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Global and regional estimates and projections of diabetes-related health expenditure: Results from the International Diabetes Federation Diabetes Atlas, 9th edition

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ABSTRACT

Aims: Diabetes and its complications have a significant economic impact on individuals and their families, health systems and national economies.

Methods: The direct health expenditure of diabetes was calculated relying on the following inputs: diagnosed and undiagnosed diabetes prevalence estimates, United Nations population estimates, World Health Organization health expenditure per capita and ratios of health expenditure for people with diabetes compared to people without diabetes.

Results: The estimated global direct health expenditure on diabetes in 2019 is USD 760 billion and is expected to grow to a projected USD 825 billion by 2030 and USD 845 billion by 2045. There is a wide variation in annual health expenditures on diabetes. The United States of America has the highest estimated expenditure with USD 294.6 billion, followed by China and Brazil, with USD 109.0 billion and USD 52.3 billion, respectively. The age group with the largest annual diabetes-related health expenditure is 60–69 years with USD 177.7 billion, followed by 50–59 years, and 70–79 years with USD 173.0 billion and USD 171.5 billion, respectively. Slightly higher diabetes-related health expenditure is seen in women than in men (USD 382.6 billion vs. USD 377.6 billion, respectively). The same difference is expected to be present in 2030 and 2045.

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Conclusions: There were large disparities between high-, middle- and low-income countries with total health expenditures in high-income countries being over 300 times those in low-income countries. The ratio for annual direct health expenditure per person between these groups of countries is more than 38-fold.

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1. Introduction

The International Diabetes Federation (IDF) Diabetes Atlas has drawn attention to the economic impact of diabetes since its first edition in 2000 [1]. The first country- and Region-specific and global estimates of diabetes-related health expenditures were published in the second edition in 2003 [2] with full details about the methods used and updated estimates and projections in the third edition [3].

The most recent edition of the IDF Diabetes Atlas (9th edition) [4] has set out to update these estimates using contemporary epidemiological data and more sophisticated economic methods. This paper summarises these findings.

The significant economic impact of diabetes and, particularly, both its acute and long-term complications on health expenditures are well known, from early estimates reported from pan-European studies [5] to, for example, the most recent assessment for the United States of America [6]. In this assessment, the costs of hospital admissions for these complications is the over-riding influence. Since many of these complications can be prevented, or at least lessened in impact or delayed, their economic impact can potentially be significantly reduced and resources diverted to preventive measures or to other health priorities. The importance of addressing socio-economic disadvantage in the prevention of type 2 diabetes mellitus has recently been highlighted by Spencer Bonilla *et al* [7].

As examples, the costs of treating a single case of diabetic ketoacidosis (DKA) in the United Kingdom is estimated to be GBP 1,387 (around USD 1,750) [8]. In the United States of America, diabetes-related Chronic Kidney Disease (CKD) increases mean annual healthcare expenditures by 49% among people with diabetes and clinical nephropathy than among those with no nephropathy and, for people with diabetes undergoing dialysis, the mean annual figure increased 2.8 times compared with end-stage renal disease (ESRD) patients not on dialysis [9]. Neurological and / or vascular damage to the lower limb resulting in the “diabetic foot” have been described as the most costly of diabetes-specific complications. Compared to people with diabetes without foot ulcers, health expenditures for people with diabetes and foot ulcers is 5.4 times higher in the year of the first episode and 2.6 times higher in the year of the second episode and compared to people without diabetes [10]. Furthermore, the cost of care for people with diabetes and coronary heart disease or congestive heart failure is higher [11].

It is clear, therefore, that the treatment of complications is a major contributor to health expenditures related to diabetes. This contribution has been estimated to be 53% of total direct costs in Germany [12] and, coincidentally, also 53% in

the United States of America [13]. These costs are clearly related to the number of complications present, with mean annual health expenditures for people with four or more complications 20 times more than in people with diabetes but without complications [14].

The aims of this paper, therefore, are (1) to draw attention to these recent IDF global estimates and projections of the direct costs of diabetes care in adults 20–79 years; (2) to provide details of the methods used in the formulation of these estimates and projections so that, with critical discussion, their precision can be improved and (3) to compare these results with others which have used different approaches.

2. Methods

The methods used in estimating diabetes-related health expenditures has remained basically consistent, with some minor modifications since their description in detail in the third edition of the IDF Diabetes Atlas [3]. The focus of this paper is on direct medical costs attributable to diabetes, which represent the opportunity costs of health care resources used for treating diabetes, diabetes-related complications, and comorbidity. Direct medical costs include hospital inpatient care, physician inpatient care, physician outpatient care, emergency department visits, nursing home care, hospice care, rehabilitation care, specialists' and other health professionals' care, diagnostic tests, prescription drugs and medical supplies.

Additional elements in economic studies of diabetes may also address direct non-medical costs (costs incurred by patients and their families that are directly associated with diabetes but are not medical in nature, such as transportation costs, relocation expenses and informal care) and productivity losses and intangible costs which refer to patients' psychological pain, discomfort, anxiety and distress related to diabetes. Although important, these are not addressed here.

As laid out in the 9th edition of the IDF Diabetes Atlas [4], estimates of diabetes-related health expenditures for 2019 and projections to 2030 and 2045 were calculated using an attributable fraction method [15], which relies on the following inputs:

- IDF Diabetes Atlas 9th edition estimates of diabetes prevalence in 2019 (diagnosed and undiagnosed) for each country and for each age and sex sub-group, stratified by rural and urban areas. The methods used to derive these are summarised in the IDF Diabetes Atlas [4] and described in more detail elsewhere [16]

- United Nations (UN) population estimates (“medium fertility variant”) for 2019 and UN population projections for 2030 and 2045.
- World Health Organization (WHO) global health expenditures per capita for 2016 (latest available data) (distribution by age and sex imputed based on mortality rates and population structure).
- The ratios of health expenditures (R) for people with diabetes compared to people without diabetes stratified by age, sex, rural versus urban area, diagnosed and undiagnosed diabetes and income per Region.

The WHO definition of health expenditures includes provision of health services (preventive and curative), family planning activities, nutrition activities and emergency aid designated for health, but does not include provision of water and sanitation services. It includes health expenditures from both public and private sources [17].

In order to obtain health expenditures stratified by age, sex, rural and urban setting, and to take into account the higher costs associated with death, the following conversion was used: the number of people in each subgroup in a country was multiplied on the one hand with death-related medical costs per person (assumed to be 80% of health care expenditures) and on the other hand with life-related medical costs adjusted by health care utilization coefficients that vary by age and between genders. The sum of both components gave the total health care costs specific to each population fraction.

Another critical component of the above is the ratio (R) of diabetes health expenditure for people with diabetes (diagnosed or undiagnosed) compared to those without diabetes. Since the publication of the IDF Diabetes Atlas 8th edition, these ratios have been significantly refined by the work of Bommer *et al.* [18], providing estimates for this ratio with much more specificity than previously in relation to age, sex, rural versus urban areas, whether diabetes is diagnosed or not and income levels of countries by region. These were the values of R used in this study.

To generate cost projections, the conservative assumptions that diabetes prevalence and mean health expenditure per person with diabetes within each age group will stay

constant were imposed, such that changes in costs are entirely driven by UN population projections.

3. Results

3.1. Global estimates and projections to 2030 and 2045 and temporal trends since 2006

In 2019, total, world-wide diabetes-related health expenditure was estimated to be USD 760 billion in adults aged 20–79 years, with the majority of the spending among those aged 50–79 years (68.7% of that for all ages). The health expenditure is expected to grow to a projected USD 825 billion per year by 2030 and USD 845 billion by 2045 (Fig. 1).

Despite the fact that some modifications have been made to the methods used for these 2019 estimates (see Discussion below), they are in line with previous IDF Diabetes Atlas estimates made in similar, though not identical ways (Fig. 2). The increase of the 2019 estimate over that of 2017 equates to 4.5%.

The age group with the largest annual diabetes-related health expenditure in 2019 was 60–69 years with USD 177.7 billion, followed by 50–59 and 70–79 years with USD 173.0 billion and USD 171.5 billion, respectively. By 2030 diabetes-related health expenditure (for those aged 70–79 years) will exceed that in all age groups and, by 2045, is expected to top USD 250 billion in this age group alone (Fig. 3).

In 2019, slightly higher diabetes-related health expenditures are seen in women than in men (USD 382.6 billion vs. USD 377.6 billion, respectively). The same difference is present in 2030 and 2045 (Fig. 4).

3.2. Regional and country estimates

Diabetes-related health expenditures in 2019 in the IDF Regions of North America and Caribbean (NAC), Western Pacific (WP), and Europe (EUR) together account for 85.2% of the global total. The NAC Region has the highest of all IDF Regions (USD 324.5 billion (20–79 years)), which corresponds to 42.7% of the global total. The second highest is the WP Region with USD 162.2 billion, followed by the EUR Region (USD 161.4 billion), which correspond to 21.3% and 21.2%, respectively, of the total global spending.

The other four Regions (Africa, AFR; Middle East and North Africa, MENA; South and Central America, SACA; and

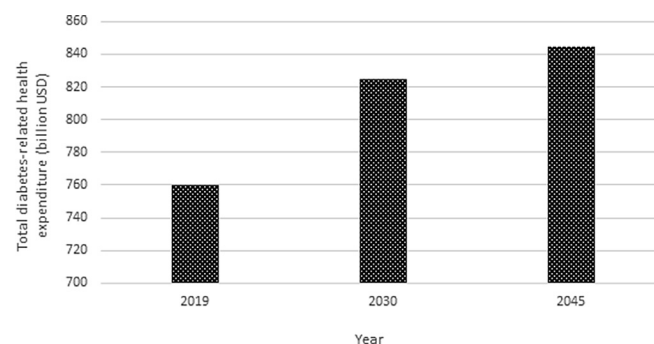


Fig. 1 – Total diabetes-related health expenditure among adults (20–79 years) with diabetes.

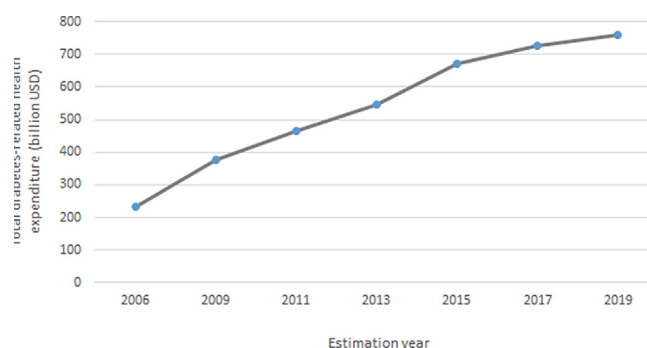


Fig. 2 – Total diabetes-related health expenditure among adults (20–79 years) with diabetes – data from successive IDF Diabetes Atlas editions – 2nd to 9th.

South-East Asia, SEA) spent significantly less, individually and collectively, despite being home to 41.8% of people with diabetes. They were collectively responsible for only 14.8% of global diabetes-related health expenditure.

The top 10 countries for total diabetes-related health expenditures and the top 10 countries for diabetes-related health expenditures per person are listed in Table 1. The United States of America had the highest estimated figure with USD 294.6 billion, followed by China and Brazil, with USD 109.0 billion and USD 52.3 billion, respectively. Countries with the highest annual expenditures per person are Switzerland (USD 11,915.6) and the United States of America (USD 9,505.6).

While a major driver for the former cost estimates is the number of people with diabetes living in that country, the determinants of the second are more complex. They include

levels of country's incomes, health insurance system, differential pricing of medications and medical supplies, personnel costs of delivering health care, and other factors.

The countries with the lowest diabetes-related health expenditures were Sao Tome and Principe, and Tuvalu with estimates of USD 1.1 million and USD 1.8 million and those with the lowest annual expenditures per person were Bangladesh (USD 63.9 per person per year), Central African Republic (USD 72.0) and Nepal (USD 80.4). The combined total health expenditures in high-income countries (at USD 494.3 billion) is more than 300 times that in low-income countries (USD 1.5 billion) and the ratio for annual direct health expenditure per person is more than 38 (USD 5338.7 vs. USD 137.6).

4. Discussion

4.1. Global estimates and projections to 2030 and 2045 and temporal trends since 2006

A recent comparable estimate of the global economic impact of diabetes is that of Bommer et al [18]. Their estimate of total costs in the age group 20–79 (in 2015) was USD 1.31 trillion (95% CI 1.28–1.36) amounting to around 1.8% of global GDP. Of this total, they estimated that 65.3% (USD 0.86 trillion (95% CI 0.83–0.89)) could be attributed to direct costs. Despite some minor differences in the methods used (for example differences in the handling of the relevant WHO data), similar disparities are seen between high-, middle- and low-income countries in both studies. Our results also mirror the findings of a recent study [19] showing that, even under the conservative assumption of constant age-specific prevalence and

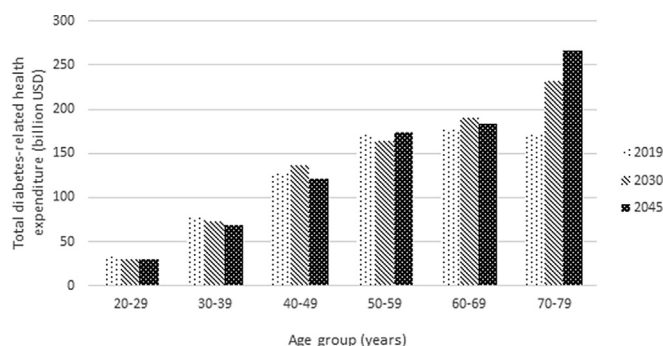


Fig. 3 – Total diabetes-related health expenditure (billion USD) by age group in 2019, 2030 and 2045.

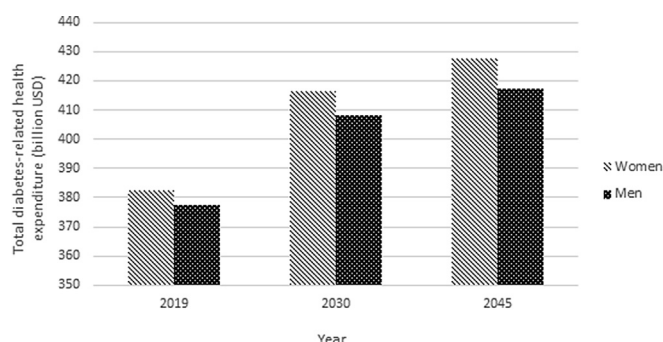


Fig. 4 – Total diabetes-related health expenditure (billion USD) by sex in 2019, 2030 and 2045.

Table 1 – Top 10 countries or territories for total health expenditure (billion USD) due to diabetes (20–79 years) in 2019 and top 10 countries or territories for mean annual diabetes-related health expenditure per person.

Rank	Country or territory	Total national diabetes-related health expenditure in 2019 (billion USD), people aged 20–79	Country or territory	Mean annual health expenditure per person with diabetes (USD), people aged 20–79
1	United States of America	294.6	Switzerland	11,915.6
2	China	109.0	United States of America	9505.6
3	Brazil	52.3	Norway	9061.4
4	Germany	43.8	Luxembourg	7977.8
5	Japan	23.5	Sweden	6643.1
6	Mexico	17.0	Ireland	6597.6
7	France	16.9	Iceland	6403.1
8	United Kingdom	14.1	Denmark	5521.1
9	Canada	12.3	Netherlands	5379.7
10	Russian Federation	10.6	Austria	5259.3

patient-level expenditures, demographic change alone would result in considerable increases in both the number of people living with diabetes and overall costs.

4.2. Regional and country estimates

The availability of economic data on diabetes is heavily skewed towards high-income countries. Among low-income countries relatively recent (within the last 10 years), data exist on diabetes-related health expenditures for Bangladesh [20], Mali [21,22], Pakistan [23], Sri Lanka [24], Sudan [25] and Sub-Saharan Africa [26]. In Iran (classified by the World Bank as an upper-middle income country), in a prospective, case control population-based study diabetes-related health expenditures totalled USD 10,627 million (in 2004) - about 5.5% of total Iranian healthcare expenditure with a value of R of 2.92 [27].

In high-income countries, particularly the United States of America and some in Europe, more detailed economic data exist, enabling trends over time to be studied. Further information (and its practical use) are particularly needed where diabetes prevalence is increasing, and national and individual incomes are low [28]. Such information as does exist suggests that incremental use of medical care associated with diabetes is much greater in Sub-Saharan Africa (and, presumably, also in other low-income countries) than in industrialized countries [26]. In Mali, the expense associated with type 2 diabetes mellitus treatment is “beyond reach for many patients, particularly when there are complications” [22].

The phenomenon of “catastrophic health spending” – health spending that exceeds a predefined threshold of a household’s ability to pay for health care [28] can be crippling for families but has not been studied in relation to diabetes in middle- and low-income countries. Anecdotally, it seems to be not uncommon. Universal health coverage, which would tend to protect households from this catastrophe, is strongly advocated in the 2030 agenda for sustainable development [29].

While being a common measure of value recognized and universally used over the world, currencies such as USD, or International Dollars, cannot meaningfully express the burden of a condition such diabetes in relation to human everyday experience. Shifting the focus from money to other

measurements such as the person’s or the family’s ability and responsibility for payments could help to put the picture in realistic settings and would better inform in public and advocacy campaigns. For example, in a hypothetical study of treating diabetic foot ulcer in five different countries in which costs were translated to days of labour, the costs were equivalent of six days of average income in the United States of America and 5.7 years of annual income in India [30].

5. Conclusion

There are three main methods used to estimate health expenditures attributed to a given condition. These are: the top-down approach, the bottom-up approach and econometric approaches [31]. All methods are valid and the selection of a particular method depends on data availability. In this case a version of the top down approach was used since the data required by this approach is the most available for nearly all countries. The most notable improvement in this latest group of estimates and projections is the use of more refined R values than has been the case in previous editions of the IDF Diabetes Atlas. Further refinement of this important component will lead to more precise conclusions.

Accurate and comprehensive information on the economic burden of diabetes can assist policy makers and clinicians to make informed decisions to plan resources needed for interventions towards diabetes prevention or slowing its progression, as well as evaluating the benefits of these interventions. Such information can also help national diabetes associations for advocacy purpose to obtain the resources needed to prevent and manage diabetes thus improving the health and well-being of those living with diabetes and at risk of its development.

Declaration of Competing Interest

The authors declared that there is no conflict of interest.

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Author contribution

All authors contributed to the identification of studies, the analysis of health expenditure estimates and projections and the writing of the paper. All authors have read and approved the final manuscript.

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