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# Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: Results from the International Diabetes Federation Diabetes Atlas, 9th edition

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A B S T R A C T

*Aims:* To provide global estimates of diabetes prevalence for 2019 and projections for 2030 and 2045.

*Methods:* A total of 255 high-quality data sources, published between 1990 and 2018 and representing 138 countries were identified. For countries without high quality in-country data, estimates were extrapolated from similar countries matched by economy, ethnicity, geography and language. Logistic regression was used to generate smoothed age-specific diabetes prevalence estimates (including previously undiagnosed diabetes) in adults aged 20–79 years.

*Results:* The global diabetes prevalence in 2019 is estimated to be 9.3% (463 million people), rising to 10.2% (578 million) by 2030 and 10.9% (700 million) by 2045. The prevalence is higher in urban (10.8%) than rural (7.2%) areas, and in high-income (10.4%) than low-income countries (4.0%). One in two (50.1%) people living with diabetes do not know that they have diabetes. The global prevalence of impaired glucose tolerance is estimated to

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be 7.5% (374 million) in 2019 and projected to reach 8.0% (454 million) by 2030 and 8.6% (548 million) by 2045.

*Conclusions:* Just under half a billion people are living with diabetes worldwide and the number is projected to increase by 25% in 2030 and 51% in 2045.



## 1. Introduction

Diabetes is a serious, long-term condition with a major impact on the lives and well-being of individuals, families, and societies worldwide. It is among the top 10 causes of death in adults, and was estimated to have caused four million deaths globally in 2017 [1]. In 2017, global health expenditure on diabetes was estimated to be USD 727 billion [1].

The three main types of diabetes are type 1 diabetes (T1D), type 2 diabetes mellitus (T2D), and gestational diabetes mellitus (GDM). Since 2000, the International Diabetes Federation (IDF) has reported the national, regional and global occurrence of diabetes. In 2009 it was estimated that 285 million people had diabetes (T1D and T2D combined) [2], increasing to 366 million in 2011 [3], 382 million in 2013 [4], 415 million in 2015 [5] and 425 million in 2017 [1].

For T2D, which accounts for approximately 90% of the total, this rising trend can be attributed to ageing, a rapid increase in urbanisation, and obesogenic environments. Incidence rates of T1D are also rising, contributing to the increase in diabetes prevalence [6,7]. The cause of this rise remains unclear. An additional contributor to the increased prevalence is better survival (in some populations) of people with diabetes through early detection, improved management of diabetes, and, consequently reduction in premature mortality [8]. Finally, the increasing number of younger adults with T2D in the recent years also contributes to the increase in overall T2D prevalence, through their longer survival.

Producing periodic prevalence estimates and future projections for diabetes, as have been presented in successive editions of the IDF Diabetes Atlas, is essential in order to promote T2D prevention and to encourage improvements in care for all who live with diabetes. The Atlas also identifies gaps in the epidemiological data which need to be filled to give a more comprehensive picture of the impact of diabetes. Here, we provide estimates of diabetes prevalence, undiagnosed diabetes, and impaired glucose tolerance (IGT) for 2019, as well as diabetes and IGT prevalence projections for 2030 and 2045. The estimates are based on the most recent high-quality epidemiological data available. Estimates and projections for hyperglycaemia in pregnancy (HIP), including GDM are provided in a separate paper (Simmons et al, in press) [9]. The complex and important aspects of diabetes in the elderly population are the subject of a separate paper in preparation.

## 2. Methods

The methods have been previously described in detail [10]. The following provides a brief summary, and includes information on updates to those methods introduced for the 9$^{th}$ edition.

### 2.1. Data search

A thorough literature search of *PubMed*, *Medline* and *Google Scholar* for data sources reporting age-stratified prevalence of diabetes published between January 1990 and December 2018 was undertaken. This extended the search carried out for the 8$^{th}$ edition by two years (2017 and 2018). The search terms used were 'diabetes' OR 'impaired glucose tolerance' AND 'prevalence' OR 'screening' AND <country name> OR <region/continent>. Additionally, relevant citations from the papers identified were accessed.

For the 9$^{th}$ edition of the IDF Diabetes Atlas, the list of countries and territories was re-evaluated based on the most recent (January 2019) World Bank list [11]. Thus, data were searched for 211 countries and territories. A more extended search of publications in languages other than English (viz. French, Arabic, Chinese, German, Spanish, Russian, Portuguese and Danish) published in 2017 and 2018 were also made. To this end, the original search strategy was translated into these languages and back translated to ensure accuracy. Additionally, data from national health surveys, personal communication, national databases and national World Health Organization (WHO) STEPwise approach to Surveillance (STEPS) studies were considered. IDF regional offices in Africa (AFR), Europe (EUR), Middle East and North Africa (MENA), North America and Caribbean (NAC), South and Central America (SACA), South-East Asia (SEA) and the Western Pacific (WP) were also approached regarding the availability of local diabetes prevalence data.

### 2.2. Data extraction

All data sources were screened, and data that included age-stratified diabetes prevalence for at least three age-groups for adults older than 20 years were extracted from the publications or by contacting the corresponding authors. The study methods, such as diagnostic criteria, sample size, sample representation, age of the data source, and type of the data sources (e.g. peer-reviewed publications, national health survey reports and WHO STEPS study reports), were also abstracted and stored as source quality characteristics. Studies were excluded if they did not include sufficient methodological information for study evaluation; if they were not population-based (e.g. they were conducted in hospital or clinic-based settings); if they reported only T1D prevalence or incidence; if they included only people in a specific age group, e.g. over 65 years; if they did not include age-stratified data (for at least three age-groups) or if they were published before 1990. In addition, WHO STEPS studies were excluded if they had used incorrect glucose thresholds to define diabetes as reported by Lin et al. [12].

### 2.3. Data source characteristics and selection

In order to evaluate the quality of the data, each data source was scored, as in previous Atlas editions, by the Analytical Hierarchy Process (AHP), an approach commonly used in operations research. This quantifies the relative value of a variety of different aspects of study methods [13]. As has been described previously [10], members of the IDF Atlas Committee completed preference charts on the relative importance of five study characteristics (diagnostic criteria, sample size, sample representation, age of the data source, and type of the publication) and these preferences were used to assign a value for each pairwise comparison (e.g. age of the data source vs method of diagnosis). Detailed information can be found elsewhere [14]. For the 9$^{th}$ edition data selection, the Committee members were requested to update these weights. The newly determined weights were then applied to the extracted studies and each study was assigned a score, with higher scores indicating a better quality. About 60% of all studies had a score above 0.29 and this value was chosen as a threshold for inclusion of data sources in data analysis. For countries with more than one qualifying study, the highest scoring study was selected together with other studies within 0.1 score range from the highest, and any other studies were excluded.

### 2.4. Estimating diabetes prevalence

The age- and sex-stratified diabetes prevalence was calculated for each country, accounting for diabetes prevalence differences in urban and rural areas. Urban to rural diabetes prevalence ratios were updated using the weighted average of the ratios in different data sources in the IDF Regions and World Bank income group, where the weights were the study scores calculated using the AHP scoring system. Logistic regression was performed to generate smoothed age- and sex- specific prevalence estimates for 5-year age groups for adults aged 20–79 years. The regression used age (as midpoint of each age-group) and the quadratic of age as separate independent variables for each sub-group (sex and urban/rural area) if available. The quadratic age term was used in the regression to allow for a drop in diabetes prevalence for the oldest age-groups to account for mortality. The United Nations (UN) population estimates for 2019, for each of the 211 countries and territories were used to generate national estimates.

The number of people with diabetes in each of the seven IDF Regions and each World Bank income group was calculated by aggregating the number of people with diabetes for each country within the respective IDF Region and World Bank income group. Global estimates were calculated by aggregating the total number of people with diabetes for each country, with population denominators obtained for each country and territory from the United Nations Population Division (UNPD) [15]. UNPD does not provide age- and sex-stratified population data for countries and territories with populations smaller than 90,000. In these cases, age- and sex-specific regional level population data was used to calculate age- and sex-specific population estimates for the small countries and territories.

In the 9$^{th}$ edition of the IDF Diabetes Atlas, similar to the previous edition, two different prevalence estimates have been produced for each country and Region: country-age standardised and world-age standardised. Country-age standardised prevalence provides an estimate of the percentage of adults with diabetes in a country, standardising the prevalence to the age and sex distribution of the specific country. However, because age distributions vary from country to country, the world-age standardised estimates should be used when comparing estimates between countries and the IDF Regions. World-age standardised diabetes prevalence was then produced by standardising each country's prevalence to the 2001 WHO standard population [16]. The 2001 WHO standard population has been calculated for the period 2000–2025 and is therefore valid to be used for 2019 world-age standardised estimates [16].

The methods of estimating undiagnosed diabetes have been described in detail elsewhere [14]. Briefly, if available, data on undiagnosed diabetes prevalence were extracted from the same group of studies used to estimate diabetes prevalence. This procedure also included a data source selection, where appropriate studies were chosen using the AHP process, similar to the methods described above. Epidemiological studies that used glycated haemoglobin (HbA1c) were included for the first time in this edition but only for countries that did not have data sources using the oral glucose tolerance test (OGTT) or fasting blood glucose (FBG) as their method for identifying undiagnosed diabetes.

### 2.5. Extrapolation of diabetes estimates for countries without in-country data or with low-quality data

For countries without data or with only low-quality in-country data, estimates were extrapolated from data from countries matched by geographical location, World Bank income group, ethnicity, language, and IDF Region. Three income groups were derived from the World Bank's 2018 classification of the world's economies: low-income; middle-income; and high-income countries [11]. Classification was based on estimates of the gross national income per capita for the previous calendar year. Data on languages and ethnicities were derived from the Central Intelligence Agency (CIA) World Factbook [17,18].

### 2.6. Estimating confidence intervals

To estimate the confidence intervals for the prevalence estimates, two separate analyses were performed: 1) A simulation study to assess raw data uncertainty, where 1000 random samples were drawn from a binomial distribution of number of people with diabetes given in the data sources. These samples were then used in the estimation procedure as conducted for the original data. The 95% range of these results was established as a confidence interval. 2) A bootstrap analysis providing information about the sensitivity of the global diabetes prevalence estimate to the study selection process. In a loop, one study at a time was randomly removed from the list and the global prevalence was calculated from the remaining studies.

The confidence interval for each age group, sex and country was constructed based on the maximum and minimum value of both bootstrap and simulation analysis to reflect the confidence intervals around the diabetes prevalence estimates. Wider confidence intervals indicate that the estimates were based on less reliable data sources [19]. All analyses were conducted using the R statistical program version 3.3.0 [20].

### 2.7. Calculation of diabetes projections

For the future projections of diabetes prevalence in 2030 and 2045 the middle 2030 and 2045 population projection data from the UNPD [15] were used and were adjusted to the rates of urbanisation [21]. The 2030 and 2045 prevalence projections did not explicitly include projected changes in any diabetes risk factors (e.g. body mass index; BMI) other than age and extent of urbanisation (projected figures for 2030 and 2045). World-age standardised diabetes prevalence was also produced for the years 2030 and 2045, by standardising each country's prevalence to the world standard population in 2030 and 2045, respectively [15]. Global age structures for 2030 and 2045 were calculated using the projected UN population estimates for 2030 and 2045, respectively.

### 2.8. Estimates for IGT in 2019 and projections in 2030 and 2045

Impaired glucose tolerance (IGT) and impaired fasting glucose (IFG) constitute the category termed "intermediate hyperglycaemia" by WHO. The term "pre-diabetes" is also in use. As the number of countries with high quality studies on IFG prevalence is limited, IFG estimates were not included in the previous nor the current (9$^{th}$) edition of the IDF Diabetes Atlas.

Data sources were searched for IGT prevalence data and selected according to the previously described criteria. The urban and rural IGT prevalence ratios were updated according to the weighted average of the ratios reported in different data sources from the 19 IDF Regions and World Bank income groups. The same method described in Sections 2.4 and 2.7 was employed for IGT estimates for 2019 and IGT prevalence projections for 2030 and 2045.

## 3. Results

### 3.1. Data source characteristics and selection

Using the AHP scoring criteria, 255 sources of diabetes prevalence data from 138 countries and territories were selected for the analysis, covering 93.5% of the total adult (20–79 years) population of the world's 211 countries and territories. The remaining 73 countries and territories did not have in-country data sources for diabetes prevalence or the available sources were of insufficient quality to meet the inclusion criteria. In a small number of cases, rejected data sources were re-evaluated and they were included in the analysis. For example, no nationally-representative study was available for Afghanistan, but several local studies with similar and well-executed methods were available. These individual studies scored low based on their low level of representativeness. However, they each reported prevalence for different regions of Afghanistan and in total, they represented a large part of the country. Thus it was decided to include these studies in the analysis. Details of all of the studies selected and those rejected on grounds of quality can be found at the IDF Diabetes Atlas website (https://www.diabetesatlas.org/).

### 3.2. Estimates of diabetes for 2019 and projections to 2030 and 2045

In 2019, a total of 463 million people are estimated to be living with diabetes, representing 9.3% of the global adult population (20–79 years). This number is expected to increase to 578 million (10.2%) in 2030 and 700 million (10.9%) in 2045. The prevalence of diabetes in women in 2019 is estimated to be 9.0%, and 9.6% in men (given by age group in Fig. 1). The increase of diabetes prevalence with age leads to a prevalence of 19.9% (111.2 million) in people aged 65–79 years.

Diabetes prevalence differed by World Bank Income group, with a higher prevalence among high-income countries (10.4%) and middle-income countries (9.5%) compared to low-income countries (4.0%). In 2045, diabetes prevalence is projected to reach 11.9%, 11.8% and 4.7% in high-, middle- and low-income countries, respectively. Of all people living with diabetes, 67.0% are living in urban areas. Although prevalence is still higher in urban than in rural areas (10.8% vs. 7.2%), this difference is less marked than that reported in previous editions of the Atlas [1], reflecting, no doubt, a degree of urbanisation or "westernisation" of rural areas. As an example, a recent study in Pakistan has reported the prevalence of diabetes to be only slightly higher in urban (28.3%) than in rural (25.3%) areas [22].

Table 1 shows the number of people with diabetes and the world-age standardised prevalence of diabetes in all IDF Regions in 2019, 2030 and 2045. In 2019, the IDF Region with the highest world-age standardised diabetes prevalence is MENA, where 12.2% of the population is estimated to have diabetes. The diabetes prevalence is lowest in the AFR Region, where, in 2019, 4.7% of people aged 20–79 years are estimated to have diabetes. By 2030 and 2045, world-age standardised diabetes prevalence is projected to increase to 13.3% and 13.9% in the MENA Region and to 5.1% and 5.2% in the AFR Region. The greatest increase in the number of people with diabetes is expected in the AFR Region, where, by 2045, 142.9% more people with diabetes are expected compared to 2019.

Table 2 presents the top 10 countries or territories for the number of people with diabetes in 2019, 2030 and 2045. At a country level, China (116 million), India (77 million), and the United States of America (31 million) are those with the highest numbers of people living with diabetes in 2019. In 2030, China, India and the United States of America will remain in the top of the list with 140, 101 and 34 million people with diabetes, respectively. In 2045, the top three countries with the highest number of people with diabetes are expected to be China, India and Pakistan, with 147, 134 and 37 million, respectively. Table 3 shows the top 10 countries or territories for the world-age standardised diabetes prevalence in 2019, 2030 and 2045. Diabetes world-age standardised prevalence

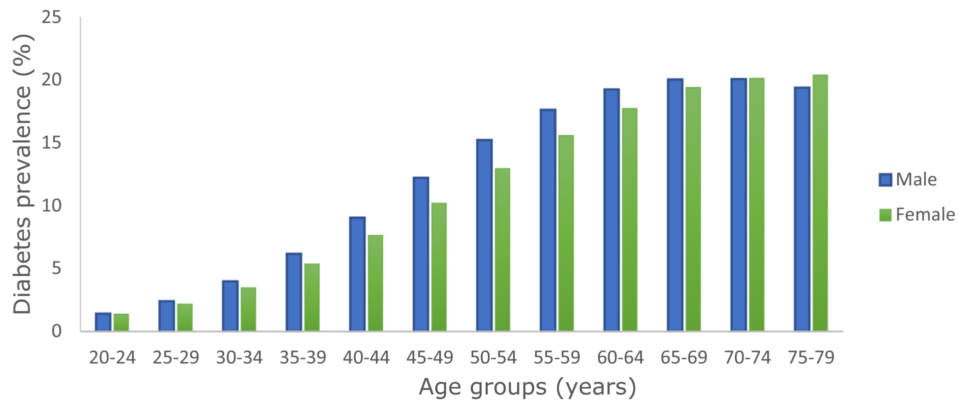


**Fig. 1 – Diabetes prevalence by age and sex in 2019.**

in 2019 is the highest in the Marshall Islands (30.5%), Kiribati (22.5%) and Sudan (22.1%).

### 3.3. *Estimates for undiagnosed diabetes in 2019*

Of the 211 countries and territories, 73 (34.6%) had good quality, in-country data sources on undiagnosed diabetes. For the remaining countries, the prevalence of undiagnosed diabetes was extrapolated according to the method outlined above.

Of the 463 million people living with diabetes, half (50.1%) are unaware of their condition. Higher proportions of undiagnosed diabetes were found in low- and middle-income countries, accounting for 84.3% of all undiagnosed people with diabetes worldwide. The IDF AFR Region has the highest proportion of all people with diabetes who are undiagnosed (59.7%), followed by the IDF SEA Region (56.7%), the IDF WP Region (55.8%) and IDF MENA Region (44.7%). Lower percentages were seen in the IDF SACA Region (41.9%), IDF EUR Region (40.7%) and IDF NAC Region (37.8%).

### 3.4. *Estimates for IGT in 2019 and predictions for 2030 and 2045*

The number of studies that satisfied the selection threshold was limited, due, in part, to the low number of data sources for IGT prevalence. Only 62 studies from 49 countries, representing 64.3% of the total world population, were selected to estimate IGT prevalence. Estimates for the remaining countries (35.7% of the population) were extrapolated.

Global IGT prevalence was estimated to be 7.5% in 2019, or 373.9 million people. By 2030, 8.0% (453.8 million) and by 2045 8.6% (548.4 million) are expected to be living with IGT. The majority (72.2%) of people with IGT live in low- and middle-income countries. Overall, there are no differences in the IGT prevalence between women (7.5%) and men (7.5%). Almost half (48.1%) of adults 20–79 years with IGT are under the age of 50 years (180 million). This age group will continue to have a high number of people with IGT in 2030 (204.1 million) and 2045 (231.8 million). It is important to note that nearly one-third (28.3%) of all those who currently have IGT are in the 20–39 year-old age group and are therefore likely to spend many years at high risk of developing diabetes and CVD.

The IDF Region with the highest world-age standardised IGT prevalence is IDF NAC Region where, in 2019, 12.3% of the population (55.5 million) is estimated to have IGT. The IDF EUR Region has the lowest world-age standardised prevalence of IGT, being present in 4.4% (36.6 million) of the population (Table 4). The ranking of the seven IDF Regions is expected to stay the same until 2045 (Table 4). Similar to the increase in diabetes, AFR is the IDF Region with the largest expected increase in IGT. By 2045, 64.9 million more people with IGT are expected in the IDF AFR Region, an increase of 143.3% compared to 2019.

## 4. Discussion

Diabetes is a major health issue that has reached alarming levels. In 2019, nearly half a billion people (9.3% of adults 20–79 years) are living with diabetes worldwide. The estimated number of people (20–79 years) living with diabetes has increased by 62% during the past 10 years; from 285 million in 2009 to 463 million, today. Currently, half (50.1%) of the people with diabetes do not know that they have diabetes.

The reasons for this increase are complex and the IDF Diabetes Atlas findings cannot estimate their various contributions but they include: increasing incidence of T1D in children, especially younger children; increasing incidence of T2D in young people and increasing incidence of T2D in adults as a result of sedentary living, high-energy dietary intakes and other as yet unknown factors; the intergenerational effects of hyperglycaemia in pregnancy and the general ageing of the global population. On the other hand, earlier diagnosis of T2D and better management of all types of diabetes leading to greater life-expectancy are also contributing to this rise in prevalence.

### 4.1. *Data source characteristics and selection*

Overall, 65% of the countries had in-country data on diabetes prevalence in this edition of the Atlas, while the proportion was lower in the previous edition (8th edition) of the IDF Diabetes Atlas (59%). Even though 93.5% of the world's population was covered by the sources of data which met the quality criteria set by the AHP process, this still left 73 countries and territories for which estimates had to be made by extrapolation. Of these 73 countries and territories, 46 did not have any type of data sources available. In the other 27 countries and territories, 37 studies were identified but were

**Table 1 – World-age standardised prevalence (%) of diabetes among ages 20–79 years in IDF Regions, ranked by 2019 world-age standardised prevalence estimates.**

| | | 2019[i] | | 2030[i] | | 2045[i] | |
|---|---|---|---|---|---|---|---|
| Rank | IDF Region | Number of people with diabetes, Million | World-age standardised diabetes prevalence, % | Number of people with diabetes, Million | World-age standardised diabetes prevalence, % | Number of people with diabetes, Million | World-age standardised diabetes prevalence, % |
| | **World** | 463.0 (368.7–600.6) | 8.3 (6.2–11.8) | 578.4 (456.5–747.6) | 9.2 (6.8–12.9) | 700.2 (540.7–904.6) | 9.6 (7.1–13.4) |
| **1** | **MENA** | 54.8 (30.7–75.1) | 12.2 (8.3–16.1) | 76.0 (43.0–104.1) | 13.3 (9.1–17.6) | 107.6 (60.6–147.4) | 13.9 (9.5–18.3) |
| **2** | **WP** | 162.6 (146.6–203.0) | 11.4 (8.3–15.6) | 196.5 (176.6–241.6) | 12.4 (9.0–16.8) | 212.2 (188.3–255.9) | 12.8 (9.3–17.4) |
| **3** | **SEA** | 87.6 (70.9–110.9) | 11.3 (8.0–15.9) | 115.1 (92.9–144.5) | 12.2 (8.6–17.2) | 152.8 (123.4–190.1) | 12.6 (8.9–17.7) |
| **4** | **NAC** | 47.6 (37.4–56.4) | 11.1 (9.0–14.5) | 56.0 (43.4–66.5) | 12.3 (10.0–15.9) | 63.2 (48.1–74.9) | 13.0 (10.5–16.5) |
| **5** | **SACA** | 31.6 (26.3–39.2) | 8.5 (6.7–11.3) | 40.2 (33.3–49.9) | 9.5 (7.4–12.6) | 49.1 (40.3–60.7) | 9.9 (7.8–13.2) |
| **6** | **EUR** | 59.3 (46.3–80.2) | 6.3 (4.9–9.2) | 66.0 (51.3–87.9) | 7.3 (5.6–10.3) | 68.1 (52.6–89.6) | 7.8 (6.0–10.8) |
| **7** | **AFR** | 19.4 (10.6–35.8) | 4.7 (3.2–8.1) | 28.6 (16.0–53.1) | 5.1 (3.4–8.8) | 47.1 (27.4–86.0) | 5.2 (3.5–9.1) |

IDF: International Diabetes Federation; AFR: Africa; EUR: Europe; MENA: Middle East and North Africa; NAC: North America and Caribbean; SACA: South and Central America; SEA: South-East Asia; WP: Western Pacific.

[i] Confidence intervals are presented in brackets.

**Table 2 – Top 10 countries or territories for number of people with diabetes (20–79 years) in 2019, 2030 and 2045.**

| 2019[i] | | | 2030[i] | | | 2045[i] | | |
|---|---|---|---|---|---|---|---|---|
| Rank | Country or Territory | Number of people with diabetes, Million | Rank | Country or territory | Number of people with diabetes, Million | Rank | Country or territory | Number of people with diabetes, Million |
| 1 | China | 116.4 (108.6–145.7) | 1 | China | 140.5 (130.3–172.3) | 1 | China | 147.2 (134.7–176.2) |
| 2 | India | 77.0 (62.4–96.4) | 2 | India | 101.0 (81.6–125.6) | 2 | India | 134.2 (108.5–165.7) |
| 3 | United States of America | 31.0 (26.7–35.8) | 3 | United States of America | 34.4 (29.7–39.8) | 3 | Pakistan | 37.1 (15.8–58.5) |
| 4 | Pakistan | 19.4 (7.9–30.4) | 4 | Pakistan | 26.2 (10.9–41.4) | 4 | United States of America | 36.0 (31.0–41.6) |
| 5 | Brazil | 16.8 (15.0–18.7) | 5 | Brazil | 21.5 (19.3–24.0) | 5 | Brazil | 26.0 (23.2–28.7) |
| 6 | Mexico | 12.8 (7.2–15.4) | 6 | Mexico | 17.2 (9.7–20.6) | 6 | Mexico | 22.3 (12.7–26.8) |
| 7 | Indonesia | 10.7 (9.2–11.5) | 7 | Indonesia | 13.7 (11.9–14.9) | 7 | Egypt | 16.9 (9.0–19.4) |
| 8 | Germany | 9.5 (7.8–10.6) | 8 | Egypt | 11.9 (6.4–13.5) | 8 | Indonesia | 16.6 (14.6–18.2) |
| 9 | Egypt | 8.9 (4.8–10.1) | 9 | Bangladesh | 11.4 (9.4–14.4) | 9 | Bangladesh | 15.0 (12.4–18.9) |
| 10 | Bangladesh | 8.4 (7.0–10.7) | 10 | Germany | 10.1 (8.4–11.3) | 10 | Turkey | 10.4 (7.4–13.2) |

[i] Confidence intervals are presented in brackets.

**Table 3 – Top 10 countries or territories for world-age standardised diabetes prevalence among ages 20–79 years in 2019, 2030 and 2045.**

| 2019[i] | | | 2030[i] | | | 2045[i] | | |
|---|---|---|---|---|---|---|---|---|
| Rank | Country or territory | World-age standardised prevalence, % | Rank | Country or territory | World-age standardised prevalence, % | Rank | Country or territory | World-age standardised prevalence, % |
| **1** | Marshall Islands | 30.5 (17.2–39.3)[i] | **1** | Marshall Islands | 33.0 (18.5–42.6) | **1** | Marshall Islands | 34.1 (18.9–44.1) |
| **2** | Kiribati | 22.5 (11.0–31.0) | **2** | Mauritius | 24.3 (9.9–28.2) | **2** | Mauritius | 25.3 (10.3–29.2) |
| **3** | Sudan | 22.1 (9.5–24.3) | **3** | Tuvalu[ii] | 23.9 (19.0–28.8) | **3** | Tuvalu[ii] | 24.7 (19.5–29.9) |
| **4** | Tuvalu[ii] | 22.1 (17.6–26.6) | **4** | Kiribati | 23.6 (11.9–32.3) | **4** | Sudan | 24.2 (10.9–26.5) |
| **5** | Mauritius | 22.0 (9.1–25.7) | **5** | Sudan | 23.5 (10.4–25.8) | **5** | Kiribati | 23.9 (12.1–33.1) |
| **6** | New Caledonia[ii] | 21.8 (17.3–26.0) | **6** | New Caledonia[ii] | 23.2 (18.2–27.8) | **6** | New Caledonia[ii] | 23.9 (18.5–28.7) |
| **7** | Pakistan | 19.9 (8.3–30.9) | **7** | Pakistan | 21.0 (9.0–32.9) | **7** | Guam | 21.5 (17.6–27.2) |
| **8** | French Polynesia | 19.5 (16.4–22.9) | **8** | Solomon Islands | 20.6 (10.1–29.8) | **8** | Pakistan | 21.5 (9.3–33.7) |
| **9** | Solomon Islands | 19.0 (9.4–27.4) | **9** | Guam | 20.6 (16.8–26.6) | **9** | Solomon Islands | 21.3 (10.3–31.1) |
| **10** | Guam | 18.7 (15.4–24.5) | **10** | French Polynesia | 20.5 (17.1–24.0) | **10** | French Polynesia | 20.9 (17.4–24.6) |

[i] Confidence intervals are presented in brackets.
[ii] Countries without in-country data sources. Estimates are extrapolated.

**Table 4 – World-age standardised prevalence (%) of IGT among ages 20–79 years in IDF Regions, ranked by 2019 world-age standardised prevalence estimates.**

| Rank | IDF Region | 2019[i] Number of people with IGT, Million | World-age standardised IGT prevalence, % | 2030[i] Number of people with IGT, Million | World-age standardised IGT prevalence, % | 2045[i] Number of people with IGT, Million | World-age standardised IGT prevalence, % |
|---|---|---|---|---|---|---|---|
| | **World** | 373.9 (248.3–616.0) | 8.6 (5.8–14.8)[i] | 453.8 (303.7–749.7) | 9.2 (6.1–15.7) | 548.4 (365.6–918.0) | 9.5 (6.3–16.1) |
| 1 | **NAC** | 55.5 (46.8–63.8) | 12.3 (10.2–14.4) | 64.0 (54.0–73.6) | 13.2 (11.0–15.5) | 70.7 (59.6–81.2) | 13.8 (11.5–16.1) |
| 2 | **WP** | 136.5 (85.5–221.0) | 10.4 (7.1–16.0) | 155.9 (98.7–253.3) | 11.0 (7.5–16.8) | 164.8 (105.0–267.8) | 11.3 (7.6–17.2) |
| 3 | **AFR** | 45.3 (26.0–100.7) | 10.1 (5.6–22.7) | 66.8 (39.1–147.7) | 10.5 (5.7–24.1) | 110.2 (64.6–241.9) | 10.7 (5.6–24.9) |
| 4 | **SACA** | 33.9 (24.4–45.0) | 9.7 (6.9–12.9) | 41.0 (29.9–54.3) | 10.3 (7.5–13.7) | 48.1 (35.5–63.1) | 10.7 (7.8–14.1) |
| 5 | **MENA** | 35.5 (22.2–51.1) | 9.2 (6.2–13.3) | 47.3 (30.0–68.4) | 9.7 (6.5–14.1) | 64.5 (40.3–93.7) | 9.9 (6.6–14.5) |
| 6 | **SEA** | 30.6 (23.0–59.9) | 7.7 (5.7–11.3) | 39.1 (29.5–74.8) | 7.9 (5.9–11.6) | 49.8 (37.7–92.9) | 8.0 (5.9–11.8) |
| 7 | **EUR** | 36.6 (20.4–74.5) | 4.4 (2.6–9.3) | 39.7 (22.5–77.4) | 4.9 (2.9–9.8) | 40.3 (22.9–77.4) | 5.1 (3.1–10.1) |

IDF: International Diabetes Federation; IGT: impaired glucose tolerance; AFR: Africa; EUR: Europe; MENA: Middle East and North Africa; NAC: North America and Caribbean; SACA: South and Central America; SEA: South-East Asia; WP: Western Pacific.
[i] Confidence intervals are presented in brackets.

rejected on one or more grounds of the source quality characteristics mentioned above. While necessary to provide global coverage, such extrapolation is no substitute for well executed and well presented in-country data. Researchers need to be encouraged to embark on studies with protocols which meet quality criteria such as those mentioned previously. The problems reported by Lin et al [12] regarding the WHO STEPS findings, which led to their rejection based on quality grounds, mean that two countries (Togo and Rwanda) that had in-country data reported in the previous editions of the Atlas, now do not have such data available.

With the aspiration to include, in future Atlas editions, more national data sources, protocols by which these data are collected, validated and presented also need to be rigorously put together and adhered to. A number of national databases (e.g. from the United Kingdom) could not be used because the data were not in a format compatible with Atlas usage.

### 4.2. *Prevalence estimates and projections of diabetes, undiagnosed diabetes, and IGT*

Similar to our estimates (463 million people with diabetes), recent findings from the Global Burden of Disease study reported that about half a billion people (475 million) in 2017 had diabetes [23]. In addition, WHO, based on the methods used by the NCD risk factor collaboration, has reported that 422 million people aged 18 years and above were living with diabetes in 2014 [24].

The largest number of people with diabetes in 2019 is estimated for the WP and SEA Regions of the IDF (163 million and 88 million, respectively). Similarly, WHO estimated the largest number of people with diabetes in these two regions in 2014 (131 million and 96 million, respectively) [24].

It should be noted that the 95% confidence intervals for prevalence of diabetes were estimated by combining the raw data uncertainty and the sensitivity of the model to the selection of data sources. However, this approach does not consider any other potential sources of uncertainty, such as those in the model used by the NCD risk factor collaboration (a Bayesian model) [24].

Considering the large number of people with diabetes and the growing projected numbers, there is an urgent need to develop and implement coordinated and multi-sectoral strategies to tackle diabetes. Without sufficient action to address the pandemic, we predict 578 million people (10.2% of adults 20–79 years) will have diabetes by 2030. The number will increase to a staggering 700 million (10.9%) by 2045.

WHO and the UN have set global targets to encourage action to improve care and strengthen healthcare systems. These actions include reducing premature death from non-communicable diseases (NCDs), including diabetes, by 30% by 2030, and establishing national diabetes plans and achieving universal health coverage (UHC) by 2030. This edition of the Atlas has also provided predictions for the year 2030 in line with the UN Sustainable Development Goals for 2030. In just 11 years, the number of people living with diabetes will increase by 25%, if well-coordinated national prevention and treatment programmes do not take place in a timely manner.

It has been shown that T2D can be prevented or delayed through lifestyle modification (LSM) or administration of some pharmacological agents [25–27]. While the effectiveness of the prevention of T2D is clear, the translation of these findings from targeting people at high-risk into national policies remains a challenge [26]. Attempts made so far target unhealthy diet and physical inactivity as the drivers of overweight and obesity, which are the most important modifiable risk factors for the development of T2D. In 2013, the Global Action Plan for the Prevention and Control of NCDs 2013–2020 established a number of targets for countries to use to curb the increasing impact of NCDs and recommended strategies for implementation [28]. Among those goals is to halt the rise in obesity and diabetes prevalence. However, the feasibility of this target through population-based interventions remains to be fully evaluated. Although global targets and strategies are useful in guiding governments to coordinate an NCDs response, solutions that work in one place may not work in another. Policy choices and prevention programmes must be tailored to the setting and coordinated across sectors. In a real-world setting, the best approach seems to be a multi-pronged coordinated strategy.

Atlas diabetes predictions do not take into account future trends in body mass index (BMI) and these predictions are likely to be conservative. However, our rationale for not including these was that 1) a surrogate measure of changing BMI (viz.: extent of urbanisation) was already included; 2) data on future trends of other risk factors for T2D such as birth weight and physical activity were not available and 3) the fewer assumptions that were made, the more likely the predictions were to be accurate.

Since estimates of undiagnosed diabetes prevalence can only be made from studies that have employed the OGTT, global coverage is limited. Therefore, based on a general consensus, in this edition of the Atlas, data sources in three countries (Ireland, New Zealand and Russian Federation) with HbA1c as their diagnostic criterion were also included in data analysis for calculating undiagnosed diabetes as they were the only available studies for the countries.

### 4.3. *Future considerations and recommendations*

The following are among the possible outcomes from this recent Atlas work:

- Agreeing guidelines for the conduct of high-quality epidemiological studies in diabetes and the presentation of their results such that they will be accepted for inclusion in future Atlas editions and other compendia of this kind. These guidelines need to be realistic in terms of the resources that might be available and might, for instance be graded in a number of rankings: the minimum acceptable; a more ambitious level and the “gold standard”. A list of pitfalls to avoid might also be considered.

- Consideration to adding participation levels to the existing list of method of diagnosis, sample size, representation, age of the data source and type of publication. Adequate participation levels need to be agreed. Should these be, for example, 60%, 70% or higher? As is well known, low participation, even if the final number of participants is high, opens the door to various forms of bias.

- Protocols for the collection, validation and presentation of data from routine administrative sources also need to be agreed so that these can be used more frequently in future Atlas editions. All countries should consider collecting national diabetes statistics and expand existing databases.

- Countries with existing national databases on diabetes should continue collecting high-quality and up-to-date information. In countries without such national databases urgent actions are required to mobilise resources for conducting epidemiological surveillance and research following high scientific standards. This can help to present the true impact of diabetes and to help establish targets for national and global health programmes.

## 5. Conclusion

It is estimated that 463 million people (95% confidence interval: 369–601 million) have diabetes in 2019. Given that half a billion people are living with diabetes, there is an urgent need for developing and implementing multi-sectoral strategies to tackle diabetes. Without urgent and sufficient actions, it is predicted that 578 million people will have diabetes in 2030 and the number will increase by 51% (700 million) in 2045.

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## Author contribution

Conception and design: PS, BM, SK, NU, SC, LG, KO, JES, RW; Analysis of data: PS; drafting the article or revising it critically: PS, IP, PS, BM, SK, NU, SC, LG, AAM, KO, JES, DB, RW; final approval of the version to be submitted: PS, IP, PS, BM, SK, NU, SC, LG, AAM, KO, JES, DB, RW.

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