by the number of people in each age and sex group to produce the total costs related to deaths for each country.
(3) The remaining 20% non-mortality-related expenditures were allocated according to age and sex group, and then adjusted based on the medical care usage at different stages of life. The per capita costs associated with non-mortality related expenditures were multiplied by the number of people who were alive in each age and sex group to estimate the total non-mortality-related expenditures for each country.
(4) The mortality-related expenditures were combined with the non-mortality-related expenditures to produce total health expenditures for each age and sex group.
(5) The total health expenditure was divided by the number of people in each age-sex group to obtain the total health expenditures per capita.

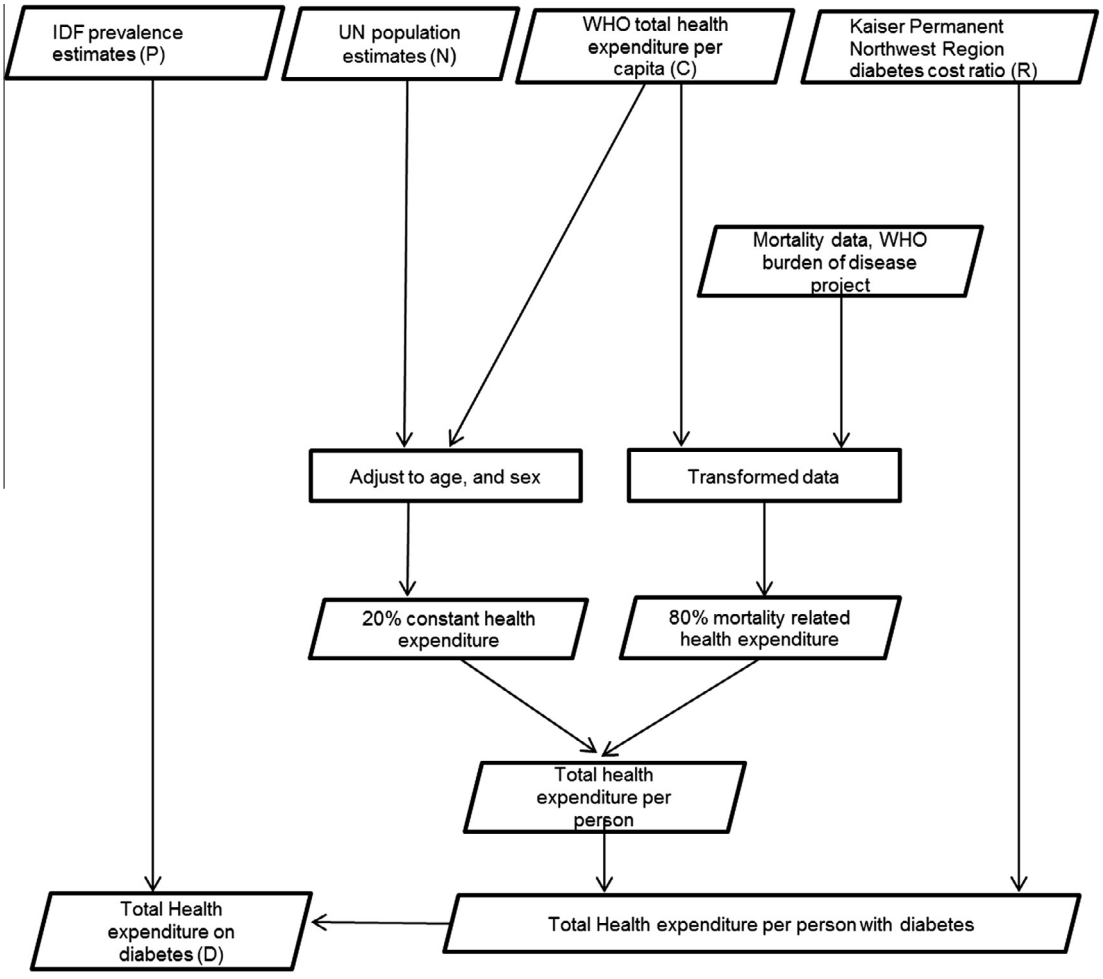

Fig. 1 – Flow chart illustrating the methodology underlying the diabetes-related health expenditure estimates used for the 2014 update of the IDF Diabetes Atlas 6th edition.

2.1.4. *Ratios of health care expenditures for people with diabetes to people without diabetes (R)*

There are a lack of data on health care expenditures ratio by age and sex sub-group for many countries. Previous studies report a ratio of expenditure per person with diabetes to expenditure per person without diabetes between 2 and 3, with the ratio decreasing with age [9–14].

Ratios of both 2 and 3 were used in these estimates, due to the heterogeneity of healthcare provision and medical costs across countries to produce two separate estimates. Adjustments of the two overall cost ratios into age and sex specific ratios (R_{as}) were based on data from the US non-profit health plan Kaiser Permanent Northwest Region [3]. Table 1 presents the adjusted age and sex ratio.

2.1.5. *Global and regional estimates*

Combining the four components (cost-ratio (R_{as}), IDF estimated prevalence of diabetes (P_{as}), and UN population projections (N_{as}), and per capita health care expenditure expenditures (C_{as})) using the fractional methods as described by Zhang et al. [3], the health expenditures were estimated per person due to diabetes according to age group (10 year bands, 20–79 years old) and sex for 194 countries and territories. The health expenditures for 23 countries were not included due to unavailability of data from the WHO. The country estimates were grouped according to IDF regions: Africa Region (AFR); European Region (EUR), Middle-East and North Africa Region (MENA); North America and Caribbean Region (NAC); South American and Central American Region (SACA); South East Asian Region (SEA); and Western Pacific Region (WP) [15]. Additionally, the estimates were grouped by income: Low-income countries, lower middle-income countries, upper middle-income countries and high-income countries, using the 2014 classification of the World Bank [16].

2.1.6. *United States dollars and international dollars*

The results of the health expenditures on diabetes were expressed in USD and ID.

ID is a hypothetical currency with the same purchasing power parity (PPP) of USD in the United States of America at a given point in time, and is used to make comparisons both between regions and over time. PPP can be used as conversion factor converting different economic aggregates from different countries and territories into the common currency unit of ID. ID are calculated by dividing the amount of national

Table 1 – Diabetes Cost Ratios (R) by age and sex from the US non-profit health plan Kaiser Permanent Northwest Region (adapted from Zhang P. et al. [3]).

Age in years	Women				Men			
	KPNW R	Adj R = 2	Adj R = 3	Sample size	KPNW R	Adj R = 2	Adj R = 3	Sample size
20–49	2.23	2.15	3.15	1145	2.74	2.66	3.66	1108
50–59	2.30	2.22	3.22	1996	2.23	2.15	3.15	2239
60–69	2.11	2.03	3.03	2031	2.03	1.95	2.95	2356
70–79	1.70	1.62	2.62	1776	1.57	1.50	2.50	1901

currency by the PPP exchange rate. As an example, the PPP between the USA and Germany is the number of euros that has the same purchasing power as 1 USD [7].

For the numbers expressed in USD, the average exchange rate for 2012 was used. For ID, the 2012 PPP was used [17,18]. The 2012 values were adjusted to 2014 values based on the assumption of an annual growth rate of 4.4%, which is in line with average growth observed in previous years [6].

In this study, global estimates were presented in both USD and ID, but for regional estimates only ID were presented in order to ensure comparability.

3. Results

The average health expenditure per person with diabetes worldwide in 2014 was estimated to range from USD 1583 (R = 2) to USD 2842 (R = 3). The global total health expenditure for all people with diabetes for the same period was estimated to range from USD 612 billion (R = 2) to USD 1099 billion (R = 3). The low estimate of the total health expenditure on diabetes, USD 612 billion (R = 2) represented 11% of the total health expenditure published by the WHO [6].

3.1. *Regional health expenditures on diabetes*

There was an unequal distribution of resources between regions (Table 2). The South East Asia Region (233.73 ID, R = 2) had the lowest mean expenditure per person with diabetes of any IDF region, 87% lower than the world average (1742.44 ID, R = 2). This was also 97% lower than the mean expenditure in North America and Caribbean Region (8040.39 ID, R = 2), which had the highest mean expenditure per person with diabetes out of the seven IDF regions.

When total spending for all people with diabetes was examined, the Africa Region had the lowest total health expenditure among all regions (7.33 billion ID). The North America and Caribbean Region had the largest total spending on diabetes (312.23 billion ID) and spent twice as much on diabetes compared to the Europe Region (155.18 billion ID) which ranked second (Table 2).

Almost half of the total health care expenditure on diabetes was spent in the North America and Caribbean Region (Fig. 2). Over 69% of total global diabetes-related health expenditure occurred in the North America and Caribbean and Europe regions, though only 24% of the people with diabetes live in these two regions. Conversely, the Africa, South East Asia, and Middle East and North Africa regions together accounted for less than 10% of the total health expenditure on diabetes, but they were home to over 34% of the total number of people with diabetes worldwide in 2014. All the country estimates can be found in the diabetesatlas.org website.

3.2. *Health expenditures on diabetes by sex and age group*

There was also an unequal distribution of resources between age groups (Fig. 3). The demographic group with the lowest amount (20.08 billion USD) spent on diabetes were aged between 20 and 29 years old. This was nine times lower than people aged between 60 and 69 years old, which was the demographic group with the highest amount (184.58 billion USD) spent on diabetes.

4. Discussion

We estimate that at least USD 612 billion (ID 674 billion) were spent globally on diabetes in 2014, representing 11% of all global health expenditures. This represents an increase of 12% compared to the estimates published in 2013 (USD 548 billion), due to increases in the total number of people with diabetes which was estimated to increase by 13% (from 382 million people in 2013 to 387 million people in 2014).

The North America and Caribbean Region spent more on diabetes than all other regions together (USD 310 billion). Despite their growing diabetes populations, health care spending on diabetes in the South-East Asia Region and the Africa Region accounted for only 2% of the global health expenditure on diabetes, with substantially less spent on average per person with diabetes than the global average.

Diabetes-related health care expenditure includes medications, supplies, hospital care, as well as treatment of complications such as nephropathy, retinopathy, amputation, and cardiovascular disease. In the United States of America, 43% of the total medical costs of diabetes were found to be due to hospital inpatient care, and 18% were due to medication for diabetes complications [10]. For type 2 diabetes, the lifetime medical costs to treat diabetes complications were estimated at 53% of the total amount of diabetes-related expenditures [19].

A similar trend is observed in middle-income countries. In Iran, the costs of complications represented 49% of the direct costs per person with diabetes [20], and in Colombia the costs of diabetes-related complications comprised 53% of the total costs of diabetes [21].

There are limited studies on diabetes-related healthcare expenditures in low-income countries, however it is estimated in the WHO Africa Region that 54–66% of diabetes-

Table 2 – Health expenditures on diabetes 2014 given in IDF regions and globally for different cost rations.

IDF Region	USD (R = 2)		ID (R = 2)		USD (R = 3)		ID (R = 3)	
	Per capita	Total (billion)	Per capita	Total (billion)	Per capita	Total (billion)	Per capita	Total (billion)
AFR	208.07	4.47	341	7.33	360.53	7.75	590.73	12.7
SEA	92.17	6.91	233.73	17.52	156.4	11.72	396.72	29.74
MENA	457.89	16.85	788.24	29	737.79	27.14	1292.51	47.55
SACA	1155.66	28.65	1382.82	34.28	2024.27	50.19	2421.29	60.03
WP	732.91	101	857.68	118.2	1333.47	183.77	1539.13	212.11
EUR	2775.98	144.29	2985.51	155.18	5194.27	269.99	5554.05	288.69
NAC	7983.95	310.04	8040.39	312.23	14,121.75	548.38	14,206.07	551.66
World average	1583.31		1742.44		2842.10		3109.86	
World total		612.21		673.75		1098.95		1202.48

AFR: Africa Region; SEA: South East Asia Region; MENA: Middle East North Africa Region; SACA: South and Central American Region; WP: West Pacific Region; EUR: Europe Region; NAC: North American and Caribbean Region; USD: American dollars; ID: International dollars (adjusted to purchasing power parity); R: Cost ratio of people with diabetes to people without diabetes.

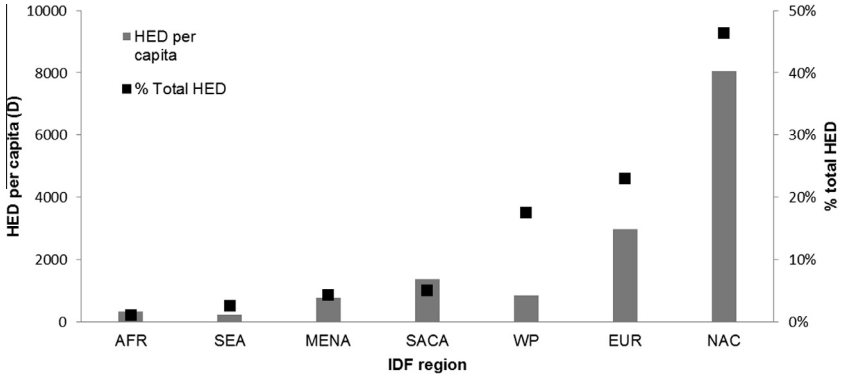

Fig. 2 – Average total diabetes-related health expenditure (HED) per person with diabetes and percentage of total health expenditure on diabetes, per IDF Region. AFR: Africa Region; SEA: South East Asia Region; MENA: Middle East North Africa Region; SACA: South and Central American Region; WP: West Pacific Region; EUR: Europe Region; HED per capita: Average total health expenditure per person with diabetes; % Total HED: Proportion of world health expenditure that was spent on diabetes in each IDF Region.

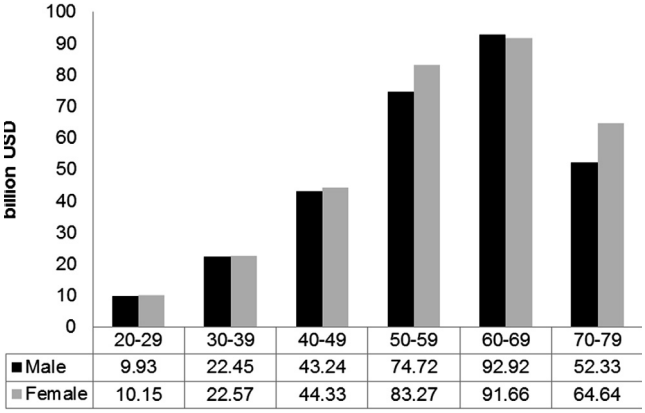

Fig. 3 – Total health expenditures on diabetes split by sex and age group.

related costs were spent on medications and supplies such as oral drugs, insulin, syringes, glucose meters, and test strips [22].

The methodology used to estimate the health expenditures on diabetes was similar to previous versions of the IDF Diabetes Atlas. The variations observed from previous editions are due to changes in the inputs used for the model, such as diabetes prevalence, WHO health expenditures per capita, and UN population estimates.

Using the same cost-ratio for high- and low-income countries and for diagnosed and undiagnosed cases is a limitation of the presented model. However, this cannot be adjusted until more detailed data on diabetes-related healthcare expenditure in low-income countries are available. Despite the limitations described, the estimates presented in this paper are consistent with other studies conducted at a national level [9–14].

Diabetes imposes a large economic burden which cannot be ignored. Moreover, the health expenditures on diabetes are expected to rise dramatically as a consequence of the rapid increase in the prevalence rate of diabetes worldwide. The results of this paper highlight the need to continue further research on the most cost-effective and cost-saving strategies to tackle the increasing burden of diabetes and its complications. It may be possible to reduce the economic impact of diabetes by reducing the incidence of type 2 diabetes. In the USA, a combination of intensive prevention strategies resulted in a 58% incidence reduction over 3 years

[23], while programs in China showed a 42% reduction in the risk of developing type 2 diabetes during a 6-year follow-up, and in India a 28% risk reduction was observed over 3 years [24,25]. The large majority of type 2 diabetes prevention strategies have been found to be cost-saving or cost-effective [26]. In addition, greater effort is required to increase the cost-effectiveness of treatment and management strategies for both type 1 and type 2 diabetes.

Conflict of interest

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Disclaimer

The contents of this paper are solely the responsibility of the authors and do not necessarily represent the official positions of the Centers for Disease Control and Prevention.

Contributors

JdRF analyzed and interpreted the data, and drafted the article. KO produced the 2014 IDF Diabetes prevalence estimates, analyzed and interpreted the data, and critically revised the article. UL assisted with data collection, analyzed the data, and critically revised the article. LG provided epidemiological expertise, analyzed the data, and critically revised the article. TS implemented the study design, and critically revised the article. PZ conceived the study design, provided health economics expertise, and critically revised the article. DC interpreted the data, provided diabetes expertise, and critically revised the article. LM supervised the study, interpreted the data, and critically revised the article. All authors approved the final article for submission.

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