International Diabetes Federation

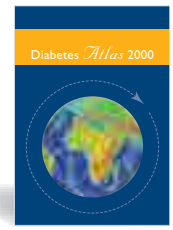
IDF **DIABETES ATLAS**

Ninth edition 2019

IDF DIABETES ATLAS

Ninth edition 2019

Table of contents



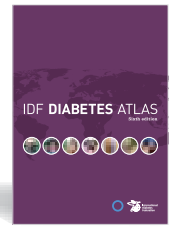
First edition, 2000

Second edition, 2003

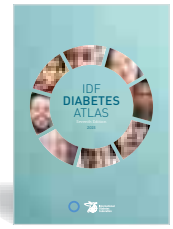
Third edition, 2006

Fourth edition, 2009

Fifth edition, 2011



Sixth edition, 2013



Seventh edition, 2015

Eighth edition, 2017

Online version of *IDF Diabetes Atlas:* www.diabetesatlas.org

Unless indicated otherwise all photographs in this edition of the IDF Diabetes Atlas were taken by the following Panos Pictures photographers: Andrew Esiebo, Jordi Ruiz Cirera, Ore Huying, Atul Loke, Dieter Telemans, Mary Turner and Mansoor Shaikh.

Other photo credits: amenic181/envatoelements (page 81); Aurélia Rusek/UNDP (page 90).

Technical editing and design by Inís Communication: www.iniscommunication.com

ISBN: 978-2-930229-87-4

Acknowledgements

IDF Diabetes Atlas, 9th Edition Committee

Rhys Williams (Chair), Stephen Colagiuri (Deputy Chair), Reem Almutairi, Pablo Aschner Montoya, Abdul Basit, David Beran, Stéphane Besançon, Christian Bommer, Wenche Borgnakke, Edward Boyko, Dominic Bright, Juliana Chan, Gisela Dahlquist, Hema Divakar, Alireza Esteghamati, Nita Forouhi, Laercio Franco, Edward Gregg, Leonor Guariguata, Mohamed Hassanein, Calvin Ke, Dinky Levitt, Lee-Ling Lim, Ayesha Motala, Graham Ogle, Katherine Ogurstova, David Owens, Chris Patterson, Meda Pavkov, Jonathan Pearson-Stuttard, Ambady Ramachandran, Wolfgang Rathmann, Musarrat Riaz, Gojka Roglic, Jonathan Shaw, David Simmons, Alan Sinclair, Eugene Sobngwi, Gyula Soltesz, Rebecca Thomas, Nigel Unwin, Heather Ward, Sarah Wild, Xilin Yang, Lili Yuen, Ping Zhang

Editorial team

Suvi Karuranga, Belma Malanda, Pouya Saeedi, Paraskevi Salpea

Contributors

Silvia Gorban de Lapertosa, Andreia Ferreira de Moura, Chani Decroux, Lisa Duke, Lucy Hammond, Esther Jacobs, Abha Kaundal, Jing Li, Jinnan Liu, Anne Wiebke Ohlrogge, Inga Petersohn, Lorenzo Piemonte, Sue Prosser and colleagues at the Singleton Hospital Library, Swansea, UK, Phil Riley, Merry Rivas Gonzalez, Els Sung, Mike Wilson, Beatriz Yáñez Jiménez, Wen Yang, Margaux Ysebaert

Data

The list of studies on which estimates in the *IDF Diabetes Atlas* are based and those considered but not used can be found at: www.diabetesatlas.org

Corporate sponsors

The 9th edition has been produced thanks to an educational grant (2018–2019) from:

Pfizer MSD Alliance

With the additional support of:

Lilly DIABETES

novo nordisk®

Forewords

Professor Nam H. Cho
President 2017–2019,
International Diabetes Federation

The *IDF Diabetes Atlas* has been our flagship publication since it was first published almost 20 years ago. Over that time, it has become a trusted source of evidence on the impact of diabetes worldwide and the publication of each edition is eagerly anticipated. Since that first edition in 2000, the estimated prevalence of diabetes (type 1 and type 2 combined, both diagnosed and undiagnosed) in people aged 20–79 years has risen from 151 million (4.6% of the global population at the time) to 463 million (9.3%) today. Without sufficient action to address the pandemic, we predict 578 million people (10.2% of the population) will have diabetes by 2030. That number will jump to a staggering 700 million (10.9%) by 2045.

Diabetes is a serious threat to global health that respects neither socioeconomic status nor national boundaries. People living with diabetes are at risk of developing a number of serious and life-threatening complications, leading to an increased need for medical care, a reduced quality of life, and undue stress on families. Diabetes and its complications, if not well managed, can lead to frequent hospital admissions and premature death. Globally, diabetes is among the top 10 causes of death.

Despite the stark truth the data represent, there is a positive message: with early diagnosis and access to appropriate care, diabetes can be managed and its complications prevented. Furthermore, type 2 diabetes can often be prevented and there is compelling evidence to suggest it can be reversed in some cases.

In recent years, the World Health Organization (WHO) and the United Nations (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, establishing national diabetes plans and achieving universal health coverage (UHC) by 2030. These are important steps towards guaranteeing access to affordable high-quality care and alleviating financial catastrophe for the close to 580 million who will then be living with diabetes.

However, many countries still lack a national diabetes plan, and at least half the world's population does not have full coverage for essential health services. Most countries are also falling short of the WHO 2025 target of halting the rise of type 2 diabetes. Urgent national actions are required to improve type 2 diabetes prevention and the management of all types of diabetes. Governments will need to adopt a health-in-all-policies approach to secure the best possible care and quality of life for people living with diabetes.

In this edition of the *IDF Diabetes Atlas*, diabetes estimates are based on information from 255 data sources from 138 countries. The data are robust and with each edition our estimates become more precise. However, there is still a significant number of countries for which high-quality data sources on diabetes prevalence are not available. Epidemiological studies and reports based on solid evidence are necessary to present the true impact of diabetes and to help establish targets for national and global health. We highly recommend, in addition to focussing on prevention and improving care, that advocacy strategies seek to mobilise resources for further epidemiological research.

We sincerely hope this latest edition of the *IDF Diabetes Atlas* will support IDF Member Associations and other key diabetes stakeholders to advocate more action to identify undiagnosed diabetes, to take further steps to prevent diabetes in those at risk, and to improve care for people with diabetes. It is our desire that the data published herein will help stimulate governments and the private sector to take action.

Professor Rhys Williams
Chair,
IDF Diabetes Atlas Committee (9th edition)

Since its first edition, the *IDF Diabetes Atlas* has been among the most quoted sources of information on the impact of diabetes and related conditions. The use of the *IDF Diabetes Atlas* information can be gauged by, for example, the 102,000 downloads of the English version that were made between release of the 8th edition in November 2017 and June 2019.

The *IDF Diabetes Atlas* is, however, not the only source of estimates of prevalence and other vital statistics on the impact of diabetes. Others have used different sources and made different assumptions. Unsurprisingly, these sometimes differ in the detail of their conclusions. Nevertheless, the consistent overall picture is one of a globally significant intrusion into the health and wealth of individuals, families and nations – an intrusion that, with a few notable exceptions, is increasing.

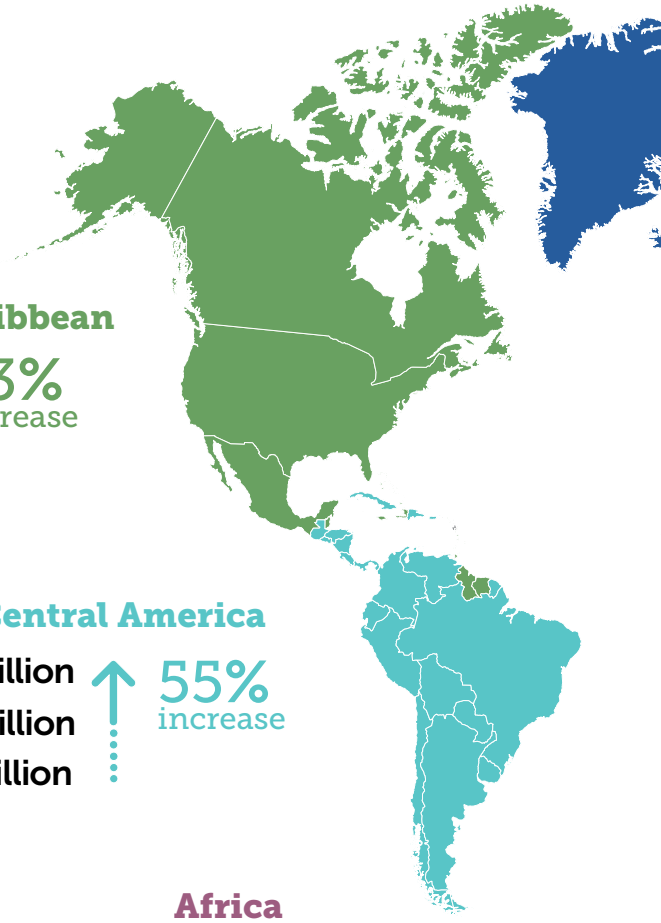
The challenges of estimating the global impact of diabetes are considerable and relate to two main issues: available data are not homogenous nor are they comprehensive. Data heterogeneity results from many factors. For example, various diagnostic tests are employed for the diagnosis of diabetes and the diagnostic criteria used may be based on those of WHO or of the American Diabetes Association (ADA). These are closely aligned but there are differences. Other areas of potential heterogeneity are the sampling frames used, the responses achieved, the age groups invited, etc., the list goes on.

The lack of comprehensive global data is epitomised by the fact that, in the 8th edition of the *IDF Diabetes Atlas*, only 131 out of 221 countries (59%) had quality data derived from in-country studies. Estimates for the remaining 90 were extrapolated from countries deemed to be similar in key respects – an essential compromise for global coverage. The improved situation for the 9th edition is that 138 out of 211 countries (65%) had quality data and the rest (73) were extrapolated.

Making projections into the future is even more perilous than making estimates for the present. In making such predictions many factors can be taken into account: predicted trends in overweight and obesity, for example. In this *IDF Diabetes Atlas* edition, we have taken the view that the fewer uncertainties we factor into projections the more likely they are to be accurate. The parameters we have included in our predictions are the same as those used in the previous edition. Reassuringly, experience has shown that past attempts to project the future of diabetes have been conservative rather than excessive. That is the way it should be: we are being realistic and not scaremongering.

An immense amount of thought and hard work has gone into this edition and I am grateful to my colleagues in the Editorial Team and members of the *IDF Diabetes Atlas* Committee for this. This *IDF Diabetes Atlas* is offered for careful and considered use in the support of continued and enhanced action to improve the lives of people with diabetes and those at risk of developing the condition.

Summary



North America & Caribbean

2045 63 million
2030 56 million
2019 48 million

33% increase

South & Central America

2045 49 million
2030 40 million
2019 32 million

55% increase

WORLD

2045 700 million
2030 578 million
2019 463 million

51% increase

Africa

2045 47 million
2030 29 million
2019 19 million

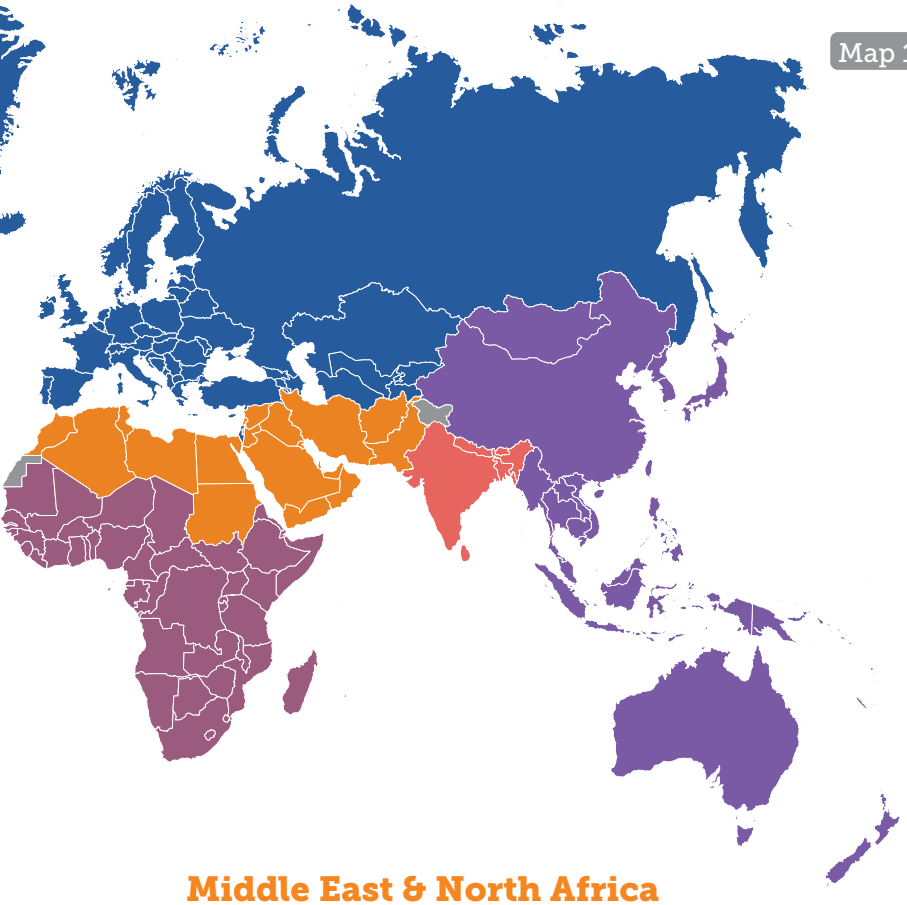
143% increase

Diabetes is a major health issue that has reached alarming levels: today, nearly half a billion people are living with diabetes worldwide.

The *IDF Diabetes Atlas* is an authoritative source of evidence on the prevalence of diabetes, related mortality and diabetes-related health expenditure at global, regional and national levels. The *IDF Diabetes Atlas* also serves as a reminder to readers of the classification of diabetes and its diagnostic criteria. It presents the global picture of diabetes, including estimates for each of the seven IDF Regions, the impact of diabetes complications based on the current literature and, finally, provides information on specific actions that can be taken on diabetes such as prevention of type 2 diabetes and close management of all forms of diabetes to avoid subsequent complications.

The credibility of diabetes estimates relies on the rigorous methods used for the selection and analysis of high-quality data sources. Every two years, the *IDF Diabetes Atlas* Committee – composed of thematic experts from each of the seven IDF Regions – reviews the methods underlying the *IDF Diabetes Atlas* estimates and projections, and available data sources. The methods have been explained in detail by Guariguata *et al*,[1] and more recently, by Saeedi *et al*.[2] The majority of the data sources used are population-based studies that have been published in peer-reviewed periodicals. Furthermore, information from national health surveys, including some of the World Health Organization (WHO) STEPwise approach to Surveillance (STEPS) are used where they meet inclusion criteria.

Findings of the current 9th edition confirm that diabetes is one of the fastest growing global health emergencies of the 21st century (see Map 1). In 2019, it is estimated that 463 million people have diabetes and this number is projected to reach 578 million by 2030, and 700 million by 2045. Two-thirds of people with diabetes live in urban areas and three



Map 1 **Number of people with diabetes worldwide and per IDF Region in 2019, 2030 and 2045 (20–79 years)**

Europe

2045 68 million
2030 66 million
2019 59 million

↑ 15% increase

South-East Asia

2045 153 million
2030 115 million
2019 88 million

↑ 74% increase

Middle East & North Africa

2045 108 million
2030 76 million
2019 55 million

↑ 96% increase

Western Pacific

2045 212 million
2030 197 million
2019 163 million

↑ 31% increase

out of four are of working age. Over four million people aged 20–79 years are estimated to die from diabetes-related causes in 2019. The number of children and adolescents (i.e. up to 19 years old) living with diabetes increases annually. In 2019, over one million children and adolescents have type 1 diabetes. An estimated 136 million people over 65 years old have diabetes, and the prevalence of diabetes in this age group varies significantly between IDF Regions.

This *IDF Diabetes Atlas* edition also shows that hyperglycaemia in pregnancy (HIP) affects approximately one in six pregnancies. Another cause for alarm is the consistently high percentage of people with undiagnosed diabetes (overwhelmingly type 2 diabetes), which is currently over 50%. This reveals the urgent need to diagnose the undiagnosed people with diabetes and provide appropriate and timely care for all people with diabetes as early as possible.

The chapter on complications of diabetes is based on up-to-date literature and includes descriptions of diabetes-related complications and co-morbidities. This edition of the *IDF Diabetes Atlas* also emphasises actions that can be taken at various levels – such as ensuring evidence is used to enhance diabetes management, highlighting the important linkages between diabetes and universal health coverage (UHC), and improving access to insulin – with a view to strengthening the global fight to reduce the impact of diabetes for individuals, their families and society.

References

1. Guariguata L, Whiting D, Weil C, Unwin N. The International Diabetes Federation Diabetes Atlas methodology for estimating global and national prevalence of diabetes in adults. *Diabetes Res Clin Pract.* 2011 Dec;94(3):322–32; DOI:10.1016/j.diabres.2011.10.040.
2. Saeedi P, Petersohn I, Salpea P, Malanda B, Karuranga S, Unwin N, et al. Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: results from the International Diabetes Federation Diabetes Atlas, 9th edition. *Diabetes Res Clin Pract;* DOI:10.1016/j.diabres.2019.107843.

Introduction

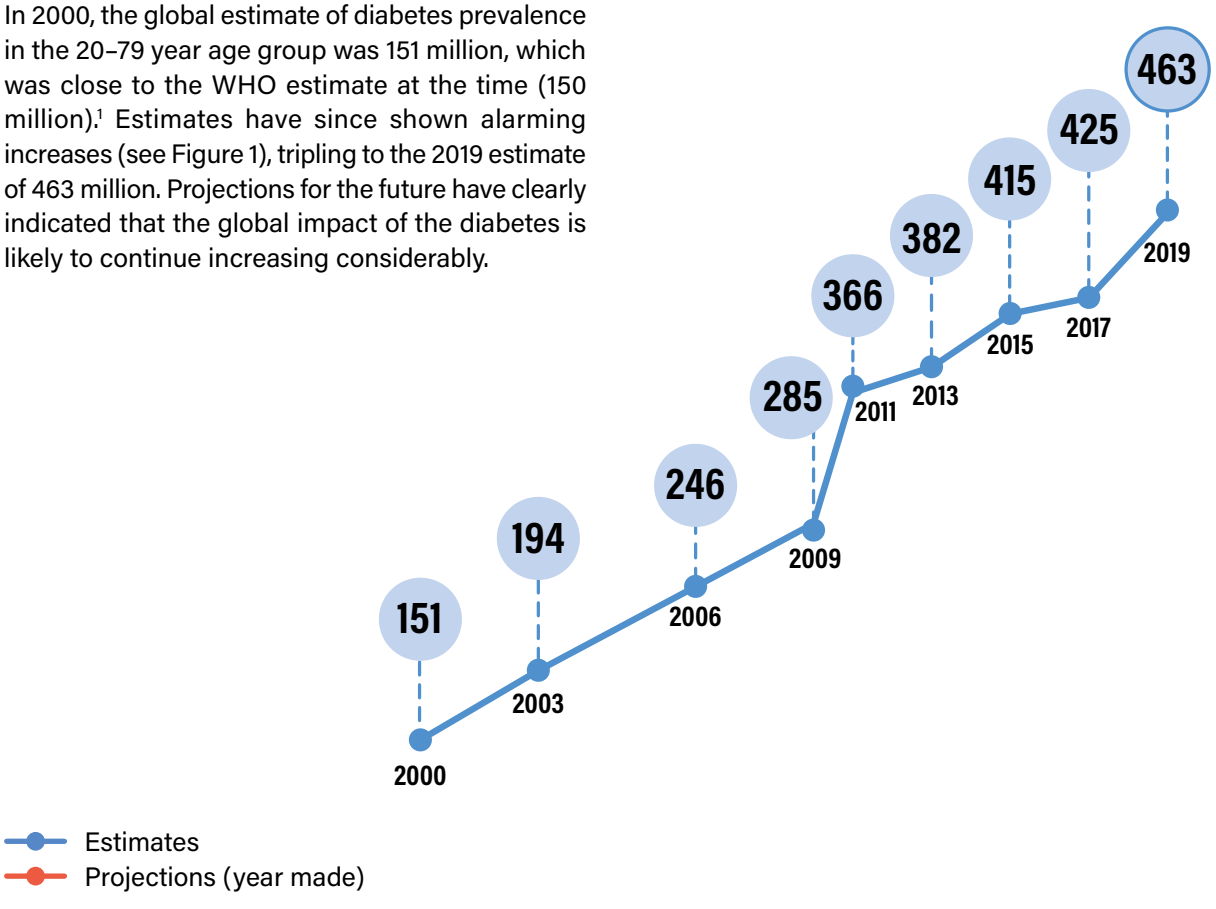
A proud history of information dissemination and advocacy

Since its 1st edition was published (2000), the *IDF Diabetes Atlas* has provided robust estimates of the prevalence of diabetes by country, IDF Region and globally. Since its 2nd edition (2003), it has also projected these estimates into the future. In doing so it has served as an advocacy tool, not only for the quantification of the impact of diabetes worldwide, but also for reducing that impact through preventive measures aimed at reducing the long-term consequences of all types of diabetes as well as primary prevention of type 2 diabetes.

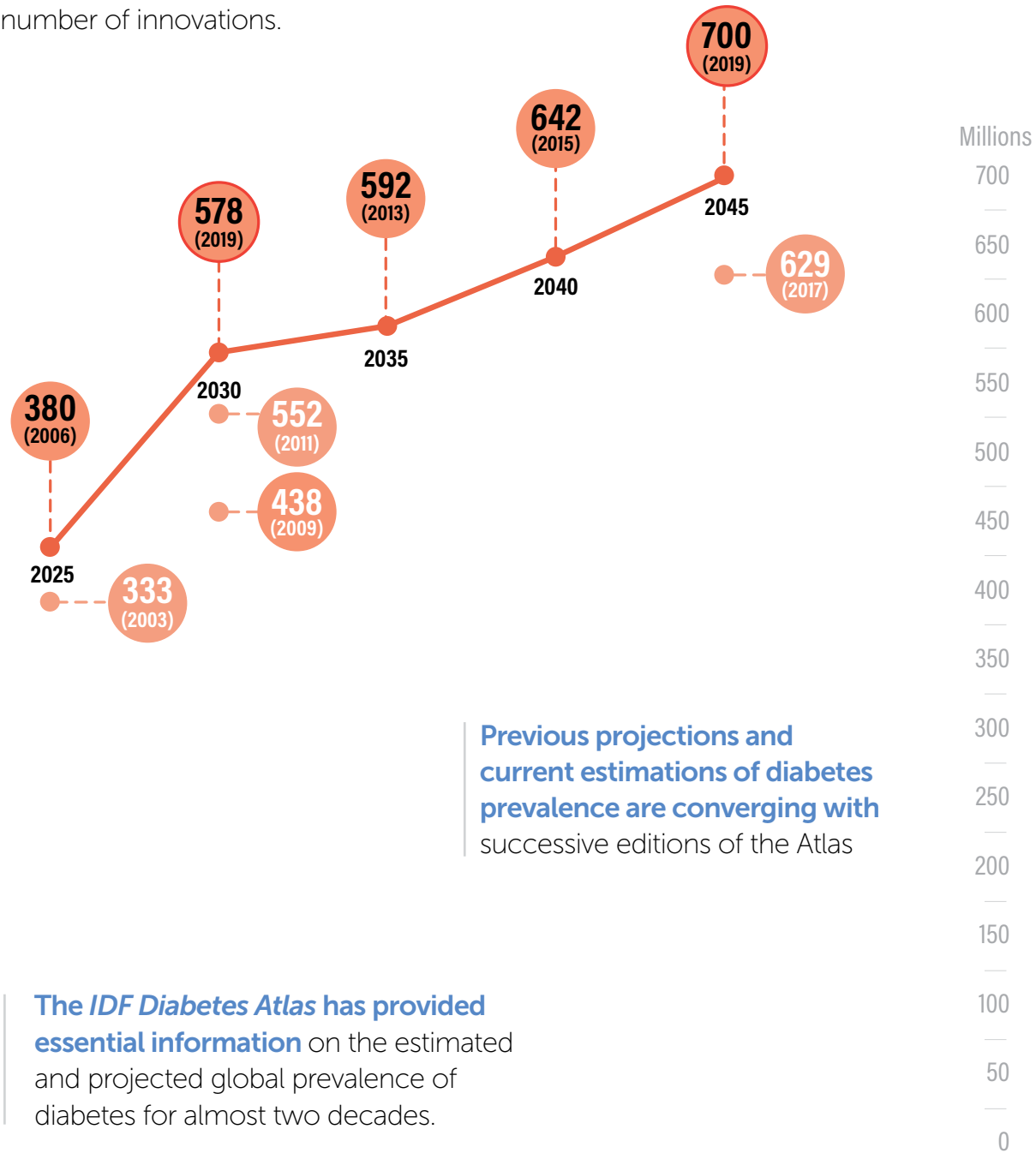
In 2000, the global estimate of diabetes prevalence in the 20–79 year age group was 151 million, which was close to the WHO estimate at the time (150 million).[1] Estimates have since shown alarming increases (see Figure 1), tripling to the 2019 estimate of 463 million. Projections for the future have clearly indicated that the global impact of the diabetes is likely to continue increasing considerably.

The *IDF Diabetes Atlas* draws attention to the importance and growing impact of diabetes in all countries and regions.

Figure 1 **Estimates and projections of the global prevalence of diabetes in the 20–79 year age group (millions)**



The 9th edition of the *IDF Diabetes Atlas* provides continuity with earlier editions in relation to the estimation and projection methods used, and also incorporates a number of innovations.



Previous projections and current estimations of diabetes prevalence are converging with successive editions of the Atlas

The *IDF Diabetes Atlas* has provided essential information on the estimated and projected global prevalence of diabetes for almost two decades.

Our vision for the *IDF Diabetes Atlas* 9th edition

Two inter-related objectives comprise the shared ambition for the latest edition of *the IDF Diabetes Atlas*:

- Advocacy for the continued and more effective use of the *IDF Diabetes Atlas* and its further improvement.
- Achieving a balance between consistency with previous editions, and innovation and continued development for the 9th edition.

Some minor changes have been made to the epidemiological methods used in preparing the 9th edition. These are summarised in Chapter 2 and are described in detail in a separate publication by Saeedi *et al*.[2] New data have been accessed and some topics have been introduced for the first time (see below). However, the basis on which estimates and projections have been calculated in this edition remain essentially the same as those used in the previous edition. Thus, continuity has been maintained and, with certain caveats, conclusions about time trends in the global progress of diabetes can be made with reasonable confidence.

What's new in the 9th edition?

For this edition, a more extended collection of data on the prevalence of diabetes in languages other than English was conducted. This has included the official United Nations (UN) languages (i.e. Arabic, Chinese, French, Russian and Spanish) as well as Danish, German and Portuguese.

The troubling emergence of type 2 diabetes in children and young people has been recognised by including this alongside type 1 diabetes in these age groups (Chapter 1) and the impact of childhood diabetes, for example on acute complications, has been given greater emphasis (Chapter 5).

Estimates of the incidence of diabetes are included for the first time, recognising that, given increased longevity of people with diabetes, influences on prevalence are complex and the global impact of diabetes is best assessed using incidence as well as prevalence (Chapter 3). Projections of hyperglycaemia in pregnancy are also included for the first time (also Chapter 3).

Indirect costs for diabetes (Chapter 3) and access to insulin, and the implications of universal health coverage (UHC), are discussed. The complex inter-relationship between diabetes and cancer is the subject of a new section (Chapter 5). The feasibility of type 2 diabetes prevention is given more prominence in this edition (Chapter 6) and the aspiration to prevent or delay the type 1 diabetes process is also declared in the same chapter.

The importance of the advocacy objective of the *IDF Diabetes Atlas* and related materials is given even more emphasis in this edition than previously (Chapter 6). For that purpose, a separate *Advocacy Guide* presenting key findings, messages and actions is also available in all of the UN languages, serving as a stimulus to the use of the *IDF Diabetes Atlas* data for advocacy purposes.

How to read this *IDF Diabetes Atlas*

Although it might be tempting to focus solely on the figures for a given country or IDF Region, other factors need be taken into account when interpreting the *IDF Diabetes Atlas* estimates and any differences from those given in the previous edition. Possible reasons for significant differences between the 8th (2017) and 9th edition (2019) figures are:

- The inclusion of new studies for some countries without in-country data sources in the previous edition.[a]
- In the case of extrapolated prevalence estimates for countries without in-country data, the inclusion of new studies for those countries used for the extrapolations.
- Changes in study selection from the previous edition as a result of an updated analytical hierarchy process (AHP) scoring (see Chapter 2).
- The exclusion of specific WHO STEPS surveys included in the previous edition, as a result of emerging concerns about their validity (see Chapter 2).

It must be stressed that any differences between the 8th and 9th edition estimates are unlikely to have occurred as a result of epidemiological changes between 2017 and 2019 but, rather, are attributable to the period of time between the dates on which individual data sets were collected. The latter is typically more than two years.

a The list of studies used as the basis of estimates, and those considered but not used, can be found at: www.diabetesatlas.org.

References

1. King H, Aubert RE, Herman WH. Global burden of diabetes, 1995–2025: prevalence, numerical estimates, and projections. *Diabetes Care.* 1998 Sep;21(9):1414–31; DOI:10.2337/diacare.21.9.1414.
2. Saeedi P, Petersohn I, Salpea P, Malanda B, Karuranga S, Unwin N, et al. Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: results from the International Diabetes Federation Diabetes Atlas, 9th edition. *Diabetes Res Clin Pract.* doi:https://doi.org/10.1016/j.diabres.2019.107843

1 WHAT IS DIABETES?

Osarenkhoe Ethel Chima-Nwogwugwu from Lagos, Nigeria, lives with type 2 diabetes

Key messages

Diabetes is a serious, long-term condition that occurs when the body cannot produce any or enough insulin or cannot effectively use the insulin it produces. The main categories of diabetes are type 1, type 2 and gestational diabetes mellitus.

Type 1 diabetes is the major cause of diabetes in childhood but can occur at any age. At present, it cannot be prevented. People with type 1 diabetes can live healthy and fulfilling lives but only with the provision of an uninterrupted supply of insulin, education, support and blood glucose testing equipment.

Type 2 diabetes accounts for the vast majority (around 90%) of diabetes worldwide. It can be effectively managed through education, support and adoption of healthy lifestyles, combined with medication as required. Evidence exists that type 2 diabetes can be prevented and there is accumulating evidence that remission of type 2 diabetes may be possible for some people.

'Prediabetes' is a term increasingly used for people with impaired glucose tolerance and/or impaired fasting glucose. It signifies a risk of the future development of type 2 diabetes and diabetes-related complications.

Pregnant women with gestational diabetes mellitus can have babies that are large for gestational age, increasing the risk of pregnancy and birth complications both for the mother and baby.

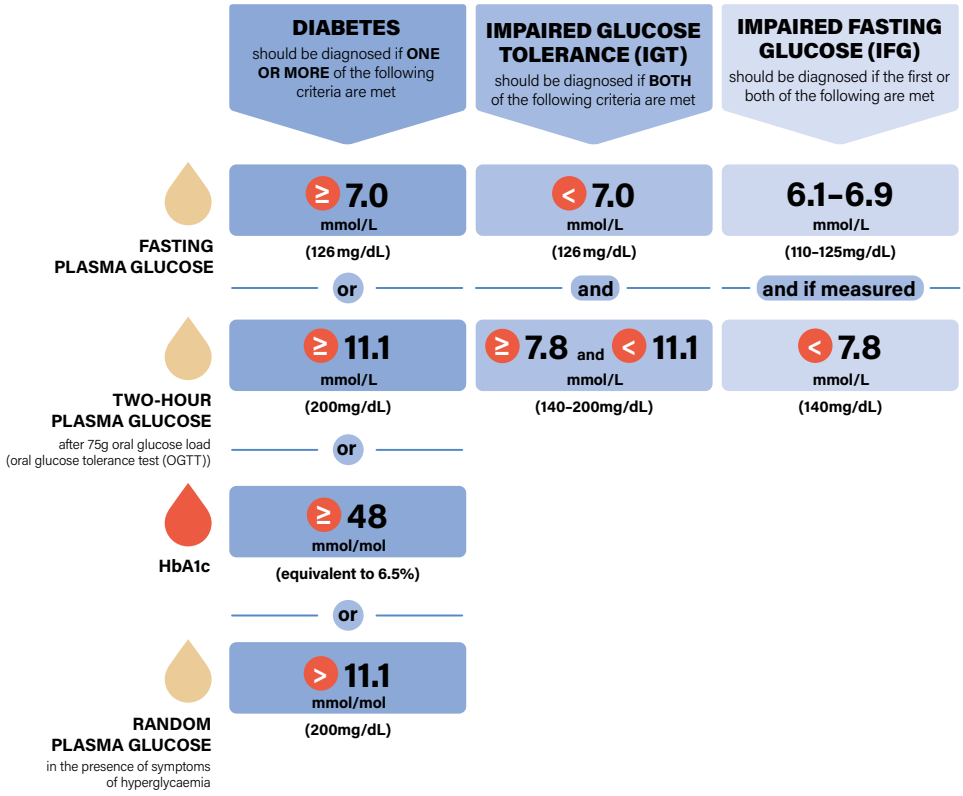
Chapter 1
What is diabetes?

Diabetes mellitus, more simply called diabetes, is a serious, long-term (or 'chronic') condition that occurs when there are raised levels of glucose in a person's blood because their body cannot produce any or enough of the hormone insulin, or cannot effectively use the insulin it produces.

Insulin is an essential hormone produced in the pancreas. It allows glucose from the bloodstream to enter the body's cells where that glucose is converted into energy. Insulin is also essential for the metabolism of protein and fat. A lack of insulin, or the inability of cells to respond to it, leads to high levels of blood glucose (hyperglycaemia), which is the clinical indicator of diabetes. The threshold levels for the diagnosis of diabetes can be found in Figure 1.1.

Insulin deficit, if left unchecked over the long term, can cause damage to many of the body's organs, leading to disabling and life-threatening health complications such as cardiovascular diseases (CVD), nerve damage (neuropathy), kidney damage (nephropathy) and eye disease (leading to retinopathy, visual loss and even blindness). However, if appropriate management of diabetes is achieved, these serious complications can be delayed or prevented altogether.

Figure 1.1 Modified diagnostic criteria for diabetes[1]



Fasting is defined as no caloric intake for at least 8 hours.

The HbA1c test should be performed in a laboratory using a method that is NGSP-certified and standardised to the Diabetes Control and Complications Trial assay.

The 2-hour postprandial glucose test should be performed using a glucose load containing the equivalent of 75g anhydrous glucose dissolved in water.

Note: The American Diabetes Association (ADA)[2] recommends diagnosing 'prediabetes' with HbA1c values between 39 and 47 mmol/mol (5.7–6.4%) and impaired fasting glucose when the fasting plasma glucose is between 5.6 and 6.9mmol/L (100–125mg/dL).

Figure 1.2 **The typical symptoms of type 1 diabetes**

Type 1 diabetes

Type 1 diabetes is caused by an autoimmune reaction in which the body's immune system attacks the insulin-producing beta cells of the pancreas. As a result, the body produces very little or no insulin. The causes of this destructive process are not fully understood but a likely explanation is that the combination of genetic susceptibility (conferred by a large number of genes) and an environmental trigger, such as a viral infection, initiate the autoimmune reaction. Toxins or some dietary factors have also been implicated.[3,4] The condition can develop at any age, although type 1 diabetes occurs most frequently in children and young people. Type 1 diabetes is one of the most common chronic diseases in childhood, although type 2 diabetes is also seen in older children, and is on the increase due to childhood overweight and obesity becoming more common.

People with type 1 diabetes need daily insulin injections to maintain a glucose level in the appropriate range. Without insulin, they would not survive. However, with appropriate daily insulin treatment, regular blood glucose monitoring, education and support, they can live healthy lives and delay or prevent many of the complications associated with diabetes.

Following a structured self-management plan – comprising insulin use, blood glucose monitoring, physical activity and a healthy diet – is especially difficult in early childhood as well as in adolescence. In many countries, especially in economically disadvantaged families, access to insulin and self-care tools, including structured diabetes education, can be limited. This may lead to severe disability and early death as a result of harmful substances known as 'ketones' building up in the body (diabetic ketoacidosis, DKA).

Living with type 1 diabetes remains a challenge for a child and the whole family, even in countries with access to multiple daily injections or an insulin pump, glucose monitoring, structured diabetes education and expert medical care. Besides the acute complications of hypoglycaemia (abnormally low blood glucose) and DKA, poor metabolic control may lead to poor growth and the early onset of circulatory (or 'vascular') complications.

The typical symptoms of type 1 diabetes are listed in Figure 1.2. The classic clinical picture of excessive thirst (polydipsia), frequent urination (polyuria) and weight loss may however not be present and the diagnosis may be delayed or even missed entirely.

Even in countries with universal health coverage (UHC), diagnosis of type 1 diabetes may be delayed until the first hospital admission for DKA, sometimes with fatal results.

In the United Kingdom around a quarter of first diagnoses of type 1 diabetes are made in the presence of DKA.[5] Similar situations are found in

France,[6] Poland,[7] the United States of America[8] and many other countries, prompting campaigns to increase awareness of type 1 diabetes among parents, school teachers and healthcare professionals.[9] The latter include advocacy for 'on-the-spot' blood glucose measurement in an unwell child with no obvious diagnosis. The frequency of a delayed diagnosis until the first episode of DKA in countries without UHC is unknown but likely to be worse than documented examples,[10] and it is thought many children must die misdiagnosed as having another condition.

Type 1 diabetes is diagnosed by an elevated blood glucose concentration (Figure 1.1) in the presence of some or, rarely, all of the symptoms listed in Figure 1.2. However, diagnosing the type of diabetes is sometimes difficult and additional testing may be required to distinguish between type 1 and type 2 diabetes or other forms of diabetes, particularly the so-called 'monogenic' types.[11]

The incidence of type 1 diabetes is increasing worldwide, but there is considerable variation by country with some regions of the world having much higher incidence than others. The reasons for this are unclear but the rapid increase over time must be due to non-genetic, probably environmental and perhaps lifestyle related changes,[4] such as rapid weight gain and/or inappropriate feeding in infancy.[12,13] The decreasing incidence of infections in western countries (the 'hygiene hypothesis')[14] has also been suggested as a risk factor for the condition.

Type 2 diabetes

In type 2 diabetes, hyperglycaemia is the result, initially, of the inability of the body's cells to respond fully to insulin, a situation termed 'insulin resistance'. During the state of insulin resistance, the hormone is ineffective and, in due course, prompts an increase in insulin production. Over time, inadequate production of insulin can develop as a result of failure of the pancreatic beta cells to keep up with demand. Type 2 diabetes is most commonly seen in older adults, but is increasingly seen in children and younger adults owing to rising levels of obesity, physical inactivity and inappropriate diet.

Type 2 diabetes may present with symptoms similar to those of type 1 diabetes but, in general, the presentation of type 2 diabetes is much less dramatic and the condition may be completely

Type 2 diabetes is the most common type of diabetes, accounting for around 90% of all diabetes worldwide.

symptomless. Also, the exact time of the onset of type 2 diabetes is usually impossible to determine. As a result, there is often a long pre-diagnostic period and as many as one-third to one-half of people with type 2 diabetes in the population may be undiagnosed. When unrecognised for a prolonged time, complications such as retinopathy or a lower-limb ulcer that fails to heal may be present at diagnosis.[15,16] The causes of type 2 diabetes are not completely understood but there is a strong link with overweight and obesity, and increasing age, as well as with ethnicity and family history. As with type 1 diabetes, type 2 diabetes results from a combination of multi-gene predisposition and environmental triggers.

The cornerstone of type 2 diabetes management is the promotion of a lifestyle that includes a healthy diet, regular physical activity, smoking cessation and maintenance of a healthy body weight. As a contribution to improving the management of type 2 diabetes, in 2017 IDF issued the *IDF Clinical Practice Recommendations for Managing Type 2 Diabetes in Primary Care*.[17] If attempts to change lifestyle are not sufficient to control blood glucose levels, oral medication is usually initiated with metformin as the first-line medicine. If treatment with a single antidiabetic medication is not sufficient, a range of combination therapy options are now available (e.g. sulphonylureas, dipeptidyl peptidase 4 (DPP-4) inhibitors, glucagon-like peptide 1 (GLP-1) analogues). When oral medications are unable to control hyperglycaemia to recommended levels, insulin injections may be necessary.

Beyond the control of raised glucose levels, it is vital to manage blood pressure and blood lipid levels and to assess metabolic control on a regular basis (at least annually). This will enable screening for the development of renal complications, retinopathy, neuropathy, peripheral arterial disease and foot ulceration. With regular check-ups and effective lifestyle management – and medication as needed – people with type 2 diabetes can lead long and healthy lives.

Globally, the prevalence of type 2 diabetes is high and rising across all regions. This rise is driven by population aging, economic development and increasing urbanisation leading to more

sedentary lifestyles and greater consumption of unhealthy foods linked with obesity.[18] However, the beneficial results of early detection, more effective treatment and the resulting longer survival are also contributing to the rise in prevalence.

As previously mentioned, type 2 diabetes has also become a concern in children and young people as a result of an increasing prevalence of obesity. Unfortunately, population-based studies in this area are scarce and there is a large variety in methods and general quality of published observations.[19] Nevertheless, it is clear that type 2 diabetes is particularly prevalent in some groups such as Pima, Navajo and Canadian First Nation people and those of Asian and Afro-American descent. In these groups, and among American-Hispanic, Japanese and Chinese children, type 2 diabetes appears to be on the increase, whereas no increase is seen in non-Hispanic white children, which probably reflects varying genetic susceptibility.[20,21] Females are more commonly affected by type 2 diabetes in all groups.[20]

Impaired glucose tolerance and impaired fasting glucose

Impaired glucose tolerance (IGT) and impaired fasting glucose (IFG) are conditions of raised blood glucose levels above the normal range and below the recommended diabetes diagnostic threshold (see Figure 1.1). The terms 'prediabetes', 'non-diabetic hyperglycaemia',[22] 'intermediate hyperglycaemia' are in use as alternatives.[1]

The importance of IGT and IFG is three-fold: first, they signify a risk of the future development of type 2 diabetes;[23–25] second, IGT and IFG denote an already heightened risk of CVD;[26,27] and, third, their detection opens the door to interventions that can lead to the prevention of type 2 diabetes (see Chapter 6).[28] However, current evidence on prevention relates to isolated IGT and combined IGT and IFG but not, as yet, to isolated IFG.[29]

Progression from IGT and IFG to type 2 diabetes is linked to severity (judged by the extent of hyperglycaemia) along with risk factors such as age and weight.[30] The cumulative incidence of type 2 diabetes progression five years after diagnosis of IGT or IFG is estimated to be between 26% and 50% respectively.[24]

The 8th edition of the *IDF Diabetes Atlas* drew attention to the importance of these categories and also highlighted the lack of information on their prevalence;[31] only 47 countries had high quality data sources on IGT. The number of countries with high quality studies on IFG prevalence was even lower and it was not considered in the 8th edition. The situation has not improved sufficiently for it to feature in this current edition.

Diagnostic criteria for diabetes

The footnote on Figure 1.1 mentions the American Diabetes Association (ADA) inclusion of HbA1c as part of the diagnostic criteria of diabetes and prediabetes. The World Health Organization (WHO) supports the use of HbA1c >6.5% for diabetes diagnosis but not for intermediate hyperglycaemia, on the grounds that quality-assured HbA1c measurement is not available on a global scale.[1] Currently, WHO and IDF recommend two-hour oral glucose tolerance test (OGTT) for the detection of IGT and IFG. However, there is accumulating evidence for the use of one-hour OGTT as a more sensitive method capable of identifying intermediate hyperglycaemia at an earlier time point.[32]

> **Most guidelines use the standard diagnostic criteria** proposed by the IDF and World Health Organization

For type 1 diabetes, in the presence of symptoms (e.g. polyuria, polydipsia and unexplained weight loss) the diagnosis can be made without OGTT if the following are present: a random venous plasma glucose concentration ≥ 11.1 mmol/l or a fasting plasma glucose concentration ≥ 7.0 mmol/l (whole blood ≥ 6.1 mmol/l or HbA1c ≥ 6.5%).

Hyperglycaemia in pregnancy

According to WHO and the International Federation of Gynaecology and Obstetrics (FIGO), hyperglycaemia in pregnancy (HIP) can be classified as either gestational diabetes mellitus (GDM) or diabetes in pregnancy (DIP).[33,34] GDM is diagnosed for the first time during pregnancy and may occur anytime during pregnancy (most

likely after 24 weeks).[35] DIP applies to pregnant women who have previously known diabetes or have hyperglycaemia that was first diagnosed during pregnancy and meets WHO criteria of diabetes in the non-pregnant state. DIP may also occur at any time during pregnancy, including the first trimester.[34] It has been estimated that most (75–90%) cases of HIP are GDM.[36]

> **Overt symptoms of hyperglycaemia during pregnancy are rare** and may be difficult to distinguish from normal pregnancy symptoms.

An OGTT is recommended for the screening of GDM between the 24th and 28th week of pregnancy, but for high-risk women the screening should be conducted earlier in pregnancy.[37] The diagnostic criteria for GDM vary and remain controversial, complicating the comparison of research data. There has been a move towards the diagnostic criteria advocated by International Association of the Diabetes and Pregnancy Study Groups (IADPSG)/WHO[33,38] and this has resulted in a general increase in the overall prevalence of GDM. Typically, an OGTT is performed by measuring the plasma glucose concentration while fasting and one or two hours after ingesting 75 grams of glucose. Table 1.1 lists the most commonly used screening methods for estimating gestational diabetes around the world, based on universal screening using a fasting 75-gram OGTT with serum glucose levels measured at 0, 1 and 2 hours. A 3-hour 100-gram OGTT is also described but not commonly used.

Table 1.1 Diagnostic criteria in studies used for estimating gestational diabetes

Criteria		Fasting		1-hour		2-hour		3-hour	
		mg/dL	mmol/L	mg/dL	mmol/L	mg/dL	mmol/L	mg/dL	mmol/L
ADA/ACOG[iii]	2003[39] 2018[2]	95	5.3	180[i]	10.0[i]	155	8.6	140	7.8
ADIPS	2014[40]	92	5.1	180[i]	10.0[i]	153	8.5	–	–
Diabetes Canada Clinical Practice Guidelines[iv]	2018[41]	95	5.3	–	10.6	–	9.0	–	–
DIPSI[v]	2014[42]	–	–	–	–	140	7.8	–	–
EASD	1991[43]	110[i]/126	6.1[i]/7.0	–	–	162[i]/180	9.0[i]/10.0	–	–
FIGO	2015[34]	92	5.1	180[i]	10.0[i]	153	8.5	–	–
WHO	1998[44]	110[ii]/126	6.1[ii]/7.0	–	–	120[ii]/140	6.7[ii]/7.8	–	–
WHO	2013[33]	92	5.1	180[i]	10.0[i]	153	8.5	–	–
IADPSG	2010[40]	92	5.1	180[i]	10.0[i]	153	8.5	–	–
NICE	2015[45]	–	5.6	–	–	–	7.8	–	–

Note: ADA: American Diabetes Association; ACOG: American College of Obstetricians and Gynaecologists; DIPSI: Diabetes Canada Clinical Practice Guidelines Diabetes in Pregnancy Society Group India; EASD: European Association for the Study of Diabetes; FIGO: International Federation of Gynaecology and Obstetrics; ADIPS: Australasian Diabetes in Pregnancy Society; WHO: World Health Organization; IADPSG: International Association of the Diabetes and Pregnancy Study Groups; NICE: National Institute for Health and Care Excellence.

i There are no established criteria for the diagnosis of diabetes mellitus in pregnancy based on the 1-h post-load value.

ii Refers to whole blood glucose level.

iii Recommends either the IADPSG one-step or two-step approach; initial screening by measuring plasma or serum glucose concentration after 1 h 50g oral glucose load (GCT). Those exceeding the cut-off perform either a 100g OGTT or 75g OGTT, requiring two or more venous plasma concentrations to be met or exceed the threshold.

iv Listed is the preferred approach, the alternate approach is the IADPSG uses a non-fasting 75g OGTT.

v Uses a non-fasting 75g OGTT.

Besides those women with hyperglycaemia early in pregnancy, GDM arises in women with insufficient insulin secretory capacity to overcome the diminished action of insulin (insulin resistance) due to hormone production by the placenta.[39] Risk factors for GDM include older age, overweight and obesity, previous GDM, excessive weight gain during pregnancy, a family history of diabetes, polycystic ovary syndrome, habitual smoking and a history of stillbirth or giving birth to an infant with a congenital abnormality. GDM is more common in some ethnic groups.

GDM usually exists as a transient disorder during pregnancy and resolves once the pregnancy ends. However, pregnant women with hyperglycaemia are at higher risk of developing GDM in subsequent pregnancies. In addition, the relative risk of developing type 2 diabetes is particularly high at 3–6 years after GDM and at less than 40 years of age. The increased risks remain markedly elevated thereafter.[46] Considering the high risk of early onset type 2 diabetes and the fact that early onset type 2 diabetes predisposes to high CVD risk, any lifestyle intervention should be started within three years after the index pregnancy in order to achieve the maximum benefit for the prevention of diabetes.[46,47] Babies born to mothers with GDM also have a higher lifetime risk of obesity and developing type 2 diabetes themselves.[48]

Women with hyperglycaemia detected during pregnancy are at greater risk of adverse pregnancy outcomes. These include high blood pressure and a large baby for gestational age (termed 'macrosomia'), which can make a normal birth difficult and hazardous, with the baby more prone to fractures and nerve damage. Identification of hyperglycaemia in pregnancy combined with good control of blood glucose during pregnancy can reduce these risks. Women of child-bearing age who are known to have diabetes prior to pregnancy should receive pre-conception advice, higher dose folic acid treatment, medication review, intensive diabetes management and a planned approach to pregnancy. All women who have HIP – be it GDM, previously undiagnosed HIP or existing and known diabetes – require optimal antenatal care and appropriate assistance in postnatal management. Women with hyperglycaemia during pregnancy may be able to control their blood glucose levels through a healthy diet, moderate exercise and blood glucose monitoring. Interaction with healthcare professionals is important to support their self-management and also to identify when medical (e.g. prescription of insulin or oral medications) or obstetric intervention is needed.

Other types of diabetes

The recently published WHO report on the classification of diabetes mellitus[49] lists a number of 'other specific types' [of diabetes] including monogenic diabetes and what was once termed 'secondary diabetes.'

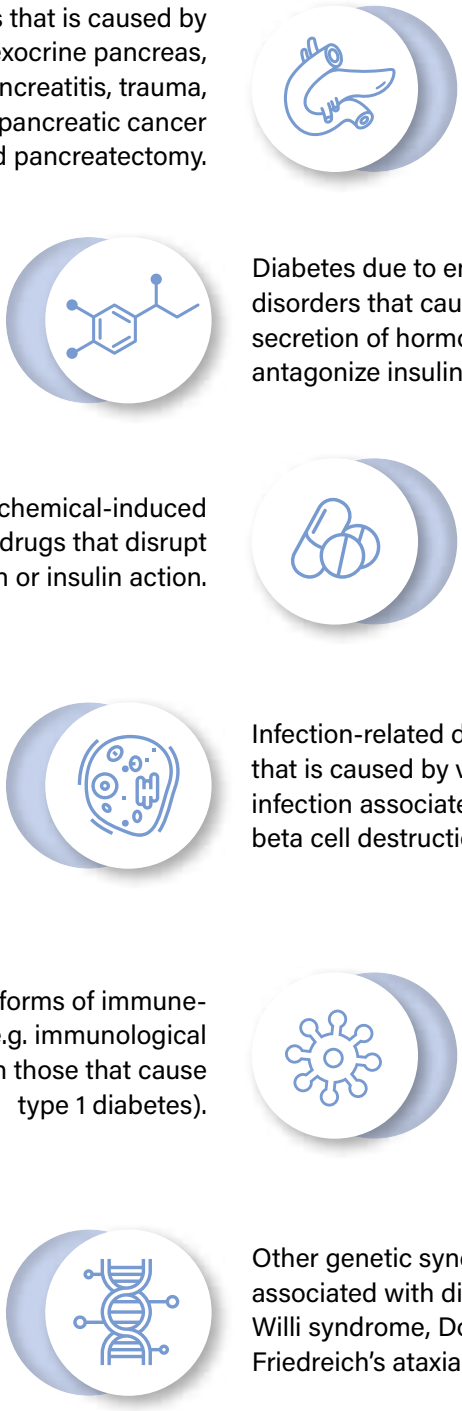
Monogenic diabetes, as the name implies, results from a single gene rather than the contributions of multiple genes and environmental factors as seen in type 1 and type 2 diabetes. Monogenic diabetes is much less common and represents 1.5–2% of all cases, though this may well be an underestimate. It is often misdiagnosed as either type 1 or type 2 diabetes.[50]

These monogenic forms present a broad spectrum, from neonatal diabetes mellitus (sometimes called 'monogenic diabetes of infancy'), maturity onset diabetes of the young (MODY) and rare diabetes-associated syndromic diseases.[51] Although rare, these can serve as 'human knockout models' providing insight into diabetes pathogenesis.[52]

From a clinical perspective, the exact diagnosis of the monogenic forms of diabetes is important because in some instances therapy can be tailored to the specific genetic defect.[50] Further distinction between the fourteen different sub-types of MODY leads not only to differences in clinical management but different predictions of complication risk. In recent years, with the accumulation of whole genome genetic studies, an increasing number of monogenic forms of diabetes is being discovered[51,53] thus the true prevalence of these types may be underestimated.

Diabetes can also arise as a consequence of other conditions. These other specific types of diabetes are listed below, in accordance with the most recent WHO diabetes classification.[49]

Figure 1.3 Other specific types of diabetes[49]



Note: newly diagnosed diabetes cases that are not able to be classified in any of the categories that were described in this chapter, are designated as 'unclassified diabetes.'

References

1. World Health Organization and International Diabetes Federation. *Definition and diagnosis of diabetes mellitus and intermediate hyperglycaemia. Report of a WHO/IDF Consultation.* Geneva; 2016. Available at: https://www.who.int/diabetes/publications/diagnosis_diabetes2006/en/.
2. American Diabetes Association. Classification and diagnosis of diabetes: Standards of medical care in diabetes – 2018. *Diabetes Care.* 2018;41(Suppl 1):S13–27; DOI:10.2337/dc18-S002.
3. Atkinson MA, Eisenbarth GS, Michels AW. Type 1 diabetes. *Lancet*. 2014 Jan 4;383(9911):69–82; DOI:10.1016/S0140-6736(13)60591-7.
4. Maahs DM, West NA, Lawrence JM, Mayer-Davis EJ. Epidemiology of type 1 diabetes. *Endocrinol Metab Clin North Am*. 2010 Sep;39(3):481–97; DOI:10.1016/j.ecl.2010.05.011.
5. Lansdown AJ, Barton J, Warner J, Williams D, Gregory JW, Harvey JN, et al. Prevalence of ketoacidosis at diagnosis of childhood onset Type 1 diabetes in Wales from 1991 to 2009 and effect of a publicity campaign. *Diabet Med*. 2012 Dec;29(12):1506–9; DOI:10.1111/j.1464-5491.2012.03638.x.
6. Choleau C, Maitre J, Elie C, Barat P, Bertrand AM, de Kerdanet M, et al. [Ketoacidosis at time of diagnosis of Type 1 diabetes in children and adolescents: effect of a national prevention campaign]. *Arch Pediatr*. 2015 Apr;22(4):343–51; DOI:10.1016/j.arcped.2014.11.001.
7. Szypowska A, Ramotowska A, Grzechnik-Gryziak M, Szypowski W, Pasierb A, Piechowiak K. High frequency of diabetic ketoacidosis in children with newly diagnosed type 1 diabetes. *J Diabetes Res.* 2016;2016:9582793; DOI:10.1155/2016/9582793.
8. Dabelea D, Rewers A, Stafford JM, Standiford DA, Lawrence JM, Saydah S, et al. Trends in the prevalence of ketoacidosis at diabetes diagnosis: the SEARCH for diabetes in youth study. *Pediatrics.* 2014 Apr;133(4):e938-945; DOI:10.1542/peds.2013-2795.
9. Deylami R, Townson J, Mann M, Gregory JW. Systematic review of publicity interventions to increase awareness amongst healthcare professionals and the public to promote earlier diagnosis of type 1 diabetes in children and young people. *Pediatr Diabetes.* 2018;19(3):566–73; DOI:10.1111/pedi.12565.
10. Ogle GD, Middlehurst AC, Silink M. The IDF Life for a Child Program Index of diabetes care for children and youth. *Pediatr Diabetes*. 2016;17(5):374–84; DOI:10.1111/pedi.12296.
11. Largay J. Case Study: New-onset diabetes: How to tell the difference between Type 1 and Type 2 Diabetes. *Clinical Diabetes*. 2012 Jan 1;30(1):25–6; DOI:10.2337/diaclin.30.1.25.
12. EURODIAB Substudy 2 Study Group. Rapid early growth is associated with increased risk of childhood type 1 diabetes in various European populations. *Diabetes Care.* 2002 Oct;25(10):1755–60; DOI:10.2337/diacare.25.10.1755.
13. Verbeeten KC, Elks CE, Daneman D, Ong KK. Association between childhood obesity and subsequent Type 1 diabetes: a systematic review and meta-analysis. *Diabet Med.* 2011 Jan;28(1):10–8; DOI:10.1111/j.1464-5491.2010.03160.x.
14. Bach J-F. The effect of infections on susceptibility to autoimmune and allergic diseases. *N Engl J Med.* 2002 Sep 19;347(12):911–20; DOI:10.1056/NEJMra020100.
15. Gregg EW, Li Y, Wang J, Burrows NR, Ali MK, Rolka D, et al. Changes in diabetes-related complications in the United States, 1990-2010. *N Engl J Med.* 2014 Apr 17;370(16):1514–23; DOI:10.1056/NEJMoa1310799.
16. King P, Peacock I, Donnelly R. The UK prospective diabetes study (UKPDS): clinical and therapeutic implications for type 2 diabetes. *Br J Clin Pharmacol.* 1999 Nov;48(5):643–8; DOI:10.1046/j.1365-2125.1999.00092.x.
17. International Diabetes Federation. *IDF Clinical practice recommendations for managing Type 2 diabetes in primary care.* Brussels; 2019. Available at: https://www.idf.org/e-library/guidelines/128-idf-clinical-practice-recommendations-for-managing-type-2-diabetes-in-primary-care.html.
18. Basu S, Yoffe P, Hills N, Lustig RH. The relationship of sugar to population-level diabetes prevalence: an econometric analysis of repeated cross-sectional data. *PLoS ONE*. 2013;8(2):e57873; DOI:10.1371/journal.pone.0057873.
19. Fazeli Farsani S, van der Aa MP, van der Vorst MMJ, Knibbe C a. J, de Boer A. Global trends in the incidence and prevalence of Type 2 diabetes in children and adolescents: a systematic review and evaluation of methodological approaches. *Diabetologia*. 2013 Jul;56(7):1471–88; DOI:10.1007/s00125-013-2915-z.
20. Mayer-Davis EJ, Lawrence JM, Dabelea D, Divers J, Isom S, Dolan L, et al. Incidence trends of Type 1 and Type 2 diabetes among Youths, 2002-2012. *N Engl J Med.* 2017 13;376(15):1419–29; DOI:10.1056/NEJMc1706291.
21. Urakami T, Miyata M, Yoshida K, Mine Y, Kuwabara R, Aoki M, et al. Changes in annual incidence of school children with Type 2 diabetes in the Tokyo Metropolitan Area during 1975-2015. *Pediatr Diabetes*. 2018;19(8):1385–92; DOI:10.1111/pedi.12750.
22. National Cardiovascular Intelligence Network (NCVIN)/NHS Diabetes Prevention Programme (NHS DPP). *Non-diabetic hyperglycaemia*. London: Public Health England; 2015. Available at: https://www.england.nhs.uk/diabetes/diabetes-prevention/.
23. Heianza Y, Hara S, Arase Y, Saito K, Fujiwara K, Tsuji H, et al. HbA1c 5·7-6·4% and impaired fasting plasma glucose for diagnosis of prediabetes and risk of progression to diabetes in Japan (TOPICS 3): a longitudinal cohort study. *Lancet.* 2011 Jul 9;378(9786):147–55; DOI:10.1016/S0140-6736(11)60472-8.
24. Richter B, Hemmingsen B, Metzendorf M-I, Takwoingi Y. Development of type 2 diabetes mellitus in people with intermediate hyperglycaemia. *Cochrane Database Syst Rev*. 2018 Oct 29;10:CD012661; DOI:10.1002/14651858.CD012661.pub2.
25. Tabák AG, Herder C, Rathmann W, Brunner EJ, Kivimäki M. Prediabetes: a high-risk state for diabetes development. *Lancet.* 2012 Jun 16;379(9833):2279–90; DOI:10.1016/S0140-6736(12)60283-9.
26. Huang Y, Cai X, Mai W, Li M, Hu Y. Association between prediabetes and risk of cardiovascular disease and all-cause mortality: systematic review and meta-analysis. *BMJ*. 2016 Nov 23;355:i5953; DOI:10.1136/bmj.i5953.
27. Yeboah J, Bertoni AG, Herrington DM, Post WS, Burke GL. Impaired fasting glucose and the risk of incident diabetes mellitus and cardiovascular events in an adult population: MESA (Multi-Ethnic Study of Atherosclerosis). *J Am Coll Cardiol.* 2011 Jul 5;58(2):140–6. DOI:10.1016/j.jacc.2011.03.025.
28. Diabetes Prevention Program Research Group, Knowler WC, Fowler SE, Hamman RF, Christophi CA, Hoffman HJ, et al. 10-year follow-up of diabetes incidence and weight loss in the Diabetes Prevention Program Outcomes Study. *Lancet.* 2009 Nov 14;374(9702):1677–86; DOI:10.1016/S0140-6736(09)61457-4.

29. Cefalu WT, Buse JB, Tuomilehto J, Fleming GA, Ferrannini E, Gerstein HC, et al. Update and next steps for real-world translation of interventions for Type 2 diabetes prevention: reflections from a Diabetes Care Editors' Expert Forum. *Diabetes Care.* 2016;39(7):1186–201; DOI; 10.2337/dc16-0873.

30. Howells L, Musaddaq B, McKay AJ, Majeed A. Clinical impact of lifestyle interventions for the prevention of diabetes: an overview of systematic reviews. *BMJ Open*. 2016 21;6(12):e013806; DOI; 10.1136/bmjopen-2016-013806.

31. International Diabetes Federation. *IDF Diabetes Atlas, 8th edition.* Brussels; 2017.

32. Bergman M, Manco M, Sesti G, Dankner R, Pareek M, Jagannathan R, et al. Petition to replace current OGTT criteria for diagnosing prediabetes with the 1-hour post-load plasma glucose ≥ 155 mg/dl (8.6 mmol/L). *Diabetes Res Clin Pract.* 2018 Dec;146:18–33; DOI:10.1016/j.diabres.2018.09.017.

33. Diagnostic criteria and classification of hyperglycaemia first detected in pregnancy: a World Health Organization Guideline. *Diabetes Res Clin Pract.* 2014 Mar;103(3):341–63.

34. Hod M, Kapur A, Sacks DA, Hadar E, Agarwal M, Di Renzo GC, et al. The International Federation of Gynecology and Obstetrics (FIGO) Initiative on gestational diabetes mellitus: A pragmatic guide for diagnosis, management, and care. *Int J Gynaecol Obstet*. 2015 Oct;131 Suppl 3:S173-211; DOI:10.1016/S0020-7292(15)30007-2.

35. Immanuel J, Simmons D. Screening and treatment for early-onset gestational diabetes aellitus: a systematic review and meta-analysis. *Curr Diab Rep*. 2017 Oct 2;17(11):115; DOI:10.1007/s11892-017-0943-7.

36. Guariguata L, Linnenkamp U, Beagley J, Whiting DR, Cho NH. Global estimates of the prevalence of hyperglycaemia in pregnancy. *Diabetes Res Clin Pract.* 2014 Feb;103(2):176–85; DOI:10.1016/j.diabres.2013.11.003.

37. American Diabetes Association. Diagnosis and classification of diabetes mellitus. *Diabetes Care*. 2014 Jan;37 Suppl 1:S81-90; DOI:10.2337/dc14-S081

38. International Association of Diabetes and Pregnancy Study Groups Consensus Panel, Metzger BE, Gabbe SG, Persson B, Buchanan TA, Catalano PA, et al. International association of diabetes and pregnancy study groups recommendations on the diagnosis and classification of hyperglycemia in pregnancy. *Diabetes Care.* 2010 Mar;33(3):676–82; DOI:10.2337/dc09-1848.

39. American Diabetes Association. Gestational diabetes mellitus. *Diabetes Care*. 2003 Jan 1;26(Supplement 1):S103–5; DOI:10.2337/diacare.26.2007.s103.

40. Nankervis A, McIntyre H, Moses R, Ross G, Callaway L, Porter C, et al. *ADIPS Consensus Guidelines for the Testing and Diagnosis of Hyperglycaemia in Pregnancy in Australia and New Zealand*. Society ADiP, editor; 2014.

41. Diabetes Canada Clinical Practice Guidelines Expert Committee, Feig DS, Berger H, Donovan L, Godbout A, Kader T, et al. Diabetes and pregnancy. *Canadian Journal of Diabetes*. 2018 Apr;42:S255–82; DOI:10.1016/j.jcjd.2017.10.038.

42. Seshiah V, Banerjee S, Balaji V, Muruganathan A, Das AK, Diabetes Consensus Group. Consensus evidence-based guidelines for management of gestational diabetes mellitus in India. *J Assoc Physicians India*. 2014 Jul;62(7 Suppl):55–62.

43. Lind T, Phillips PR. Influence of pregnancy on the 75-g OGTT. A prospective multicenter study. The Diabetic Pregnancy Study Group of the European Association for the Study of Diabetes. *Diabetes.* 1991 Dec;40 Suppl 2:8–13; DOI:10.2337/diab.40.2.s8.

44. Alberti KG, Zimmet PZ. Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1: diagnosis and classification of diabetes mellitus provisional report of a WHO consultation. *Diabet Med.* 1998 Jul;15(7):539–53; DOI:10.1002/(SICI)1096-9136(199807)15:7<539::AID-DIA668>3.0.CO;2-S.

45. National Institute for Health and Care Excellence. *Diabetes in pregnancy: management of diabetes and its complications from preconception to the postnatal period (NG3).* London; 2015.

46. Song C, Lyu Y, Li C, Liu P, Li J, Ma RC, et al. Long-term risk of diabetes in women at varying durations after gestational diabetes: a systematic review and meta-analysis with more than 2 million women. *Obes Rev.* 2018;19(3):421–9.

47. Bellamy L, Casas J-P, Hingorani AD, Williams D. Type 2 diabetes mellitus after gestational diabetes: a systematic review and meta-analysis. *Lancet.* 2009 May 23;373(9677):1773–9.

48. Fetita L-S, Sobngwi E, Serradas P, Calvo F, Gautier J-F. Consequences of fetal exposure to maternal diabetes in offspring. *J Clin Endocrinol Metab.* 2006 Oct;91(10):3718–24.

49. World Health Organization. *Classification of diabetes mellitus.* Geneva: World Health Organization; 2019. Available from: https://apps.who.int/iris/handle/10665/325182.

50. Murphy R, Ellard S, Hattersley AT. Clinical implications of a molecular genetic classification of monogenic beta-cell diabetes. *Nat Clin Pract Endocrinol Metab*. 2008 Apr;4(4):200–13.

51. Vaxillaire M, Bonnefond A, Froguel P. The lessons of early-onset monogenic diabetes for the understanding of diabetes pathogenesis. *Best Pract Res Clin Endocrinol Metab*. 2012 Apr;26(2):171–87.

52. Cnop M, Toivonen S, Igoillo-Esteve M, Salpea P. Endoplasmic reticulum stress and eIF2α phosphorylation: The Achilles heel of pancreatic β cells. *Mol Metab*. 2017;6(9):1024–39.

53. Flannick J, Johansson S, Njølstad PR. Common and rare forms of diabetes mellitus: towards a continuum of diabetes subtypes. *Nat Rev Endocrinol*. 2016;12(7):394–406.

2 METHODS

Narsimha Raju Dichpally from Hyderabad, India, carer for his father with type 2 diabetes

Key messages

255 data sources – mainly peer-reviewed published studies – from 138 countries were selected to estimate diabetes prevalence in the current *IDF Diabetes Atlas*.

Data from other sources, such as national reports, have also been included but only, as for the peer-reviewed publications, after rigorous scrutiny of their quality.

Data sources are from countries that account for over 93% of the global population.

Future projections have been calculated using the United Nations population predictions and degree of urbanisation. They do not, however, take into account any likely changes in overweight and obesity.

Chapter 2
Methods

Gathering and selecting data sources

The data used for the estimation of diabetes prevalence in this edition of the *IDF Diabetes Atlas* came from a variety of sources. The vast majority were extracted from peer-reviewed publications and national health surveys including the WHO STEPwise approach to surveillance (STEPS) studies, where appropriate.[1] Data from other official sources such as ministries of health and reports from health regulatory bodies were also used, providing there was sufficient information to assess their quality. Data sources with sufficient methodological information on key areas of interest, such as method of diagnosis, representativeness of the sample, and at least three age-specific estimates, were included. Data sources published before 1990 were excluded.

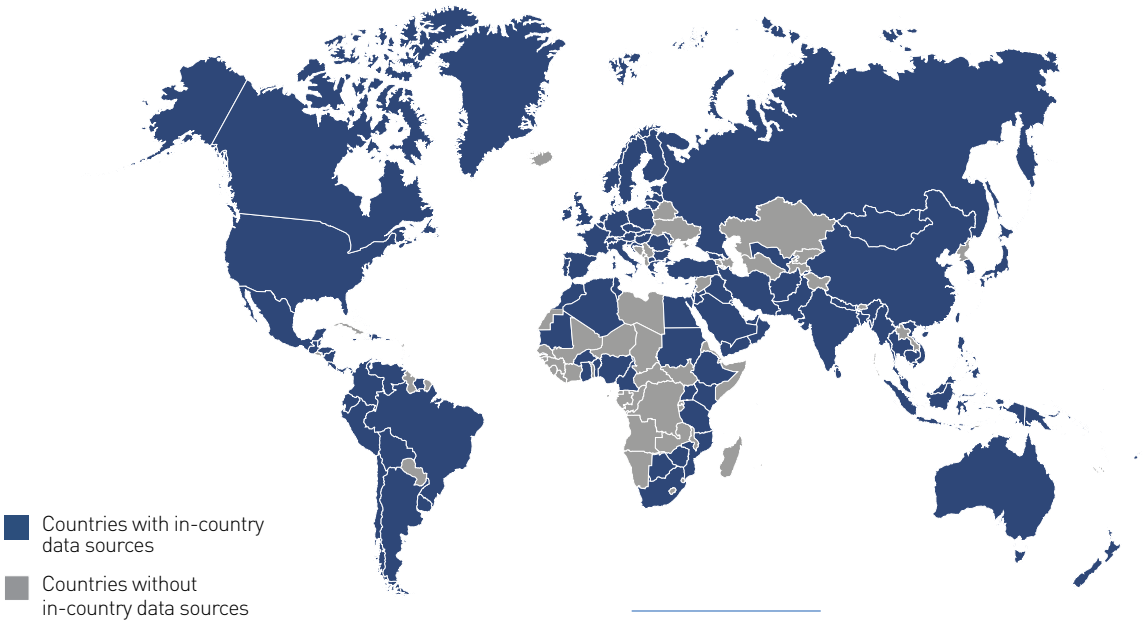
WHO STEPS studies that have been recently reported to present overestimated diabetes prevalence[2] were excluded from this edition of the *IDF Diabetes Atlas*. The excluded STEPS surveys are those for the following countries: Bermuda, Cambodia, Ethiopia, Mongolia, Rwanda and Togo.

Furthermore, territories that are not part of the current World Bank list of countries[a] were excluded. As a result, this edition presents data for 211 countries and territories compared to the previous edition, which had 221. The territories excluded are: Anguilla, Cook Islands, French Guiana, Guadeloupe, Martinique, Montserrat, Niue, Reunion, Tokelau and Western Sahara.

In addition, data sources published between January 2017 and December 2018 were screened and added to the existing database if they met the inclusion criteria mentioned below. This added 40 data sources from 31 countries to the existing database (Map 2.1).

To evaluate the quality of available data, each data source was scored, as in the previous *IDF Diabetes Atlas* editions, using an analytical hierarchy process (AHP)[3] taking into account the criteria mentioned in Figure 2.1. In this figure, the classification possibilities for each of the criteria are presented, arranged from the highest to the lowest degree of preference. In total, 255 out of 769 data sources (33.2%) met the rigorous inclusion criteria of this 9th edition.

Map 2.1 Countries and territories with data sources on diabetes



a World Bank Group. Countries and economies. Available from: https://data.worldbank.org/country.

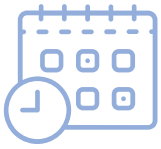
Figure 2.1 Classification of diabetes data sources

Method of diabetes diagnosis

- Oral glucose tolerance test (OGTT)
- Fasting blood glucose (FBG)
- Self-reported diabetes
- Medical record or clinical diagnosis
- Haemoglobin A1c (HbA1c)[i]

Sample size

- Equal to or greater than 5000 people
- 1500 to 4999 people
- 700 to 1499 people
- Less than 700 people



Age of the data source
(i.e. time since study conducted)

- Less than 5 years
- 5 to 9 years
- 10 to 19 years
- 20 or more years

Representativeness of study sample

- Nationally representative
- Regionally representative
- Locally representative
- Ethnic (or other) specific group representative

Type of publication

- Peer-reviewed publication
- National health survey
- Other official report or publication by a health regulatory body
- Unpublished study

i HbA1c is classified as least preferred because quality-assured HbA1c measurement is not available on a global scale.

The final score of a data source is the summary of all scores on the five criteria mentioned in Figure 2.1. Data sources that received a score over a certain threshold (agreed in consensus with members of the *IDF Diabetes Atlas* Committee) were used to generate the estimates and projections. Preference was given to data sources that were nationally representative, conducted in the past five years, published in peer-reviewed journals and were based on the objective measurement of diabetes status (rather than self-reporting).[b]

Estimating diabetes prevalence and projections for the future

After the selection of data sources, age- and sex-specific diabetes prevalence was estimated using a generalised linear regression model. If more than one data source was available for an individual country, the country level diabetes estimates were derived using an average of the data sources, weighted by the quality score of each data source based on the AHP scoring. Therefore, higher quality studies contribute more to the final country estimate than the studies with lower scores. The details of the generalised linear regression model are described in a previous publication[4] and any changes and developments of the methods are summarised more recently by Saeedi *et al*.[5]

For each country, the age- and sex-specific diabetes estimates were generated accounting for diabetes prevalence differences in urban and rural areas. This was achieved by updating urban to rural diabetes prevalence ratios according to the weighted average of the ratios reported in different data sources in the 19 economic regions (i.e. IDF Region and World Bank income classification). The number of data sources selected to estimate diabetes prevalence and projections was 255, emanating from 138 countries and territories.

The 2019 population data from the United Nations Population Division (UNPD)[6] were used in estimating the number of people with diabetes. In order to project diabetes estimates forward to the years 2030 and 2045, population projections for 2030 and 2045 from the UNPD were used. The 2030 and 2045 diabetes projections assume that diabetes prevalence does not change for each age group, but takes into account the changes in population age structure and degrees of urbanisation.[7] This is likely to underestimate diabetes prevalence as

b Data sources used in this edition can be found in the IDF Diabetes Atlas website (https://www.diabetesatlas.org).

it does not take into account changes in obesity and other risk factors that might result in a higher diabetes incidence. However, estimating diabetes projections for 2030 and 2045 in this way allows comparison with projections made, for the same years, in previous editions of the *IDF Diabetes Atlas*.

Any increase or decrease in diabetes prevalence in specific countries in this edition compared to the previous editions of the *IDF Diabetes Atlas* is usually the result of updates or changes in data sources, and may not be a complete or precise reflection of actual changes in diabetes prevalence occurring in that country.

Extrapolating data

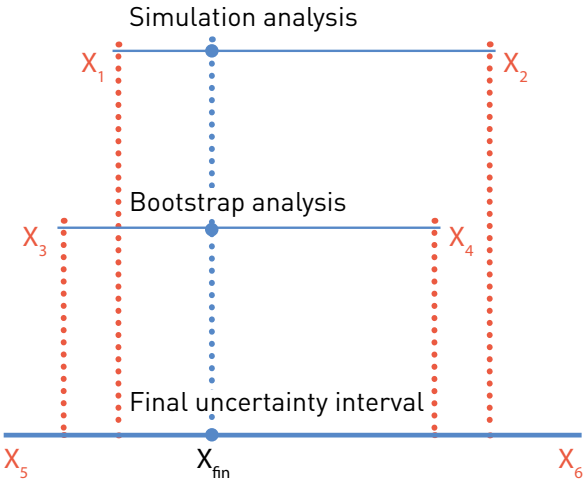
A significant number of countries (73 countries, 35%) do not have in-country data sources on diabetes prevalence that fulfil the *IDF Diabetes Atlas* inclusion criteria. Under such circumstances, estimates were generated by extrapolation using diabetes prevalence data from countries that are similar in terms of ethnicity,[8] language,[9] World Bank income classification[10] and geographical proximity. Naturally, extrapolated estimates are less reliable than estimates based on national data sources, and should therefore be interpreted with caution. Countries with extrapolated estimates are designated in the country summary table (Appendix) and Map 2.1. This data heterogeneity emphasises the importance of conducting high quality studies that help to address gaps in diabetes prevalence information.

Estimating confidence intervals

Confidence intervals are provided to indicate the degree of uncertainty around each of the estimates. In order to calculate these, two separate analyses were performed: a bootstrap analysis and a simulation study. These procedures are described more fully elsewhere.[5]

The confidence interval for each age group, sex and country was constructed based on the maximum and minimum values derived during both bootstrap and simulation analyses (Figure 2.2).

Figure 2.2 Bootstrap and simulation analysis



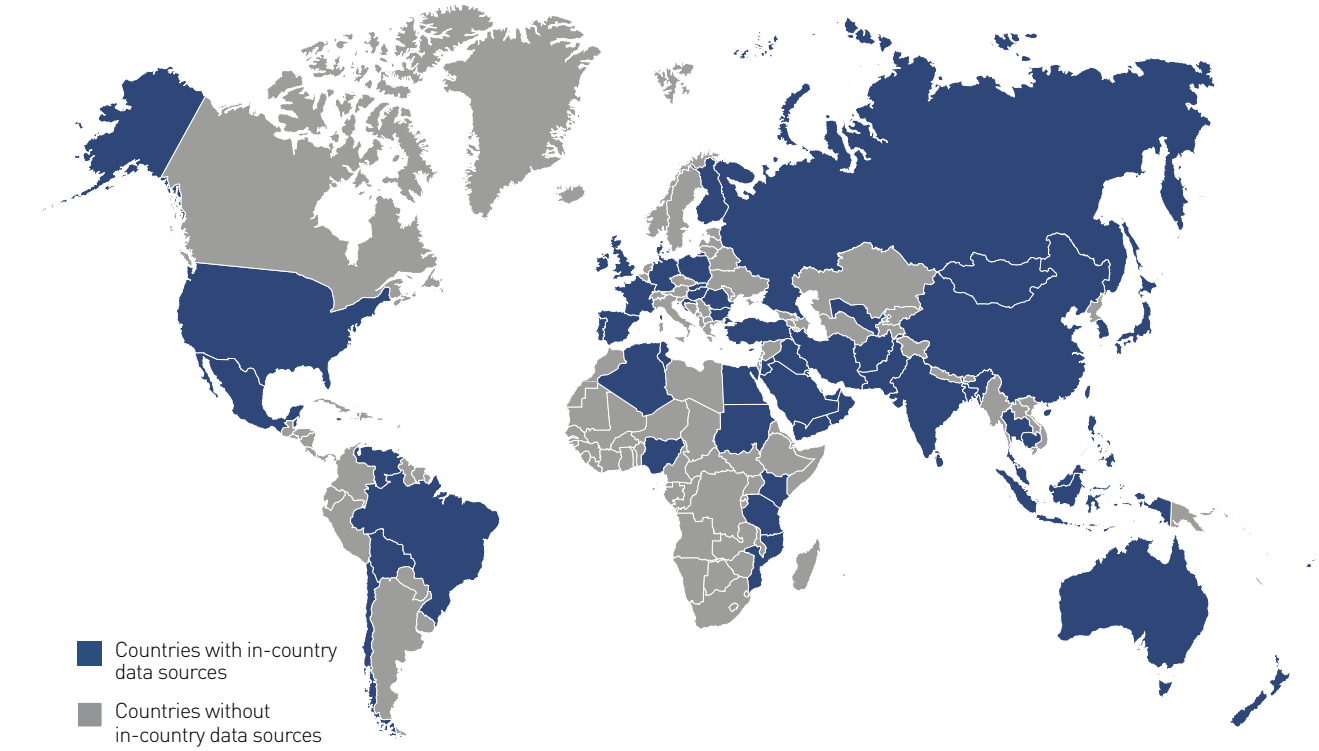
Age-adjusted comparative estimates

To compare diabetes prevalence between countries, age-adjusted comparative estimates were calculated. These were produced by standardising each country's 2019 prevalence estimate to the age structure of the world population.[11] This removed the effect of differences in age structure between countries, making this a suitable measure for comparisons. The age-adjusted comparative diabetes prevalence in 2030 and 2045 was calculated using the UN projected global age structures for 2030 and 2045, respectively.[6]

Estimating undiagnosed diabetes

The prevalence of undiagnosed diabetes can only be estimated from population-based studies that include testing of blood glucose or haemoglobin A1c (HbA1c). For countries with data sources on undiagnosed diabetes, the weighted average of the estimates from their data sources was calculated, where weights corresponded to the quality score of the respective studies. However, in countries without relevant in-country data sources, a random effect generalised linear regression model was used and prevalence of undiagnosed diabetes was calculated based on the estimates from countries with in-country data sources within the same IDF Region and World Bank income group (Map 2.2).

Map 2.2 **Countries and territories with data sources on the proportion of adults (20–79 years) with undiagnosed diabetes**



Estimating the incidence and prevalence of type 1 diabetes in children and adolescents

The incidence and prevalence estimates of type 1 diabetes in children and adolescents (0–14 and 0–19 years of age) were produced by researchers from Queen's University, Belfast.[12]

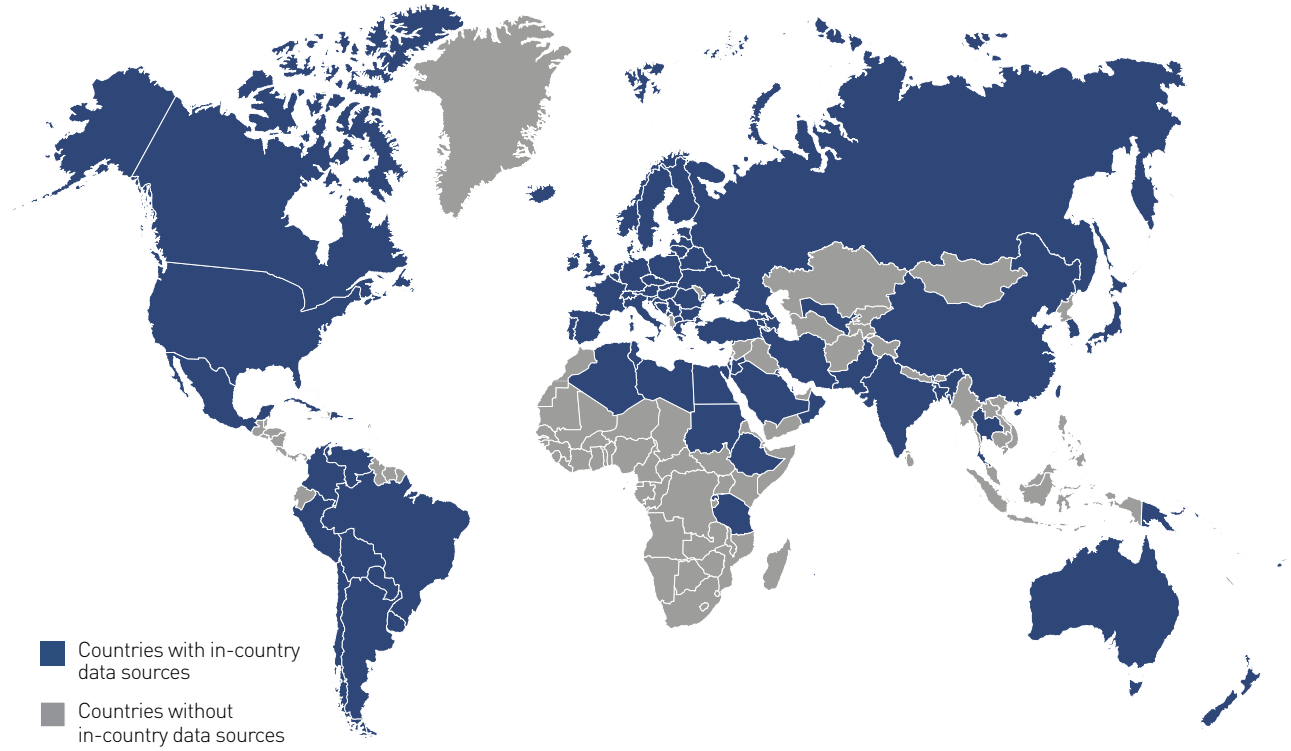
The scientific literature was searched, without language restrictions, for data sources that contained population-based studies on type 1 diabetes incidence (new cases each year) or prevalence (existing total cases) in children and adolescents aged up to 20 years. If more than one study was available for a country, the following criteria were applied to select the most suitable: recent; population-based studies; high (≥90%) ascertainment level; covering a large part of the country; providing age- and sex-specific rates; and including the age ranges 0–14 and 15–19 years. For some countries where two or more studies met these criteria to an equal extent, results were combined by averaging age- and sex-specific rates.

The 67 studies used in the analysis provided data for incidence rates in 94 countries (see Map 2.3).

If a country did not have any information available, the incidence rate for ages under 15 years was estimated using data from a similar country, based on geographical proximity, income and ethnicity. For ages 15–19 years, the incidence rate was estimated using the average regional ratio of incidence rates in the 15–19 years and 0–14 years age groups.

Prevalence estimates were then derived from these incidence rates and both were applied to UN population estimates for respective countries to obtain estimates of the numbers of incident and prevalent cases. However, particularly in low-income countries, there was a need to adjust prevalence estimates derived from the incidence rates to allow for case fatality. A mortality-adjusted prevalence was calculated for each country, based on a standardised mortality ratio for people with type 1 diabetes predicted from the country's infant mortality rate (IMR) and using a relationship derived in a systematic review of mortality studies in children with type 1 diabetes.[13] IMR data were obtained from the WHO Global Health Observatory

Map 2.3 **Countries and territories with data sources available on the incidence of type 1 diabetes in children and adolescents (0–19 years)**

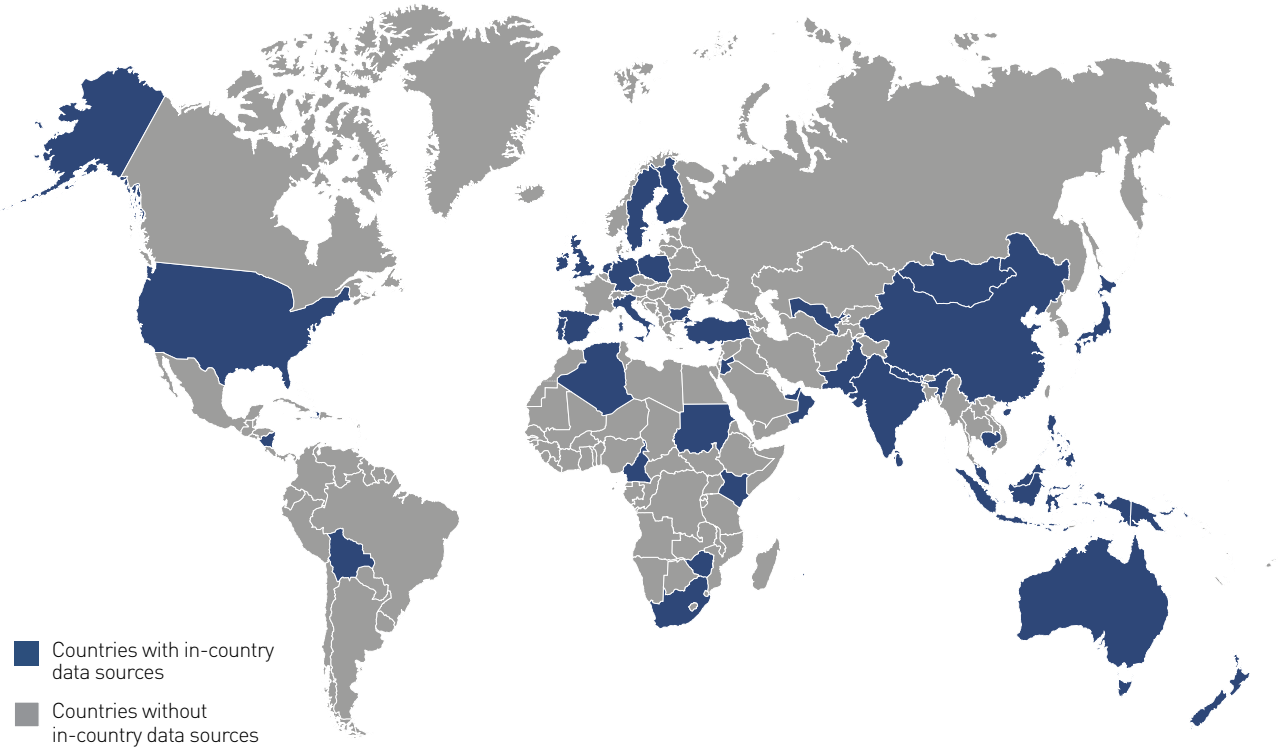


data repository.[14] For countries not included in the repository, the Central Intelligence Agency World Factbook,[15] UN country profile[16] or IndexMundi[17] were used.

Estimating the prevalence of impaired glucose tolerance

Data sources for impaired glucose tolerance (IGT) prevalence were identified 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 various data sources from 19 economic regions (i.e. IDF Region and World Bank income classification). A generalised linear regression model was used to estimate prevalence of IGT by country. The number of studies that satisfied the selection criteria was limited to 62 studies (from 49 countries). IGT prevalence estimates for the remaining countries were extrapolated from countries deemed to be similar, as for total diabetes prevalence (Map 2.4).

Map 2.4 **Countries and territories with data sources on impaired glucose tolerance in adults (20–79 years)**



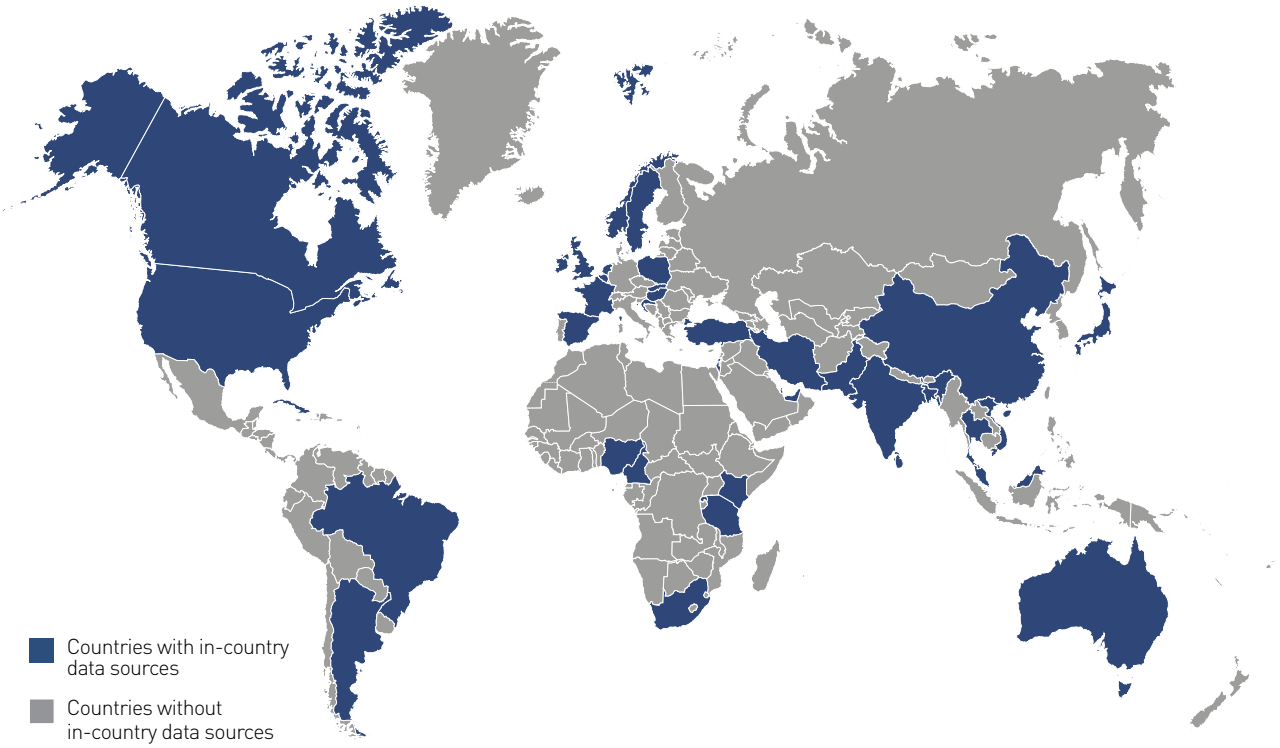
Estimating the prevalence of hyperglycaemia in pregnancy

Data sources reporting age-specific prevalence of gestational diabetes mellitus (GDM) and diabetes first detected in pregnancy were searched and selected according to the criteria described previously. UN fertility projections[6] and IDF estimates of diabetes were used to estimate the total percentage of live births affected by hyperglycaemia in pregnancy (HIP). The studies were scored according to the diagnostic criteria used, the year the study was carried out, study design, the representativeness of the sample and the screening approach. Studies over a certain threshold were then selected to calculate country level estimates. For this edition of the *IDF Diabetes Atlas*, 51 studies from 41 countries were used to estimate country-level, age-specific prevalence of HIP using a generalised linear regression model (Map 2.5). The detailed methods for estimation of HIP prevalence have been described previously.[18] HIP was also projected to 2030 and 2045 by carrying forward the 2019 HIP estimates against the UN population estimates, multiplied by the UN fertility rate.[19] To calculate projections for countries without HIP prevalence estimates, such countries were matched with those with available data sources from the most appropriate data region, i.e. based on ethnicity and World Bank income classification.

It should be noted that the method for selecting data sources has been updated for the 9th edition of the *IDF Diabetes Atlas*. Thus, any comparison of these prevalence estimates with those of previous editions must be viewed with caution. The changes in the selection of data sources include:

- IADPSG diagnostic criteria have been given more weight in this edition compared to previously.
- A new criterion, termed 'screening approach', has been added that includes the following options: universal one step, selective, 2+ steps, and selective 2+ steps.

Map 2.5 **Countries and territories with data sources on hyperglycaemia in pregnancy (adults 20–49 years)**



Estimating diabetes-related mortality

The total number of deaths attributable to diabetes by country was calculated by combining information on the number of annual deaths from all-causes stratified by age and sex,[20] age- and sex-specific mortality relative risks in people with diabetes compared to those without diabetes, and country-specific diabetes prevalence by age and sex for the year 2019. Relative risks attributable to diabetes are derived from cohort studies comparing death rates in those with and without diabetes.[21,22] This method of estimating diabetes-related mortality is described in more detail elsewhere.[23–25]

Estimating the economic impact of diabetes

The direct cost estimates in this edition of the *IDF Diabetes Atlas* were calculated using an attributable fraction method, which relies on the following inputs:

- *IDF Diabetes Atlas* estimates of diagnosed and undiagnosed diabetes prevalence (i.e. those produced for this edition), for each country and for each age and sex sub-group, stratified by rural and urban areas.
- UN population estimates for 2019 and UN population projections for 2030 and 2045.[6]
- WHO global health expenditures per capita for 2016 (latest available data) (distribution by age and sex imputed based on mortality rates).[26]
- The ratios of health expenditures 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 expenditure 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.[26] The same method was used as in the previous editions to distribute the total health expenditure in a given country into expenditure by age and sex.[27]

Another critical component of the above is the ratio 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.* (2017),[28] providing estimates for this ratio with much more specificity in relation to age, sex, rural versus urban areas, whether diabetes is diagnosed or not and income levels of countries by region. The expenditure estimates are presented in US dollars (USD) and, in the Country Summary Table (Appendix), for comparison between countries, in international dollars (ID).

The indirect costs of diabetes, which include loss of production resulting from labour-force drop out (from disability), mortality, absenteeism and presenteeism (reduced productivity when at work), have not been calculated *de novo* but estimates are given, in Chapter 3, based on the work of Bommer *et al*.[28]

References

1. World Health Organization. *STEPS: A framework for surveillance*. Geneva; 2003.
2. Lin S, Rocha VM, Taylor R. Artefactual inflation of type 2 diabetes prevalence in WHO STEP surveys. *Trop Med Int Health.* 2019;24(4):477–483; DOI:10.1111/tmi.13213.
3. Saaty TL. Relative measurement and its generalization in decision making why pairwise comparisons are central in mathematics for the measurement of intangible factors the analytic hierarchy/network process. *Revista de la Real Academia de Ciencias Exactas, Fisicas y Naturales Serie A Matematicas.* 2008 Sep;102(2):251–318; DOI:10.1007/bf03191825.
4. Guariguata L, Whiting D, Weil C, Unwin N. The International Diabetes Federation diabetes atlas methodology for estimating global and national prevalence of diabetes in adults. *Diabetes Res Clin Pract.* 2011 Dec;94(3):322–32; DOI:10.1016/j.diabres.2011.10.040.
5. Saeedi P, Petersohn I, Salpea P, Malanda B, Karuranga S, Unwin N, et al. Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: results from the International Diabetes Federation Diabetes Atlas, 9th edition. *Diabetes Res Clin Pract*; DOI:10.1016/j.diabres.2019.107843.
6. United Nations. *World population prospects (2017 revision).* New York; 2017.
7. United Nations. *World urbanization prospects (2018 revision).* New York; 2018.
8. Central Intelligence Agency. *World factbook: Ethnic groups.* Washington, DC; 2015.
9. Central Intelligence Agency. World factbook: Languages. Washington, DC; 2015.
10. The World Bank. *World Bank country and lending groups*. Washington, DC; 2015.
11. Ahmad OB, Boschi-Pinto C, Lopez AD, Murray CJ, Lozano R, Inoue M. *Age standardization of rates: a new WHO standard*. GPE Discussion Paper Series: No.31. EIP/GPE/EBD. Geneva: World Health Organization; 2001.
12. Patterson C, Karuranga S, Salpea P, Saeedi P, Dahlquist G, Soltesz G, et al. Worldwide estimates of incidence, prevalence and mortality of Type 1 diabetes in children and adolescents: results from the International Diabetes Federation Diabetes Atlas, 9th edition. *Diabetes Res Clin Pract* (in press); DOI:10.1016/j.diabres.2019.107842.
13. Morgan E, Cardwell CR, Black CJ, McCance DR, Patterson CC. Excess mortality in Type 1 diabetes diagnosed in childhood and adolescence: a systematic review of population-based cohorts. *Acta Diabetol.* 2015 Aug;52(4):801–7. DOI:10.1007/s00592-014-0702-z.
14. *Global Health Observatory data repository: life tables by country.* Geneva: World Health Organization; 2015. Available from: http://apps.who.int/gho/data/node.main.LIFECOUNTRY.
15. Central Intelligence Agency. *World factbook.* Washington, DC: Central Intelligence Agency; 2015. Available from: https://www.cia.gov/library/publications/the-world-factbook/
16. United Nations. UNdata Country Profile. United Nations; 2019. Available from: http://data.un.org/en/index.html.
17. IndexMundi – Country facts (2019). Available from: http://www.indexmundi.com
18. Linnenkamp U, Guariguata L, Beagley J, Whiting DR, Cho NH. The IDF Diabetes Atlas methodology for estimating global prevalence of hyperglycaemia in pregnancy. *Diabetes Res Clin Pract.* 2014 Feb;103(2):186–96. DOI:10.1016/j.diabres.2013.11.004.
19. Yuen L, Saeedi P, Riaz M, Karuranga S, Divakar H, Levitt N, et al. Projections of the prevalence of hyperglycaemia in pregnancy in 2019 and beyond: results from the International Diabetes Federation Diabetes Atlas, 9th edition. *Diabetes Res Clin Pract.* 2019; DOI:10:107841.
20. World Health Organization. *Global health estimates: 2016 summary tables.* Geneva; 2016. Available from: http://www.who.int/healthinfo/global_burden_disease/en/
21. Colagiuri S, Borch-Johnsen K, Glümer C, Vistisen D. There really is an epidemic of type 2 diabetes. *Diabetologia.* 2005;48(8):1459–63. DOI:10.1007/s00125-005-1843-y.
22. McEwen LN, Karter AJ, Curb JD, Marrero DG, Crosson JC, Herman WH. Temporal trends in recording of diabetes on death certificates: results from Translating Research Into Action for Diabetes (TRIAD). *Diabetes Care.* 2011 Jul;34(7):1529–33. DOI:10.2337/dc10-2312.
23. Saeedi P, Salpea P, Karuranga S, Petersohn I, Malanda B, Gregg EW, et al. Mortality attributable to diabetes in 20–79 year-old adults, 2019 estimates. *Diabetes Res Clin Pract.* 2019 (in press).
24. Roglic G, Unwin N. Mortality attributable to diabetes: estimates for the year 2010. *Diabetes Res Clin Pract.* 2010 Jan;87(1):15–9. DOI:10.1016/j.diabres.2009.10.006.
25. IDF Diabetes Atlas Group. Update of mortality attributable to diabetes for the IDF Diabetes Atlas: estimates for the year 2011. *Diabetes Res Clin Pract.* 2013 May;100(2):277–9. DOI:10.1016/j.diabres.2013.02.005.
26. World Health Organization. Global health expenditure database. Geneva; 2019. Available from: https://apps.who.int/nha/database.
27. Williams R, Karuranga S, Malanda B, Saeedi P, Basit A, Besancon S, et al. IDF Diabetes Atlas estimates of 2019 global health expenditures on diabetes. *Diabetes Res Clin Pract.* 2019 (in press).
28. Bommer C, Heesemann E, Sagalova V, Manne-Goehler J, Atun R, Bärnighausen T, et al. The global economic burden of diabetes in adults aged 20-79 years: a cost-of-illness study. *Lancet Diabetes Endocrinol.* 2017;5(6):423–30. DOI:10.1016/S2213-8587(17)30097-9.

3 GLOBAL PICTURE

Erum Ghafoor from Karachi, Pakistan, living with type 2 diabetes and consultant diabetes educator

Key messages

An estimated 463 million adults aged 20–79 years are currently living with diabetes. This represents 9.3% of the world's population in this age group. The total number is predicted to rise to 578 million (10.2%) by 2030 and to 700 million (10.9%) by 2045.

The estimated number of adults aged 20–79 years with impaired glucose tolerance is 374 million (7.5% of the world population in this age group). This is predicted to rise to 454 million (8.0%) by 2030 and 548 million (8.6%) by 2045.

An estimated 1.1 million children and adolescents (aged under 20 years) have type 1 diabetes. It is currently not possible to estimate the number of children and adolescents with type 2 diabetes.

The number of deaths resulting from diabetes and its complications in 2019 is estimated to be 4.2 million.

An estimated 15.8% (20.4 million) of live births are affected by hyperglycaemia in pregnancy in 2019.

Annual global health expenditure on diabetes is estimated to be USD 760 billion. It is projected that expenditure will reach USD 825 billion by 2030 and USD 845 billion by 2045.

Chapter 3
Global picture

In this 9th edition of the *IDF Diabetes Atlas*, the prevalence of diabetes is estimated for the year 2019 and projected to the years 2030 and 2045. The diabetes estimates are for adults aged 20–79 years, and include both type 1 and type 2 diabetes, diagnosed and undiagnosed.

An estimated 463.0 million adults aged 20–79 years worldwide (9.3% of all adults in this age group) have diabetes (Map 3.1, Map 3.2). It is estimated that 79.4% live in low- and middle-income countries. Based on the 2019 estimates, by 2030 a projected 578.4 million, and by 2045, 700.2 million adults aged 20–79 years, will be living with diabetes.

Map 3.1 Estimated total number of adults (20–79 years) with diabetes in 2019

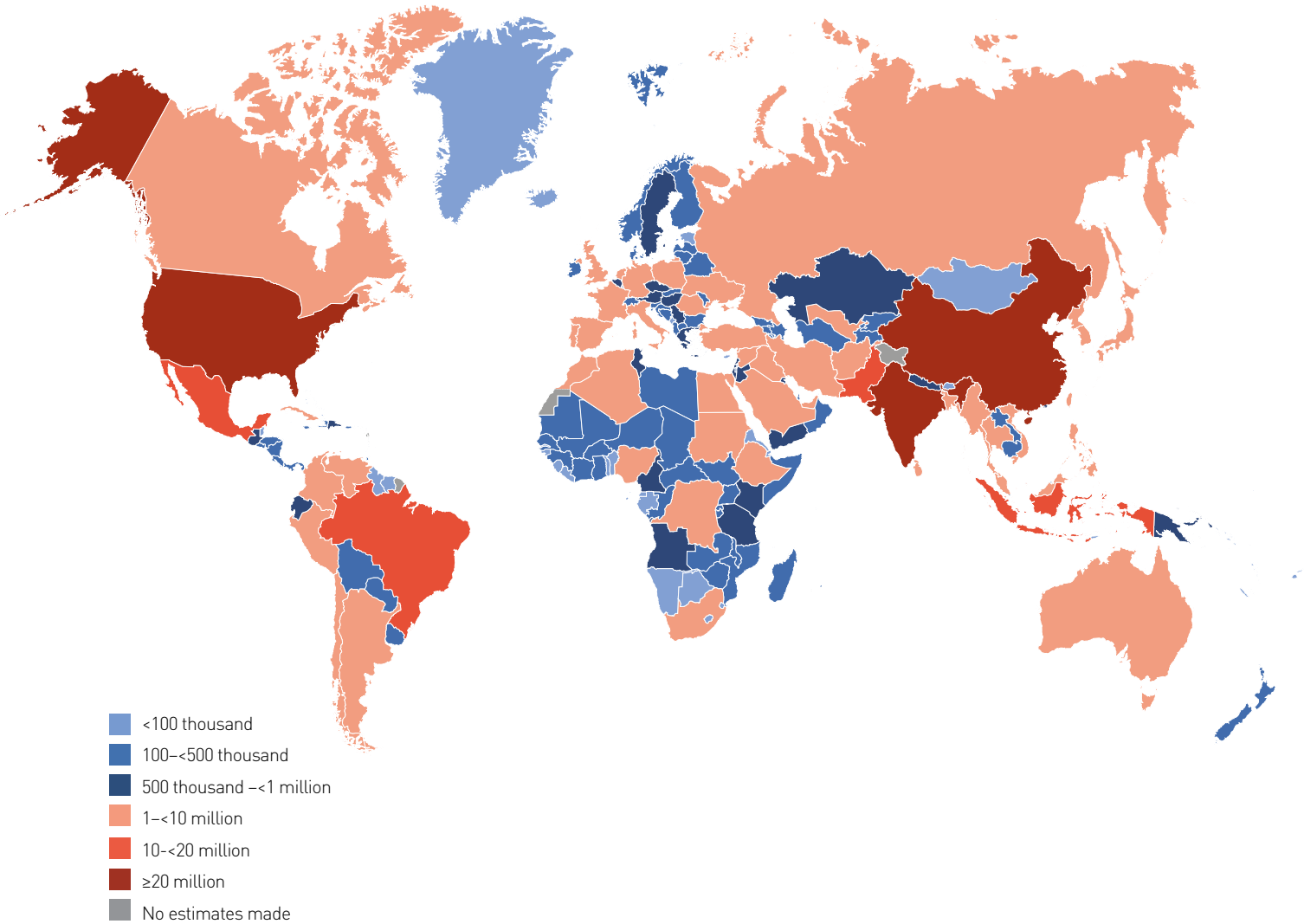


Table 3.1 **Global diabetes estimates and projections**

At a glance	2019	2030	2045
Total world population	7.7 billion	8.6 billion	9.5 billion
Adult population (20–79 years)	5.0 billion	5.7 billion	6.4 billion
Diabetes (20–79 years)			
Global Prevalence	9.3%	10.2%	10.9%
Number of people with diabetes	463.0 million	578.4 million	700.2 million
Number of deaths due to diabetes	4.2 million	-	-
Total health expenditures for diabetes[i]	USD 760.3 billion	USD 824.7 billion	USD 845.0 billion
Hyperglycaemia in pregnancy (20–49 years)			
Proportion of live births affected	15.8%	14.0%[ii]	13.3%[ii]
Number of live births affected	20.4 million	18.3 million	18.0 million
Impaired glucose tolerance (20–79 years)			
Global prevalence	7.5%	8.0%	8.6%
Number of people with impaired glucose tolerance	373.9 million	453.8 million	548.4 million
Type 1 diabetes (0–19 years)			
Number of children and adolescents with type 1 diabetes	1,110,100	-	-
Number of newly diagnosed cases each year	128,900	-	-

i Health expenditures for people with diabetes are assumed to be on average two-fold higher than people without diabetes.

ii Age-adjusted prevalence.

If current trends continue,

700 million adults will have diabetes by 2045.

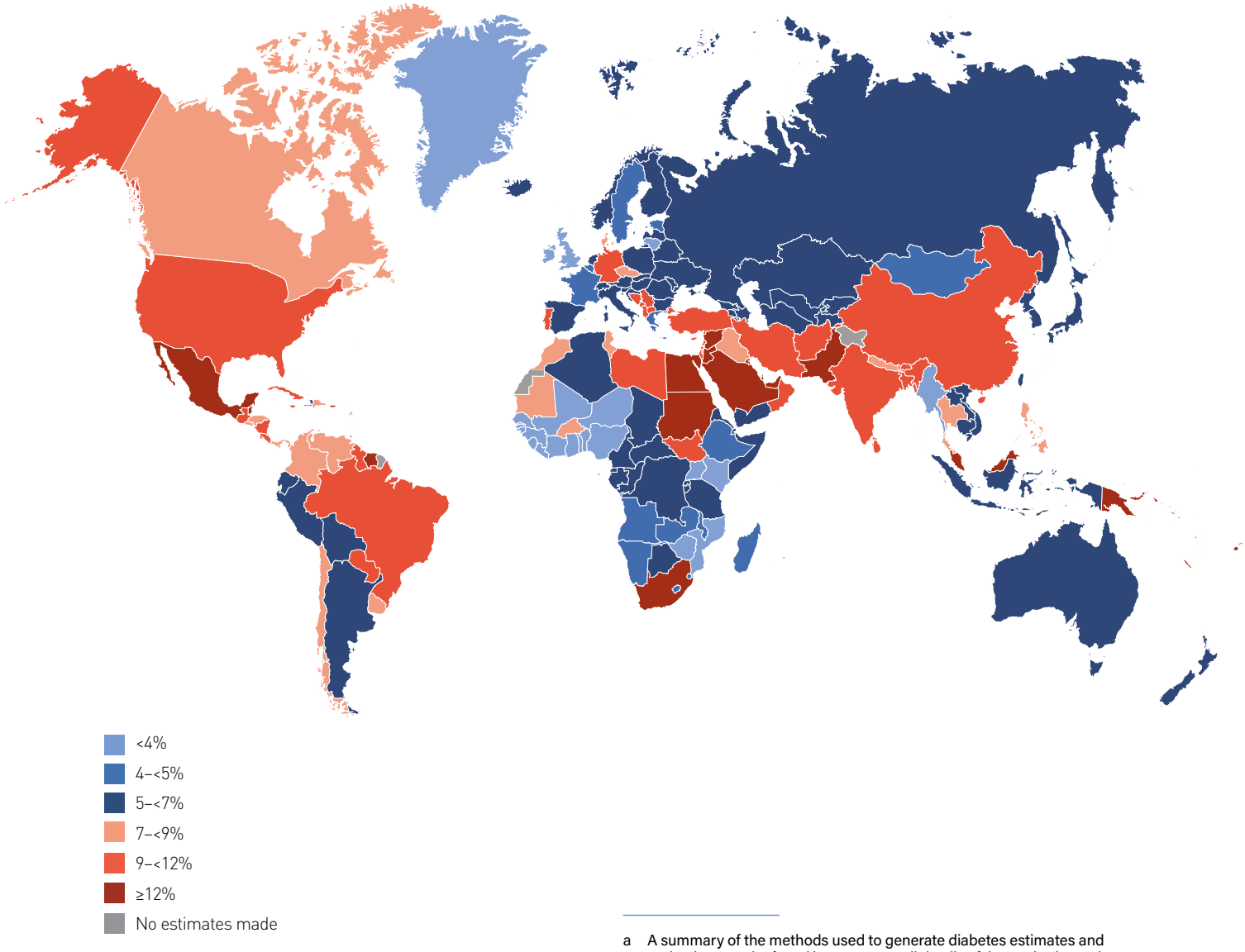
The largest increases will take place where economies are moving from low- to middle-income status.

Diabetes prevalence in 2019 and projections to 2030 and 2045 (20–79 years)

The estimates in this 9th edition of the *IDF Diabetes Atlas* are provided for 211 countries and territories, grouped into the seven IDF Regions: 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). In total 255 data sources from 138 countries were included in the analysis.[a]

There are currently 351.7 million people of working age (20–64 years) with diagnosed or undiagnosed diabetes in 2019. This number is expected to increase to 417.3 million by 2030 and to 486.1 million by 2045. The largest increase will take place in regions where economies are moving from low- to middle-income status (Table 3.2).

Map 3.2 **Estimated age-adjusted comparative prevalence of diabetes in adults (20–79 years) in 2019**



a A summary of the methods used to generate diabetes estimates and projections can be found in Chapter 2. Full details of the methods used, including how the data sources were evaluated and processed, can be found online (www.diabetesatlas.org) and in Saeedi *et al.*[1]

Table 3.2 **Number of adults (20–79 years) with diabetes per World Bank income classification in 2019, 2030 and 2045**

	2019		2030		2045	
World Bank income classification	**Prevalence of diabetes (%)**	**Number of people with diabetes (millions)**	**Prevalence of diabetes (%)**	**Number of people with diabetes (millions)**	**Prevalence of diabetes (%)**	**Number of people with diabetes (millions)**
High-income countries	10.4 (8.6–13.3)[i]	95.2 (78.7–120.9)	11.4 (9.4–14.3)	107.0 (88.3–134.4)	11.9 (9.8–14.8)	112.4 (92.2–139.2)
Middle-income countries	9.5 (7.6–12.3)	353.3 (280.1–455.3)	10.7 (8.4–13.7)	449.6 (353.0–576.7)	11.8 (9.0–15.0)	551.2 (422.7–705.2)
Low-income countries	4.0 (2.8–6.7)	14.5 (10.0–24.3)	4.3 (3.0–7.1)	21.9 (15.2–36.4)	4.7 (3.3–7.8)	36.5 (25.8–60.2)

i 95% confidence intervals are reported in brackets.

Age distribution

Diabetes estimates for 2019 show a typically increasing prevalence of diabetes by age. Similar trends are predicted for the years 2030 and 2045. Prevalence is lowest among adults aged 20–24 years (1.4% in 2019). Among adults aged 75–79 years diabetes prevalence is estimated to be 19.9% in 2019 and predicted to rise to 20.4% and 20.5% in 2030, and 2045, respectively (Figure 3.1).

Gender distribution

The estimated prevalence of diabetes in women aged 20–79 years is slightly lower than in men (9.0% vs 9.6%). In 2019, there are about 17.2 million more men than women living with diabetes. The prevalence of diabetes is expected to increase in both men and women by 2030 and 2045 (Table 3.3).

Figure 3.1 **Prevalence of diabetes by age group in adults (20–79 years) in 2019, 2030 and 2045**

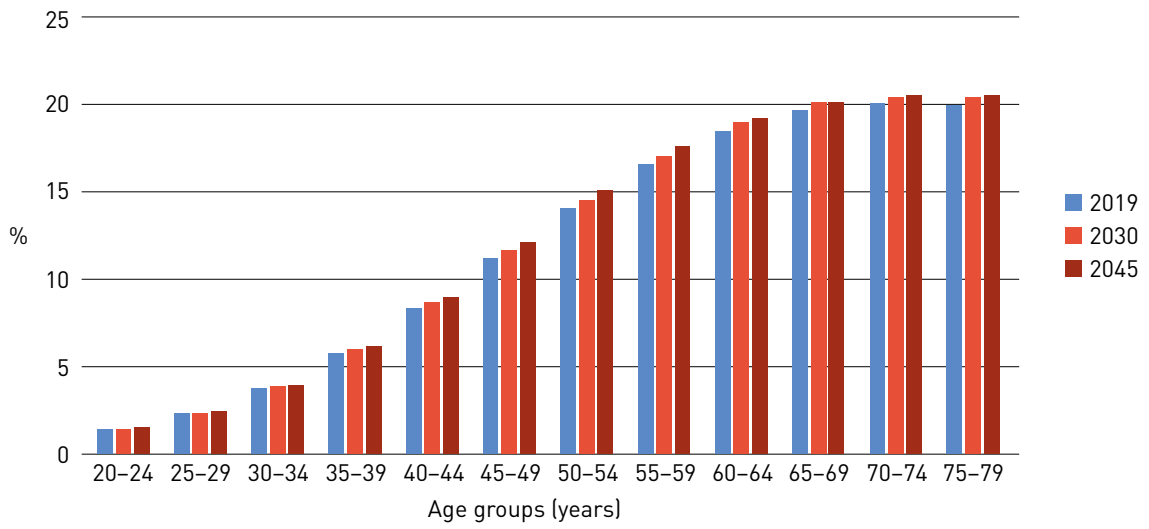


Table 3.3 **Number of men and women (20–79 years) with diabetes in 2019, 2030 and 2045**

	2019		2030		2045	
	Number of people with diabetes (millions)	**Prevalence (%)**	**Number of people with diabetes (millions)**	**Prevalence (%)**	**Number of people with diabetes (millions)**	**Prevalence (%)**
Men	240.1	9.6	296.7	10.4	357.7	11.1
Women	222.9	9.0	281.8	10.0	342.5	10.8

Urban and rural distribution

In 2019, more people with diabetes live in urban (310.3 million) than in rural (152.6 million) areas – the prevalence in urban areas being 10.8% and in rural areas 7.2%. The number of people with diabetes in urban areas is expected to increase to 415.4 million in 2030, and to 538.8 million in 2045 (Figure 3.2), as a result of global urbanisation. This equates to a prevalence of 11.9% in 2030 and 12.5% in 2045.

Regional distribution

As explained in Chapter 2, age-adjusted comparative prevalence estimates and projections have been used to make comparisons at IDF regional and country levels. The MENA Region has the highest age-adjusted comparative prevalence of diabetes in people aged 20–79 years in 2019, 2030 and 2045 (12.2%, 13.3% and 13.9% respectively). The AFR Region has the lowest age-adjusted comparative prevalence in 2019, 2030 and 2045 (4.7%, 5.1% and 5.2%), which can be attributed to lower levels of urbanisation, under-nutrition, and lower levels of overweight and obesity (Table 3.4).

Figure 3.2 **Number of people with diabetes (20–79 years) living in urban and rural areas in 2019, 2030 and 2045**

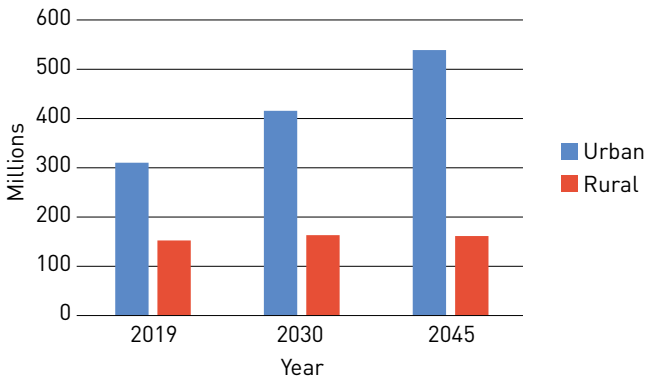


Table 3.4 **Prevalence of diabetes in adults (20–79 years) in IDF Regions in 2019, 2030 and 2045, ranked by 2019 age-adjusted comparative diabetes prevalence**

		2019		2030		2045	
Rank	IDF Region	Raw diabetes prevalence (%)	Age-adjusted comparative diabetes prevalence (%)	Raw diabetes prevalence (%)	Age-adjusted comparative diabetes prevalence (%)	Raw diabetes prevalence (%)	Age-adjusted comparative diabetes prevalence (%)
	World	9.3 (7.4–12.1)[i]	8.3 (6.2–11.8)	10.2 (8.1–13.2)	9.2 (6.8–12.9)	10.9 (8.4–14.1)	9.6 (7.1–13.4)
1	MENA	12.8 (7.2–17.6)	12.2 (8.3–16.1)	14.2 (8.1–19.5)	13.3 (9.1–17.6)	15.7 (8.8–21.5)	13.9 (9.5–18.3)
2	WP	9.6 (8.6–11.9)	11.4 (8.3–15.6)	11.0 (9.9–13.5)	12.4 (9.0–16.8)	11.8 (10.5–14.3)	12.8 (9.3–17.4)
3	SEA	8.8 (7.1–11.1)	11.3 (8.0–15.9)	9.7 (7.9–12.2)	12.2 (8.6–17.2)	11.3 (9.2–14.1)	12.6 (8.9–17.7)
4	NAC	13.3 (10.5–15.8)	11.1 (9.0–14.5)	14.2 (11.0–16.9)	12.3 (10.0–15.9)	15.0 (11.4–17.7)	13.0 (10.5–16.5)
5	SACA	9.4 (7.8–11.7)	8.5 (6.7–11.3)	10.6 (8.8–13.1)	9.5 (7.4–12.6)	11.8 (9.7–14.6)	9.9 (7.8–13.2)
6	EUR	8.9 (7.0–12.0)	6.3 (4.9–9.2)	9.8 (7.6–13.0)	7.3 (5.6–10.3)	10.3 (7.9–13.5)	7.8 (6.0–10.8)
7	AFR	3.9 (2.1–7.1)	4.7 (3.2–8.1)	4.1 (2.3–7.5)	5.1 (3.4–8.8)	4.4 (2.5–8.0)	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 95% confidence intervals are reported in parenthesis.

Country distribution

The countries with the largest numbers of adults with diabetes aged 20–79 years in 2019 are China, India and the United States of America, and are anticipated to remain so in 2030 (Table 3.5). It is projected that the number of adults with diabetes in Pakistan will exceed that in the United States of America, and will move to third place by 2045. The countries that have the highest number of people with diabetes do not, of course, necessarily have the highest prevalence. The highest age-adjusted comparative diabetes prevalence in 2019 are in the Marshall Islands (30.5%), Kiribati (22.5%) and Sudan (22.1%) (Table 3.6). Marshall Islands is expected to have the highest age-adjusted comparative diabetes prevalence in 2030 and 2045.

Table 3.5 **Top 10 countries or territories for number of adults (20–79 years) with diabetes in 2019, 2030 and 2045**

2019			2030			2045		
Rank	**Country or territory**	**Number of people with diabetes (millions)**	**Rank**	**Country or territory**	**Number of people with diabetes (millions)**	**Rank**	**Country or territory**	**Number of people with diabetes (millions)**
1	China	116.4 (108.6–145.7)[i]	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 (7.4–13.3)

i 95% confidence intervals are reported in brackets.

Table 3.6 **Top 10 countries or territories for age-adjusted comparative diabetes prevalence in adults (20–79 years) in 2019, 2030 and 2045**

2019			2030			2045		
Rank	**Country or territory**	**Age-adjusted comparative diabetes prevalence (%)**	**Rank**	**Country or territory**	**Age-adjusted comparative diabetes prevalence (%)**	**Rank**	**Country or territory**	**Age-adjusted comparative diabetes 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 95% confidence intervals are reported in brackets.

ii Countries without in-country data sources. Estimates are extrapolated.

Diabetes prevalence in 2019 and projections to 2030 and 2045 (65–99 years)

Diabetes prevalence increases with age so the highest estimated prevalence is in people older than 65 (Figure 3.1). In 2019, the estimated number of people with diabetes aged 65–99 years is 135.6 million (19.3%). If this trend continues, the number of people above 65 years (65–99 years) with diabetes will be 195.2 million in 2030 and 276.2 million in 2045 (Table 3.7). These data point to a significant increase in the diabetes population of the aging societies in the next 25 years and the inevitable public health and economic challenges this will bring.

Table 3.7 **Global diabetes estimates in people older than 65 years in 2019, 2030 and 2045**

	2019	2030	2045
Adult population (65–99 years)	704.4 million	995.2 million	1.4 billion
Prevalence (65–99 years)	19.3% (15.3–24.2%)[i]	19.6% (15.5–24.8%)	19.6% (15.2–25.4%)
Number of people older than 65 years with diabetes (65–99 years)	135.6 million (107.6–170.6)	195.2 million (154.7–247.1)	276.2 million (214.8–358.9)

i 95% confidence intervals are reported in brackets.

Regional distribution

There are significant regional differences in the prevalence of diabetes in people older than 65 years. The NAC Region has the highest prevalence in this age group and AFR the lowest. This is true for 2019, 2030 and 2045 (Table 3.8). The projected diabetes prevalence to 2045 in this age group does not forecast significant increases. For example, in the SACA Region the figures are 22.7% in 2019 and 23.1% in both 2030 and 2045, and in AFR 8.4% in 2019, 8.7% in 2030 and 8.4% in 2045.

Table 3.8 **Diabetes prevalence in people older than 65 years by IDF Region in 2019, 2030 and 2045**

		2019		2030		2045	
Rank	**IDF Region**	**Prevalence (%)**	**Number of people with diabetes (millions)**	**Prevalence (%)**	**Number of people with diabetes (millions)**	**Prevalence (%)**	**Number of people with diabetes (millions)**
1	NAC	27.0 (22.2–32.6)[i]	19.2 (15.7–23.1)	27.3 (22.4–33.0)	26. 9 (22.0–32.5)	27.5 (21.9–33.9)	34.0 (27.1–42.0)
2	MENA	24.2 (13.2–34.0)	8.4 (4.6–11.8)	24.7 (13.7–34.6)	13.7 (7.6–19.2)	25.2 (13.9–35.6)	25.2 (13.9–35.6)
3	SACA	22.7 (18.3–29.3)	10.3 (8.3–13.2)	23.1 (18.7–29.7)	15.7 (12.7–20.2)	23.1 (18.5–30.1)	24.0 (19.2–31.2)
4	EUR	20.1 (15.3–25.8)	31.0 (23.5–39.8)	20.2 (15.2–26.1)	38.8 (29.2–50.0)	20.5 (15.2–26.8)	46.3 (34.5–60.8)
5	WP	18.9 (16.7–22.1)	50.3 (44.4–58.9)	19.6 (17.2–23.1)	75.4 (66.4–89.1)	19.8 (17.3–23.9)	107.3 (93.5–129.6)
6	SEA	13.6 (10.1–18.6)	13.6 (10.1–18.6)	13.9 (10.3–19.1)	20.5 (15.3–28.2)	14.0 (10.4–19.7)	32.2 (24.0–45.1)
7	AFR	8.4 (3.0–15.5)	2.8 (1.0–5.1)	8.7 (3.1–16.2)	4.2 (1.5–7.8)	8.4 (3.1–16.8)	7.3 (2.7–14.6)

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 95% confidence intervals are reported in brackets.

Map 3.3 Number of people older than 65 years with diabetes in 2019

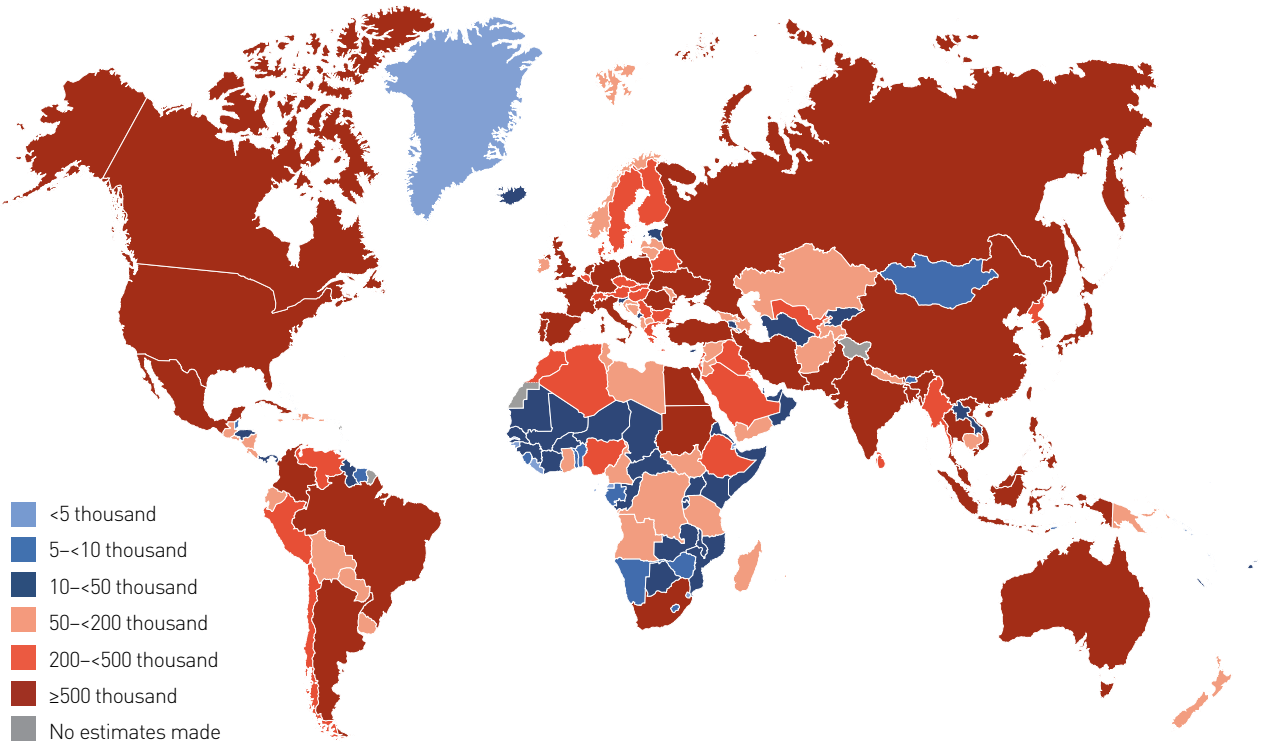


Table 3.9 Top 10 countries or territories for the number of people older than 65 years with diabetes in 2019, 2030 and 2045

2019			2030			2045		
Rank	**Country or territory**	**Number of people with diabetes (millions)**	**Rank**	**Country or territory**	**Number of people with diabetes (millions)**	**Rank**	**Country or territory**	**Number of people with diabetes (millions)**
1	China	35.5 (32.6–40.6)[i]	1	China	54.3 (49.7–62.6)	1	China	78.1 (70.9–92.3)
2	United States of America	14.6 (12.5–17.1)	2	United States of America	20.0 (17.1–23.4)	2	India	27.5 (20.6–38.6)
3	India	12.1 (9.0–16.4)	3	India	18.0 (13.5–24.7)	3	United States of America	23.2 (19.8–27.3)
4	Germany	6.3 (5.2–7.0)	4	Brazil	9.6 (8.6–10.9)	4	Brazil	14.9 (13.4–17.0)
5	Brazil	6.1 (5.5–6.9)	5	Germany	7.6 (6.3–8.5)	5	Germany	8.7 (7.2–9.8)
6	Japan	4.9 (4.0–5.7)	6	Japan	5.1 (4.1–6.0)	6	Mexico	7.7 (4.5–10.8)
7	Russian Federation	3.7 (2.2–4.3)	7	Russian Federation	4.6 (2.7–5.4)	7	Pakistan	6.4 (3.0–10.0)
8	Italy	2.9 (2.6–3.3)	8	Mexico	4.3 (2.5–5.9)	8	Japan	5.4 (4.4–6.5)
9	Mexico	2.7 (1.6–3.8)	9	Pakistan	3.8 (1.8–5.9)	9	Turkey	4.8 (3.3–6.4)
10	Pakistan	2.6 (1.2–3.9)	10	Italy	3.4 (3.1–3.9)	10	Indonesia	4.8 (4.2–5.5)

i 95% confidence intervals are reported in brackets.

Country distribution

Countries with the highest number of people older than 65 years with diabetes are China, the United States of America and India. The United States of America ranked higher than India in the number of people older than 65 years with diabetes for 2019 and 2030. However, trends predict that by 2045 India will exceed the United States of America in the number of people older than 65 years with diabetes (Map 3.3 and Table 3.9).

Undiagnosed diabetes

Available data sources on the prevalence of undiagnosed diabetes were 136, representing 73 countries. For countries with either low quality or no in-country data on undiagnosed diabetes (138 countries, 65.4%), the proportion of undiagnosed diabetes was extrapolated from countries within the same IDF Region and World Bank income group (see Chapter 2).

In 2019, one in two (50.1%), or 231.9 million of the 463 million adults living with diabetes, (overwhelmingly type 2 diabetes, aged 20–79 years) are unaware that they have the condition. These estimates point to an urgent need for prompt detection for improved global screening of diabetes. Early detection is of crucial importance; since prolonged undiagnosed diabetes can have negative effects, such as a higher risk of diabetes-related complications, increased healthcare use and related costs.[2]

Regional distribution

Undiagnosed diabetes has regional differences in its prevalence. The highest proportion of undiagnosed diabetes (59.7%) occurs in the AFR Region (Table 3.10). Geographical constraints, such as vast rural areas, limited resources and prioritisation of other health issues may contribute to this. The lowest proportion of undiagnosed diabetes is found in the NAC Region (37.8%).

Table 3.10 **Adults (20–79 years) with undiagnosed diabetes in IDF Regions in 2019, ranked by proportion undiagnosed**

Rank	IDF Region	Proportion undiagnosed (%)	Number of people with undiagnosed diabetes (millions)
	World	50.1	231.9 (186.4–300.3)[i]
1	AFR	59.7	11.6 (6.6–21.0)
2	SEA	56.7	49.6 (40.2–62.8)
3	WP	55.8	90.8 (81.9–113.1)
4	MENA	44.7	24.5 (13.7–33.4)
5	SACA	41.9	13.3 (11.1–16.3)
6	EUR	40.7	24.2 (18.8–32.4)
7	NAC	37.8	18.0 (14.1–21.3)

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 95% confidence intervals are reported in brackets.

Income group distribution

Due, no doubt, to limited access to healthcare services, low-income countries have the highest proportion of undiagnosed diabetes (66.8%). However, in high-income countries, the percentage of people unaware of their condition (38.3%) is also of concern (Table 3.11).

Country distribution

The number of people with undiagnosed diabetes varies by country (Map 3.4), with the countries with the greatest number of people with undiagnosed diabetes being the same as those with the highest number of people with diabetes: China (65.2 million); India (43.9 million); and the United States of America (11.8 million) (Table 3.12). However, globally, Mozambique has the greatest proportion of undiagnosed diabetes (86.7%), followed by the United Republic of Tanzania 79.8% and Tunisia 75.0%.

Table 3.11 Number of adults (20–79 years) with undiagnosed diabetes by World Bank income classification in 2019

World Bank income classification	Proportion undiagnosed (%)	Number of people with undiagnosed diabetes (millions)
High-income countries	38.3	36.4 (30.1–46.1)[i]
Middle-income countries	52.6	185.8 (149.6–238.1)
Low-income countries	66.8	9.7 (6.7–16.1)

i 95% confidence intervals are reported in brackets.

Map 3.4 Number of adults (20–79 years) with undiagnosed diabetes in 2019

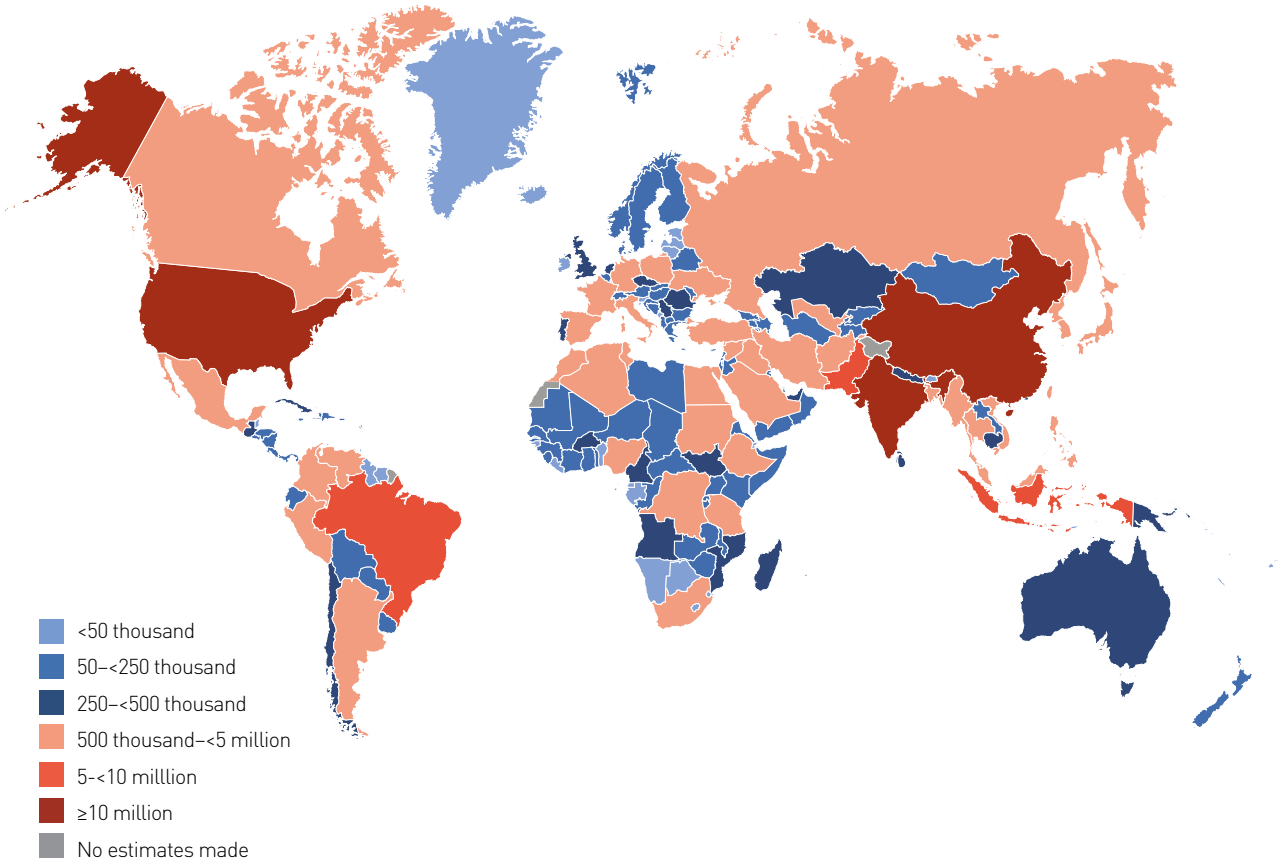


Table 3.12 **Top 10 countries or territories for the number of adults (20–79 years) with undiagnosed diabetes in 2019**

Rank	Country or territory	Number of people with undiagnosed diabetes (millions)	Proportion undiagnosed (%)
1	China	65.2 (60.8–81.6)[i]	56.0
2	India	43.9 (35.5–54.9)	57.0
3	United States of America	11.8 (10.2–13.6)	38.1
4	Pakistan	8.5 (3.5–13.3)	43.8
5	Indonesia	7.9 (6.8–8.5)	73.7
6	Brazil	7.7 (6.9–8.6)	46.0
7	Mexico	4.9 (2.8–5.9)	38.6
8	Egypt	4.8 (2.6–5.5)	54.4
9	Bangladesh	4.7 (3.9–6.0)	56.0
10	Germany	4.5 (3.7–5.0)	47.6

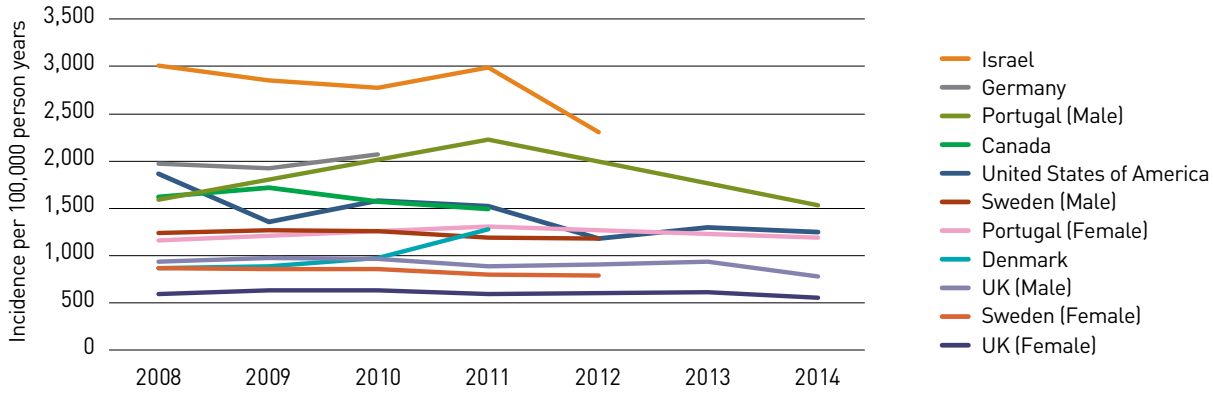
i 95% confidence intervals are reported in brackets.

Diabetes incidence

The *IDF Diabetes Atlas* tracks the global impact of diabetes using measures of diabetes prevalence and total numbers of people with diabetes. While this is certainly an important way of understanding the impact of diabetes, it has some limitations. For example, a rising prevalence is typically interpreted as being entirely due to increasing risk within the population and a failure to control factors such as obesity and poor diets. However, prevalence can also rise because people with diabetes are living longer as a result of improved care and also the general increasing life expectancy trends worldwide. This leads to each person staying longer in the 'pool' of people with diabetes, thus increasing prevalence. Therefore, it would be possible to see diabetes prevalence rising, even if obesity and other risk factors are declining, as long as the care of people with diabetes also improves.

In order to understand how a population's risk for diabetes is changing over time, it is necessary to assess the incidence of diabetes. The annual incidence, which measures the rate at which new cases of diabetes are occurring, is a much more direct indication of the risk for diabetes in the general population than prevalence. Unfortunately, incidence is more difficult to measure than prevalence, as it usually requires much larger studies. Nevertheless, in recent years, adequately sized studies, particularly those drawn from very large administrative databases (e.g. insurance claims databases or electronic medical records), have begun to report on changes in diabetes incidence over time. It is not yet possible to attempt country-by-country estimates of diabetes incidence, as there are far too few studies. However, a recent systematic review of studies reporting trends in the incidence of diabetes among adults has shown that between 2006 and 2014, 27% of reported populations had a stable incidence over time, while 36% reported a declining trend; only 36% reported an increasing trend in the incidence of diabetes (Figure 3.3).[3] This contrasts with earlier years during which an increasing trend in incidence was much more common. It also contrasts with diabetes prevalence data, as reported elsewhere in the *IDF Diabetes Atlas*, which has continued to show a rise in most countries.

Figure 3.3 **Trends in annual incidence of diabetes among adults aged 55–69 years, adapted from a systematic review[3]**



Studies reporting trends in the incidence of diabetes are almost entirely from high-income countries. This is not surprising, given the cost of the infrastructure needed to collect these data (large administrative databases or large annual health surveys). In such studies, it is difficult to determine accurately the type of diabetes, and these reports should be seen as reflecting type 1 and 2 diabetes combined. However, since the data come from adult populations, in which the incidence of type 2 diabetes is an order of magnitude higher than the incidence of type 1 diabetes, any trends can be reasonably attributed to type 2 diabetes.

These findings open an important new window onto the impact of diabetes. It is apparent that, at least in some high-income countries, there is evidence of falling incidence of diabetes, despite the inexorable rise in prevalence. It is not yet clear what is driving the observed falls in incidence. The data all apply to diagnosed diabetes, and so it is possible that changes in diabetes screening and diagnostic practice might be playing a part. The increasing use of HbA1c as a diagnostic test in recent years, rather than blood glucose, may have contributed, although the timing of declines in a number of countries do not quite match the gradual introduction of HbA1c from 2010. There may also have been a fall in screening rates, though a study from Israel reported increasing screening rates at the same time as incidence fell.[4] The possibility, therefore, remains that these reported falls in observed incidence reflect true reductions in incidence, and may point to some success in starting to curb the diabetes epidemic.

Diabetes incidence and prevalence in children and adolescents

The number of children and adolescents with diabetes is increasing every year. In populations of European origin, nearly all children and adolescents with diabetes have type 1 diabetes, but in other populations (e.g. Japan) type 2 diabetes is more common than type 1 diabetes in this age group.

It is estimated that the incidence of type 1 diabetes among children and adolescents is increasing in many countries particularly in those aged less than 15 years. The overall annual increase is estimated to be around 3% with strong indications of geographic differences.[5,6]

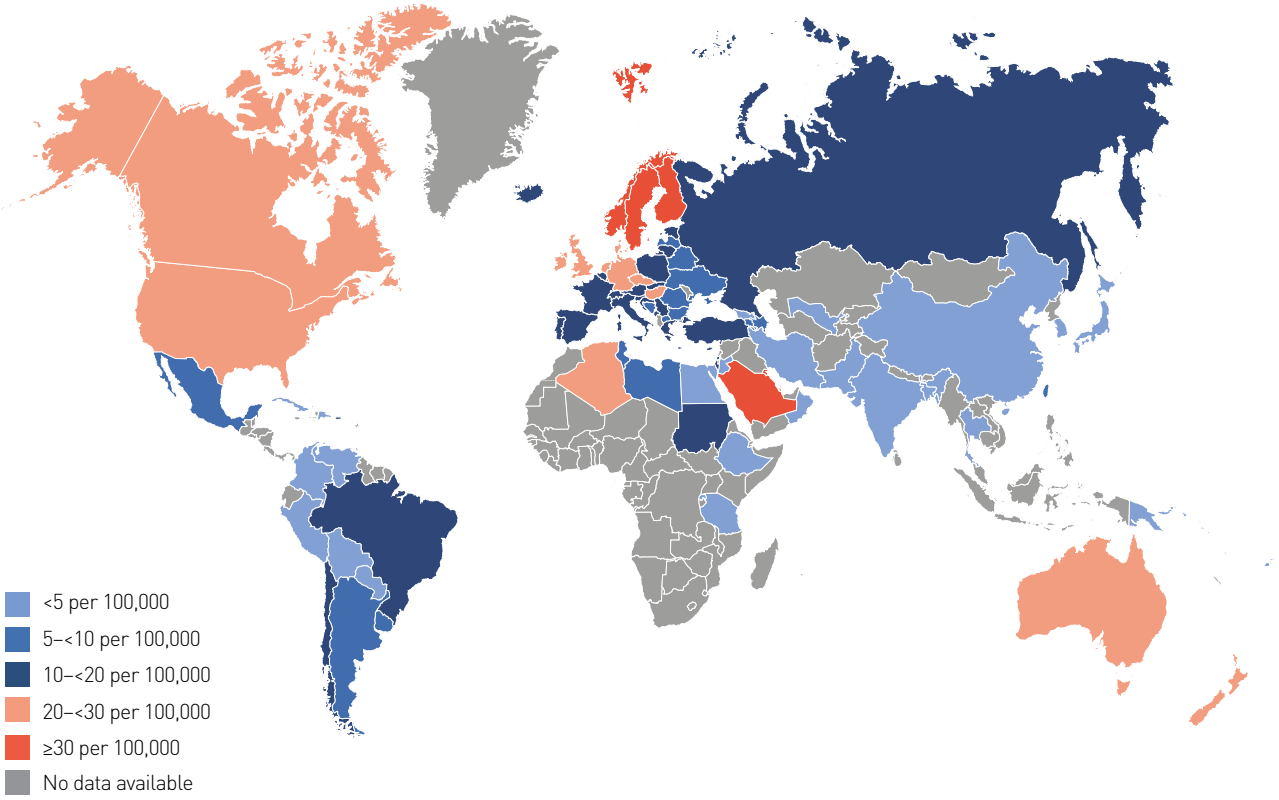
Table 3.13 **Global estimates for type 1 diabetes in children and adolescents (0–14 years and 0–19 years) in 2019**

Population (0–14 years)	1.98 billion
Population (0–19 years)	2.58 billion
Type 1 diabetes in children and adolescents (0–14 years)	
Number of prevalent (existing) cases of type 1 diabetes	600,900
Number of incident (new) cases of type 1 diabetes per year	98,200
Type 1 diabetes in children and adolescents (0–19 years)	
Number of prevalent (existing) cases of type 1 diabetes	1,110,100
Number of incident (new) cases of type 1 diabetes per year	128,900

In total, 1,110,100 children and adolescents younger than 20 years are estimated to have type 1 diabetes globally. It is estimated that around 98,200 children and adolescents under the age of 15 years are diagnosed with type 1 diabetes annually and this estimated number increases to 128,900 when the age range extends to under 20 years (Table 3.13).

There are more countries with data on type 1 diabetes incidence for the age group 0–14 and therefore the data presented here will focus on this age group. Map 3.5 shows the country-specific incidence rates (per 100,000) of type 1 diabetes in children and adolescents under the age of 15 years. In countries with limited access to insulin and inadequate health service provision, children and adolescents with type 1 diabetes, even when correctly diagnosed, face serious complications and consequently premature mortality.

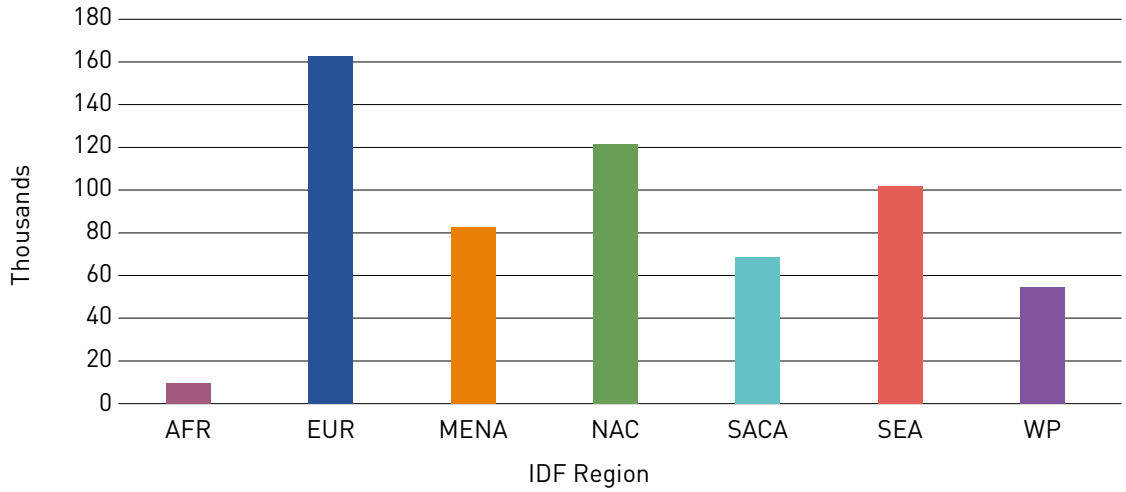
Map 3.5 **Age-sex standardised incidence rates (per 100,000 population per annum) of type 1 diabetes in children and adolescents aged 0–14 years**



There are considerable regional and national differences in the number of children and adolescents (0–14 years) with prevalent (existing) and incident (new) type 1 diabetes (Figures 3.4 and 3.5). The IDF EUR and NAC Regions have the largest estimated number of prevalent type 1 diabetes: 162,600 and 121,400, respectively. More than one quarter (27.0 %) of the world's total live in EUR, and one fifth (20.0%) in NAC (Figure 3.4).

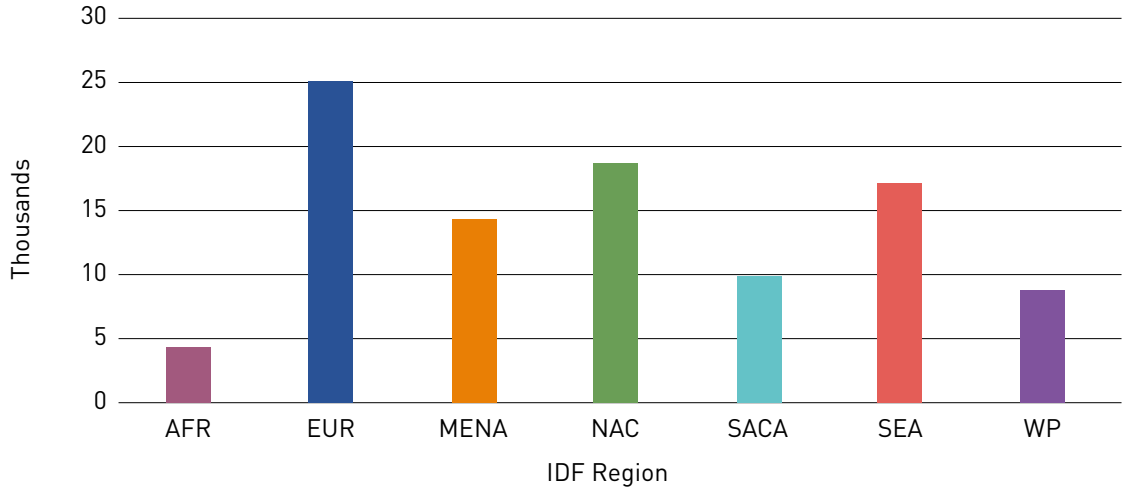
India, the United States of America and Brazil have the largest number of children and adolescents (0–14 years) with prevalent (existing) and incident (new) type 1 diabetes (Tables 3.14 and 3.15). In terms of incidence per 100,000 population per year, Finland (62.3), Sweden (43.2) and Kuwait (41.7) have the highest incidence rates of type 1 diabetes (0–14 years) (Table 3.16).

Figure 3.4 **Estimated number of children and adolescents (0–14 years) with prevalent (existing) type 1 diabetes by IDF Region in 2019 (adjusted for mortality)**



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.

Figure 3.5 **Estimated annual incident (new) cases of type 1 diabetes in children and adolescents (0–14 years) by IDF Region in 2019**



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.

Table 3.14 **Top 10 countries or territories for estimated number of incident (new) cases (incidence) of type 1 diabetes in children and adolescents (0–14 years), per annum**

Rank	Country or territory	Number of incident (new) cases (0–14 years) in thousands
1	India	15.9
2	United States of America	14.7
3	Brazil	7.3
4	China	4.8
5	United Kingdom	3.5
6	Russian Federation	3.2
7	Algeria	3.1
8	Germany	2.6
9	Saudi Arabia	2.5
10	Morocco[i]	2.4

i The figure for Morocco uses incidence rates extrapolated from Algeria.

Table 3.15 **Top 10 countries or territories for estimated number of prevalent (existing) children and adolescents with type 1 diabetes (0–14 years) in 2019**

Rank	Country or territory	Number of children and adolescents with type 1 diabetes (0–14 years) in thousands
1	India	95.6
2	United States of America	94.2
3	Brazil	51.5
4	China	28.7
5	Russian Federation	21.6
6	United Kingdom	21.2
7	Algeria	20.1
8	Germany	17.2
9	Morocco[i]	16.4
10	Mexico	14.8

i The figure for Morocco uses incidence rates extrapolated from Algeria.

Type 2 diabetes in children

There is evidence that type 2 diabetes in children and adolescents is increasing in some countries. However, reliable data are sparse.[7] As with type 1 diabetes, many children and adolescents with type 2 diabetes risk developing complications in early adulthood, which places a significant impact on the individual, the family and society. With increasing levels of obesity and physical inactivity among children and adolescents in many countries, type 2 diabetes in childhood and adolescence has the potential to become a global public health issue leading to serious adverse health outcomes.[8,9] More information about this aspect of the increase in diabetes prevalence is needed urgently.

Table 3.16 **Top 10 countries or territories for the incidence rates (per 100,000 population per annum) of type 1 diabetes in children (aged 0–14 years)**

Rank	Country or territory	Incidence rates (per 100,000 population per year) 0–14 years
1	Finland	62.3
2	Sweden	43.2
3	Kuwait	41.7
4	Norway	33.6
5	Saudi Arabia	31.4
6	Canada	29.9
7	United Kingdom	29.4
8	Qatar	28.4
9	Ireland	27.5
10	Denmark	27.0

Impaired glucose tolerance

In this edition of the *IDF Diabetes Atlas*, 62 studies from 49 countries were available for the estimation of the prevalence of impaired glucose tolerance (IGT). In 2019, 373.9 million adults aged 20–79 years worldwide, 7.5% of the adult population, are estimated to have IGT. The vast majority (72.2%) live in low- and middle-income countries. The number of adults aged 20–79 years with IGT is projected to increase to 453.8 million – or 8.0% of the adult population – by 2030 and to 548.4 million – or 8.6% of the adult population – by 2045 (Table 3.17).

Age distribution

Almost half (48.1%) of adults aged 20–79 years with IGT are under the age of 50 years (180.0 million) (Figures 3.6 and 3.7). This age group will continue to have the highest number of people with IGT in 2030 and 2045, rising to 204.1 million and to 231.8 million, respectively. It is important to note that nearly one-third (28.3%) of all those who currently have IGT are in the 20–39 years age group and are therefore likely to spend many years at risk of type 2 diabetes and of adverse cardiovascular diseases (CVD) outcomes.

Regional distribution

The NAC Region has the highest age-adjusted comparative prevalence of IGT (12.3%) in 2019, 2030 (13.2%) and 2045 (13.8%), while EUR Region has the lowest in 2019 (4.4%), 2030 (4.9%) and 2045 (5.1%) (Table 3.18).

Table 3.17 Number of adults (20–79 years) with impaired glucose tolerance, by World Bank income classification in 2019, 2030 and 2045

	2019		2030		2045	
World Bank income classification	**Prevalence of IGT (%)**	**Number of people with IGT (millions)**	**Prevalence of IGT (%)**	**Number of people with IGT (millions)**	**Prevalence of IGT (%)**	**Number of people with IGT (millions)**
High-income countries	11.4 (8.5–15.8)[i]	104.1 (77.7–144.0)	12.1 (9.1–16.5)	114.0 (85.3–155.4)	12.5 (9.3–17.0)	117.8 (87.7–159.7)
Middle-income countries	6.5 (4.1–11.0)	239.6 (151.2–407.9)	7.0 (4.5–11.9)	294.5 (189.0–498.4)	7.6 (4.9–12.8)	354.8 (228.7–598.4)
Low-income countries	8.3 (5.3–17.6)	30.2 (19.4–64.1)	8.8 (5.7–18.6)	45.3 (29.4–95.8)	9.8 (6.4–20.7)	75.8 (49.2–159.8)

IGT: impaired glucose tolerance.

i 95% confidence intervals are reported in brackets.

Figure 3.6 Number of adults (20–79 years) with impaired glucose tolerance by age group, in 2019, 2030 and 2045

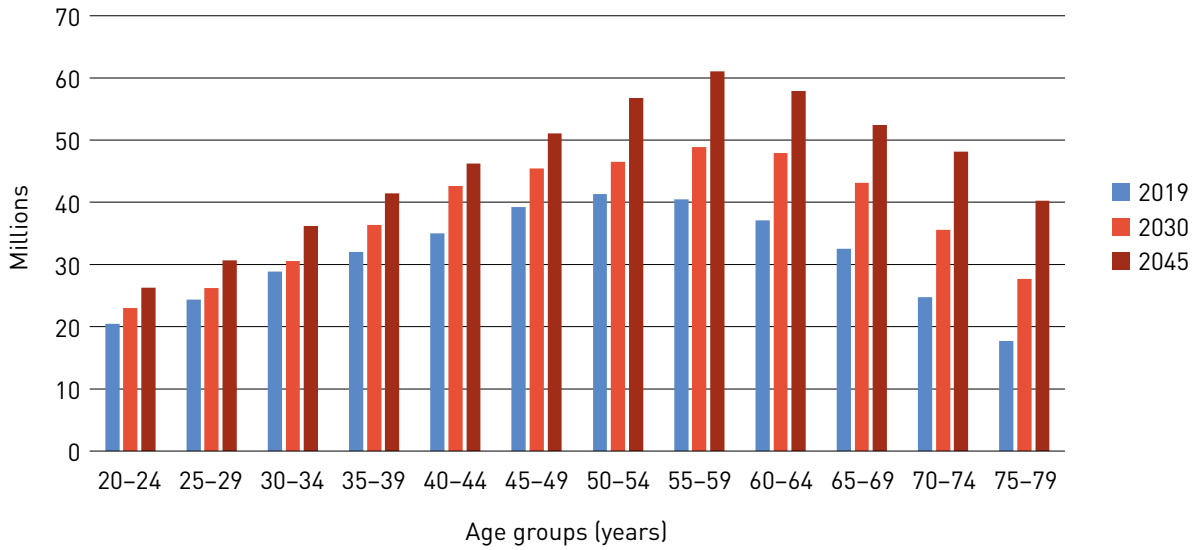


Figure 3.7 **Prevalence of impaired glucose tolerance in adults (20–79 years) by age and sex in 2019**

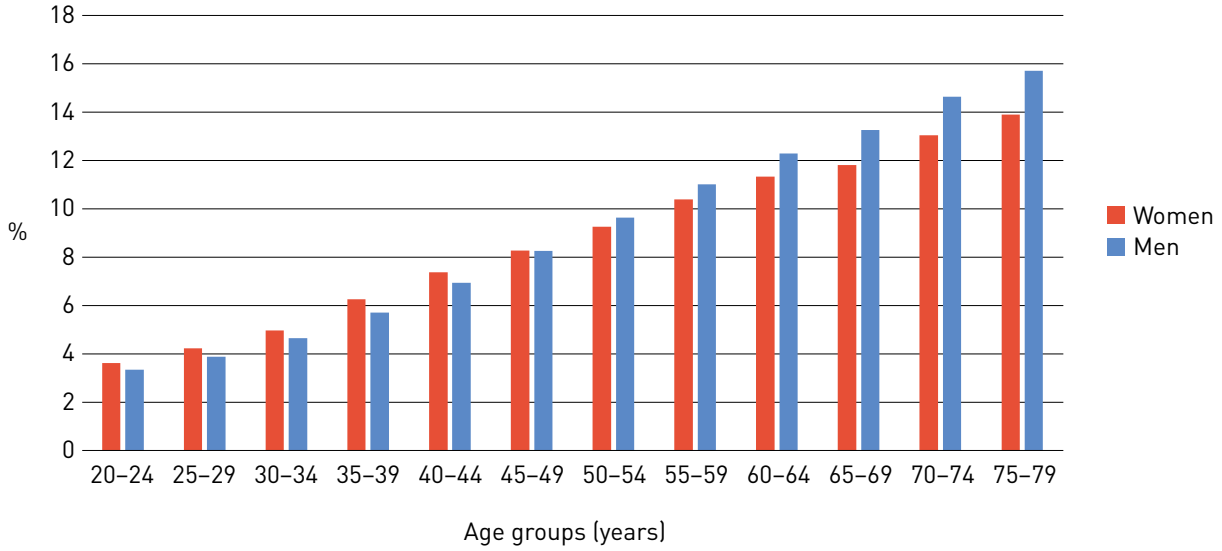


Table 3.18 **Age-adjusted comparative prevalence of impaired glucose tolerance in adults (20–79 years) in IDF Regions in 2019, 2030 and 2045, ranked by 2019 age-adjusted comparative prevalence estimates**

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

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 95% confidence intervals are reported in brackets.

Table 3.19 Top 10 countries or territories for the number of adults (20–79 years) with impaired glucose tolerance in 2019, 2030 and 2045

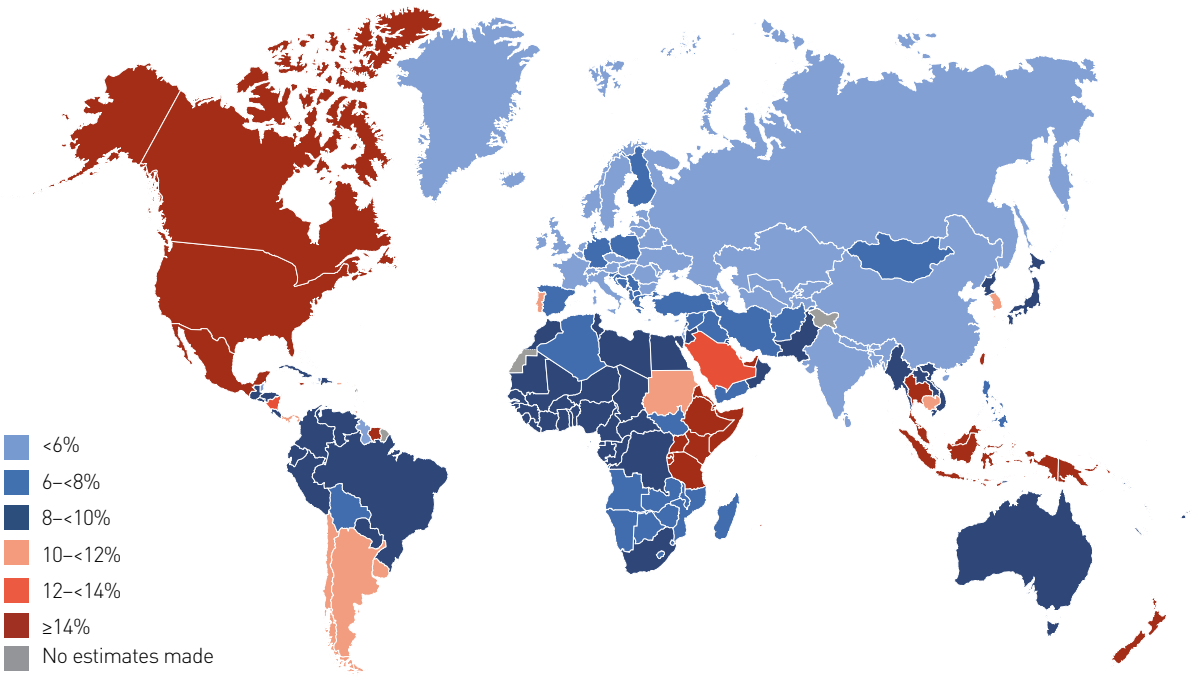
2019			2030			2045		
Rank	**Country or territory**	**Number of people with IGT (millions)**	**Rank**	**Country or territory**	**Number of people with IGT (millions)**	**Rank**	**Country or territory**	**Number of people with IGT (millions)**
1	China	54.5 (28.5–123.1)[i]	1	China	63.7 (33.1–143.2)	1	China	65.7 (32.5–148.5)
2	United States of America	37.4 (31.5–42.8)	2	United States of America	41.5 (35.0–47.6)	2	United States of America	43.3 (36.6–49.6)
3	Indonesia	29.1 (14.8–30.2)	3	Indonesia	32.8 (18.5–34.4)	3	India	40.7 (31.3–77.9)
4	India	25.2 (19.3–50.6)	4	India	32.2 (24.6–62.9)	4	Indonesia	35.7 (22.2–37.7)
5	Brazil[ii]	15.1 (10.9–20.0)	5	Brazil[ii]	18.1 (13.2–23.9)	5	Mexico[ii]	20.7 (17.5–23.7)
6	Mexico[ii]	12.6 (10.7–14.4)	6	Mexico[ii]	16.3 (13.8–18.6)	6	Brazil[ii]	20.5 (15.2–26.7)
7	Japan	12.1 (10.4–15.4)	7	Pakistan	11.8 (6.1–16.6)	7	Nigeria[ii]	18.3 (7.2–42.6)
8	Pakistan	8.8 (4.4–12.5)	8	Nigeria[ii]	11.5 (4.6–27.3)	8	Pakistan	16.5 (8.6–23.3)
9	Thailand[ii]	8.3 (6.9–10.5)	9	Japan	11.4 (9.8–14.4)	9	Ethiopia[ii]	14.7 (11.6–31.1)
10	Nigeria[ii]	8.2 (3.2–19.5)	10	Thailand[ii]	8.9 (7.4–11.3)	10	Japan	10.5 (9.0–13.2)

IGT: impaired glucose tolerance.

i 95% confidence intervals are reported in brackets.

ii Estimates are extrapolated from similar countries.

Map 3.6 Age-adjusted comparative prevalence of impaired glucose tolerance in adults (20–79 years) in 2019



Country distribution

The countries with the highest number of people in the age group 20–79 years with IGT in 2019 are China (54.5 million), United States of America (37.4 million) and Indonesia (29.1 million). It is projected that, by 2045, India will exceed Indonesia and it will be third in terms of the number of people aged 20–79 years with IGT (Table 3.19).

In 2019, Papua New Guinea (29.2%), Indonesia (17.8%) and New Zealand (17.5%) have the highest age-adjusted comparative prevalence of IGT. In addition, Bulgaria (1.3%), Ireland (1.2%) and the Faroe Islands (1.1%) are countries with the lowest age-adjusted comparative prevalence of IGT (Map 3.6).

Hyperglycaemia in pregnancy

A total number of 51 studies on hyperglycaemia in pregnancy (HIP), representing 41 countries, were included in the analysis. It is estimated that 20.4 million or 15.8% of live births to women in 2019 had some form of hyperglycaemia in pregnancy. Of which, 83.6% were due to gestational diabetes mellitus (GDM), while 7.9% were the result of diabetes detected prior to pregnancy, and 8.5% due to diabetes (including type 1 and type 2) first detected in pregnancy (Table 3.20). Differences in these results compared to earlier editions of the *IDF Diabetes Atlas* are partly due to substantial changes in the methods used in selecting studies. More information on the methods can be found in Chapter 2. It is projected that in 2030 and 2045, 18.3 million and 18.0 million of live births will be affected by HIP, respectively.

There are some regional differences in the prevalence of HIP, with the SEA Region having the highest age-adjusted comparative prevalence at 27.0% compared to 7.5% in the MENA Region. These differences are also projected for the years 2030 and 2045 (Table 3.21). The vast majority (86.8%) of cases of HIP are seen in low- and middle-income countries, where access to antenatal care is often limited.

Prevalence of HIP, as a proportion of all pregnancies, increases rapidly with age, with the highest prevalence (37.0%) in 45–49 year-old women, although there are fewer pregnancies in this age group. Of course, this age group also has a higher prevalence of diabetes generally. As a result of higher fertility rates in younger women, half (50.1%) of all cases of HIP (10.2 million) occur in women under the age of 30 years (Figure 3.8).

Table 3.20 **Global estimates of hyperglycaemia in pregnancy in 2019**

Total live births to women (20–49 years)	129.5 million
Hyperglycaemia in pregnancy	
Global prevalence	15.8%
Number of live births affected	20.4 million
Proportion of cases due to gestational diabetes mellitus	83.6%
Proportion of cases due to other types of diabetes first detected in pregnancy	8.5%
Proportion of cases due to diabetes detected prior to pregnancy	7.9%

Figure 3.8 **Prevalence of hyperglycaemia in pregnancy by age group in 2019**

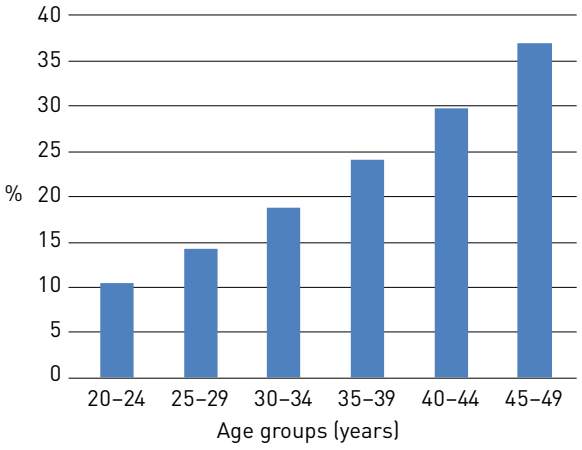


Table 3.21 **Hyperglycaemia in pregnancy in women (20–49 years) by IDF Region in 2019, 2030 and 2045 , ranked by 2019 age-adjusted comparative prevalence estimates**

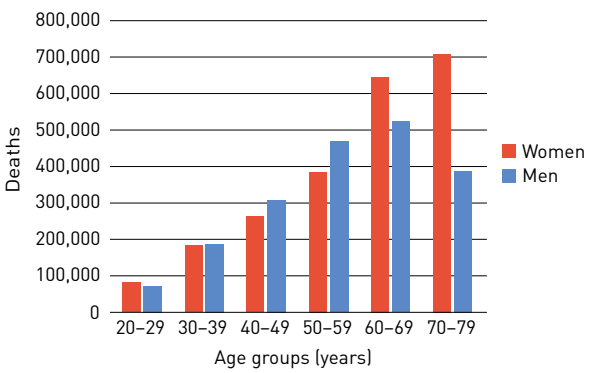
		2019		2030		2045	
Rank	IDF Region	Age-adjusted comparative prevalence (%), 2019	Number of live births affected (millions), 2019	Age-adjusted comparative prevalence (%), 2030	Number of live births affected (millions), 2030	Age-adjusted comparative prevalence (%), 2045	Number of live births affected (millions), 2045
	World	14.4	20.4	14.0	18.3	13.3	18.0
1	SEA	27.0	6.6	27.4	7.3	27.4	6.4
2	NAC	20.8	1.6	21.4	1.5	21.4	1.4
3	EUR	16.3	2.0	12.5	1.2	9.9	1.0
4	SACA	13.5	1.0	10.5	0.7	10.5	0.6
5	WP	12.3	3.8	10.2	2.6	10.2	2.5
6	AFR	9.6	3.5	10.3	4.0	10.4	4.9
7	MENA	7.5	1.9	6.2	1.0	6.2	1.1

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.

Diabetes-related mortality

Approximately 4.2 million adults aged 20–79 years are estimated to die as a result of diabetes and its complications in 2019. This is equivalent to one death every eight seconds. Diabetes is estimated to be associated with 11.3% of global deaths from all causes among people in this age group. Almost half (46.2%) of deaths associated with diabetes among the 20–79 years age group are in people under the age of 60 years – the working age group (Figure 3.9).

Figure 3.9 **Number of deaths due to diabetes in adults (20–79 years) by age and sex in 2019**



Globally, there are more deaths associated with diabetes in women (2.3 million) than in men (1.9 million).

Premature death and disability due to diabetes are also associated with a negative economic impact for countries, often called the 'indirect costs' of diabetes. In the United States of America, it is estimated that premature death cost USD 19.9 billion to the economy annually and a total USD 90 billion is indirectly lost due to diabetes.[10]

Regional distribution

The IDF Region with the highest estimated number of diabetes-related deaths in adults aged 20–79 years in 2019 is WP, where 1.3 million deaths attributable to diabetes occurred. This is followed by SEA with 1.2 million deaths. The IDF Region with the lowest number of diabetes-related deaths is SACA (0.2 million).

The highest estimated number of deaths attributable to diabetes under the age of 60 years (working age) occurred in SEA (0.6 million), while the AFR Region has the highest estimate of the proportion of diabetes-related deaths under the age of 60 years (73.1%) (Table 3.22). In the EUR Region, only 31.4% of deaths due to diabetes are estimated to occur under the age of 60 years.

Country distribution

Partly as a consequence of the age distribution of their populations, Mozambique (91.1%), Kenya (88.4%), Uganda (88.0%), Eswatini (87.7%) and Zimbabwe (86.4%) are the countries with the highest estimated proportion of deaths due to diabetes before the age of 60 years among adults aged 20–79 years. Japan (15.8%), North Macedonia (15.8%), Slovakia (17.3%), Serbia (17.7%), and Bulgaria (17.9%) are among the countries with the lowest proportion of deaths attributable to diabetes under the age of 60 years among adults aged 20–79 years (Map 3.7).

Table 3.22 Proportion and number of adults who died from diabetes before the age of 60 years in 2019, globally and by IDF Region, ranked by the proportion of deaths due to diabetes

IDF Region	Number of deaths due to diabetes before the age of 60 years (thousands)	Proportion of deaths due to diabetes occurring before the age of 60 years (%)
World	1,945.1 (1,528.7–2,525.3)[i]	46.2
AFR	267.6 (157.4–461.8)	73.1
MENA	223.3 (131.0–281.1)	53.3
SEA	592.3 (499.5–713.5)	51.5
NAC	132.7 (106.4–151.1)	44.0
SACA	105.8 (90.6–126.8)	43.5
WP	477.1 (428.3–590.7)	37.7
EUR	146.2 (115.5–200.3)	31.4

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 95% confidence intervals are reported in brackets..

Map 3.7 Proportion (%) of people who died from diabetes before the age of 60 years in countries around the world in 2019

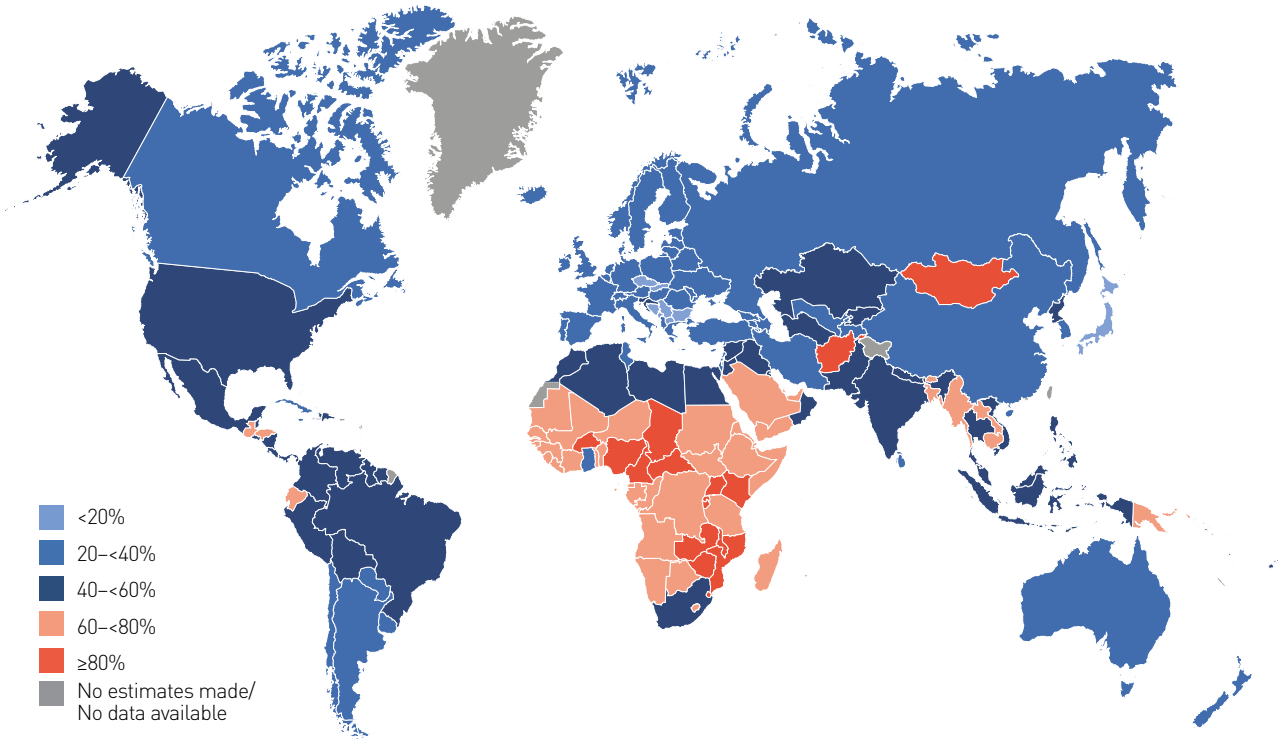
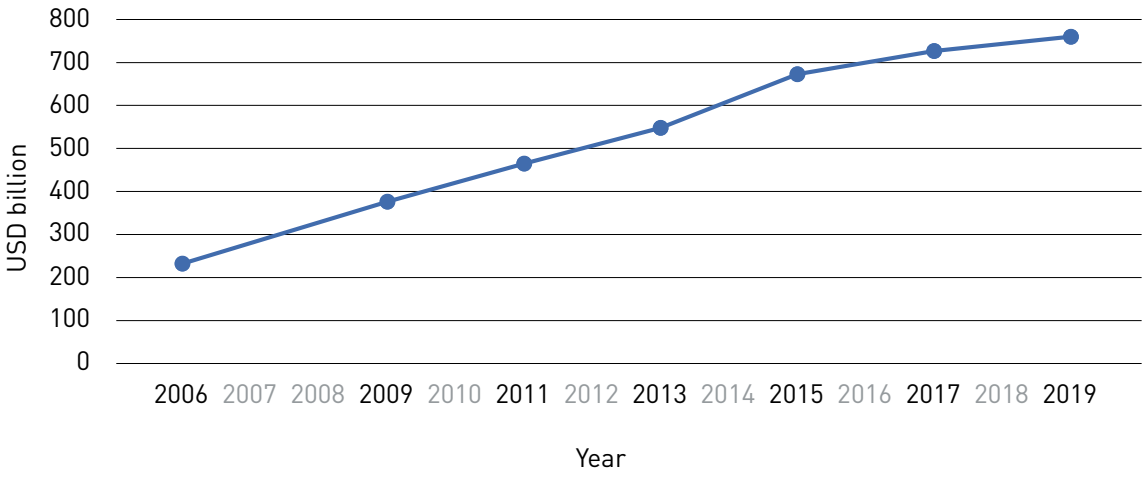


Figure 3.10 **Total diabetes-related health expenditure for adults (20–79 years) with diabetes**



Economic impact of diabetes

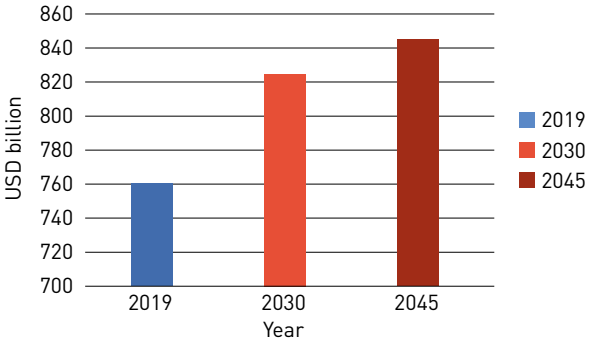
Despite its impact characterised by premature mortality and lower quality of life due to diabetes-related complications, diabetes also imposes a significant economic impact on countries, health systems and, when healthcare needs to be funded 'out-of-pocket', for individuals with diabetes and their families.[10–12]

Direct costs of diabetes

Direct costs are the health expenditures due to diabetes – regardless of whether this expenditure is born by patients themselves or by private or public payers or by government. Since its 3rd edition in 2006, the *IDF Diabetes Atlas* has included estimates of health expenditure due to diabetes.[13–18] The rise in this expenditure has been considerable, growing from USD 232 billion spent worldwide in 2007, to USD 727 billion in 2017 for adults aged 20–79 years (Figure 3.10). In 2019, IDF estimates that total diabetes-related health expenditure will reach USD 760 billion. This represents a 4.5% increase on the 2017 estimate.

The economic impact of diabetes is expected to continue to grow. It is projected that expenditure will reach USD 825 billion by 2030 and USD 845 billion by 2045. This represents an increase of 8.6% and 11.2%, respectively (Figure 3.11). These projections are conservative, as they assume that the mean expenditure per person and diabetes prevalence remain constant, while taking into account only demographic changes.

Figure 3.11 **Total diabetes-related health expenditure for adults (20–79 years) with diabetes in 2019, 2030 and 2045**



Regional distribution

The NAC Region has the highest total diabetes-related health expenditure of the IDF Regions (USD 324.5 billion), which corresponds to 42.7% of the total diabetes-related health expenditure in 2019. 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 Regions spent significantly less, despite being home to 41.8% of people with diabetes, and were collectively responsible for only 14.8% of the total diabetes-related health expenditure (Figure 3.12).

Expenditure due to diabetes has a significant impact on health budgets worldwide. On average, 19.4% of the total health spending was allocated to diabetes in the SACA Region, the highest percentage from the IDF Regions, followed by 15.2% observed in the MENA Region. The Region that spent the lowest percentage of health expenditure due to diabetes was the EUR Region with only 8.3% (Figure 3.13).

Figure 3.12 **Total health expenditure (USD billion) on diabetes and mean health expenditure (USD) per adult with diabetes (20–79 years) in 2019 by IDF Region**

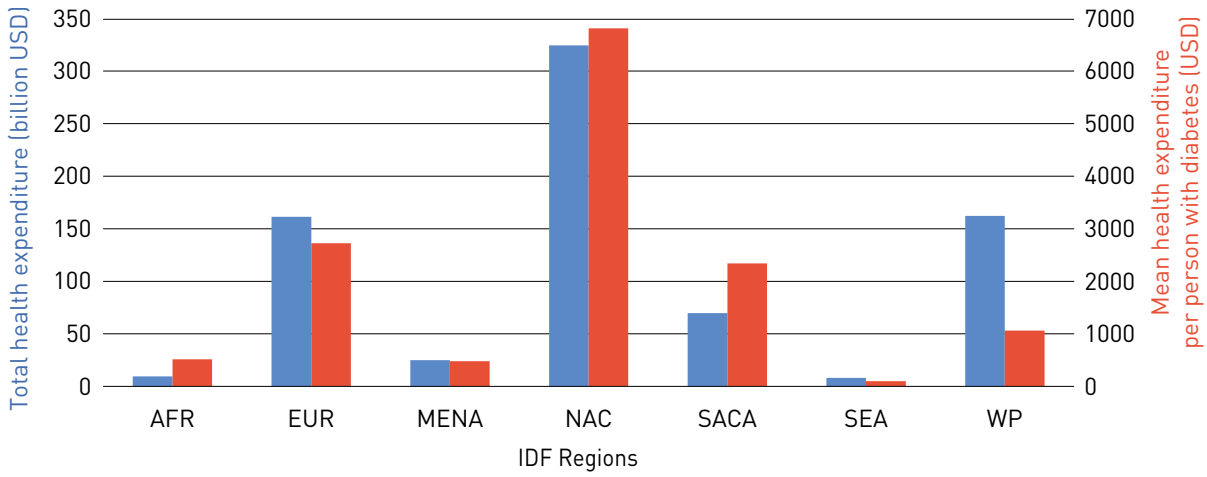
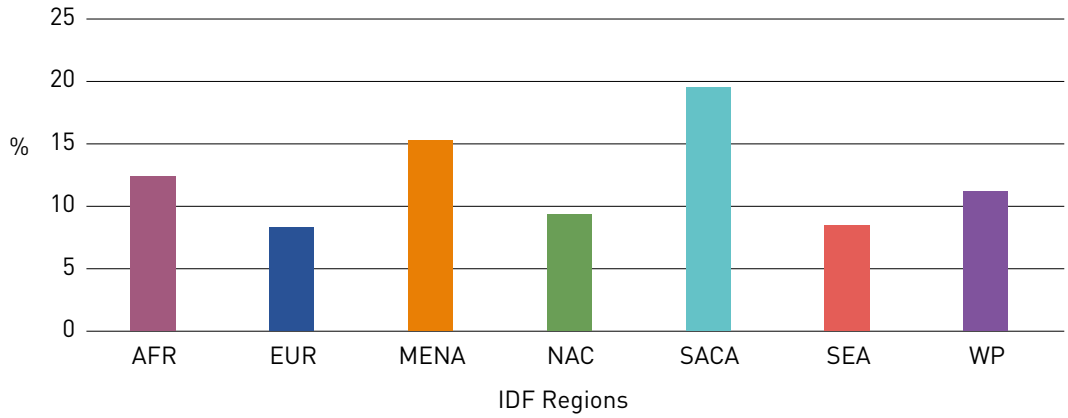


Figure 3.13 **Percentage of health expenditure spent on diabetes (20-79 years) in 2019 by IDF Region**



Country distribution

On a country level, the highest diabetes-related health expenditures were estimated for the United States of America with USD 294.6 billion, followed by China and Brazil, with USD 109.0 billion and USD 52.3 billion, respectively (Table 3.23).

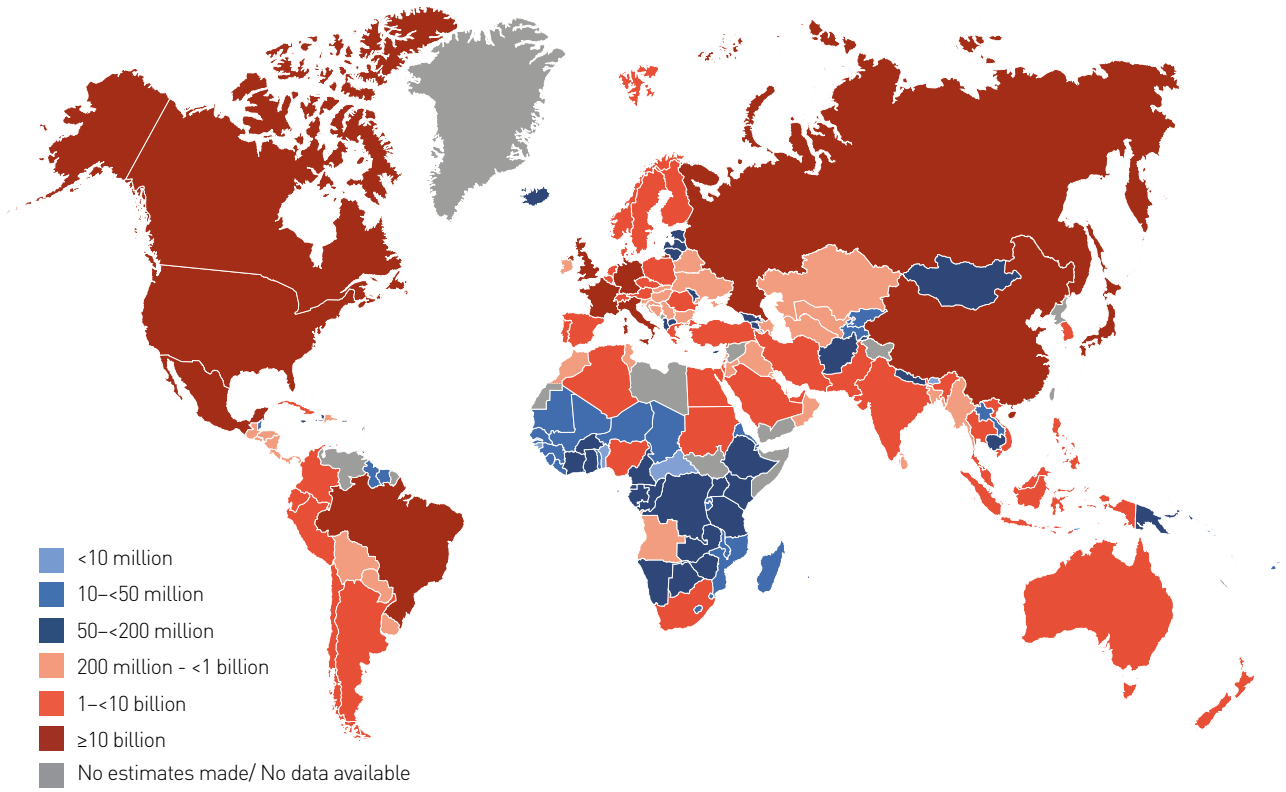
The countries with the lowest diabetes-related health expenditures were Sao Tome and Principe, and Tuvalu with estimates of USD 1.1 million and USD 1.8 million (Map 3.8).

Looking at the diabetes-attributable health expenditure per person with diabetes in 2019, large disparities exist between countries. Those with the highest yearly expenditure per person are Switzerland with USD 11,916, followed by the United States of America and Norway with USD 9,506 and USD 9,061, respectively. Countries with the lowest annual expenditure per person are Bangladesh (USD 64), Central African Republic (USD 72) and Nepal (USD 80) (Map 3.9).

Table 3.23 **Top 10 countries or territories for total health expenditure (USD billion) due to diabetes (20–79 years) in 2019**

Rank	Country or territory	Total diabetes-related health expenditure in 2019 (USD billion) (20–79 years)
1	United States of America	294.6
2	China	109.0
3	Brazil	52.3
4	Germany	43.8
5	Japan	23.5
6	Mexico	17.0
7	France	16.9
8	United Kingdom	14.1
9	Canada	12.3
10	Russian Federation	10.6

Map 3.8 **Total diabetes-related health expenditure (USD) among adults (20–79 years) with diabetes in 2019**



Map 3.9 **Mean diabetes-related health expenditure (USD) per person with diabetes (20–79 years) in 2019**

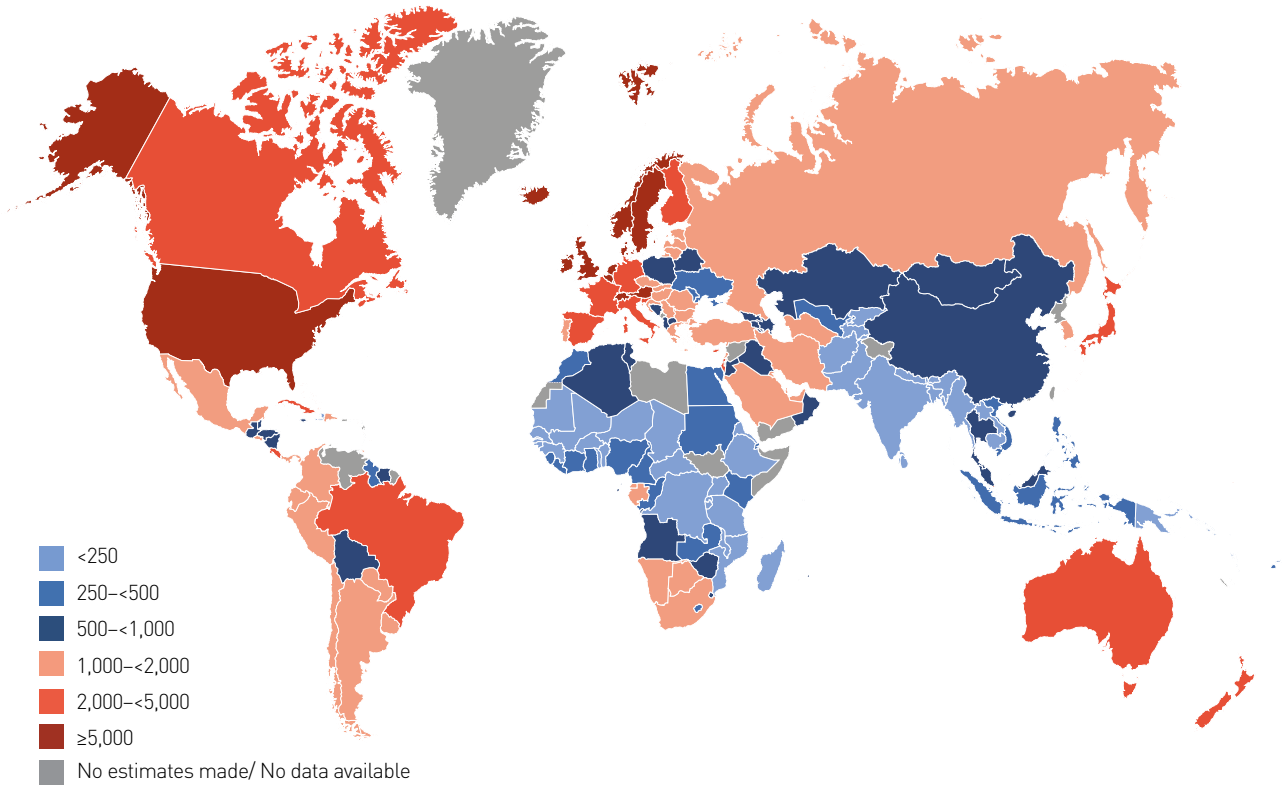


Table 3.24 **Top 10 countries or territories for mean health expenditure (USD) per person with diabetes (20–79 years) in 2019**

Rank	Country or territory	Mean health expenditure per person with diabetes (USD)
1	Switzerland	11,916
2	United States of America	9,506
3	Norway	9,061
4	Luxembourg	7,978
5	Sweden	6,643
6	Ireland	6,598
7	Iceland	6,403
8	Denmark	5,521
9	Netherlands	5,380
10	Austria	5,259

Of the top 10 countries with the highest health expenditure per person on diabetes, nine are from the EUR Region and one is from the NAC Region (Table 3.24).

Age distribution

In 2019, the age group with the largest diabetes-related health expenditure was 60–69 year-olds, 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 (Figure 3.14). The reason behind the large expenditure observed in older age groups is almost certainly the higher frequency of diabetes-related complications in later stages of life.

Gender distribution

In 2019, a slightly higher diabetes-related health expenditure is seen in women than in men, with USD 382.6 billion and USD 377.6 billion, respectively (Figure 3.15). The same difference is present in 2030 and 2045.

Figure 3.14 **Total diabetes-related health expenditure (USD billion) by age group**

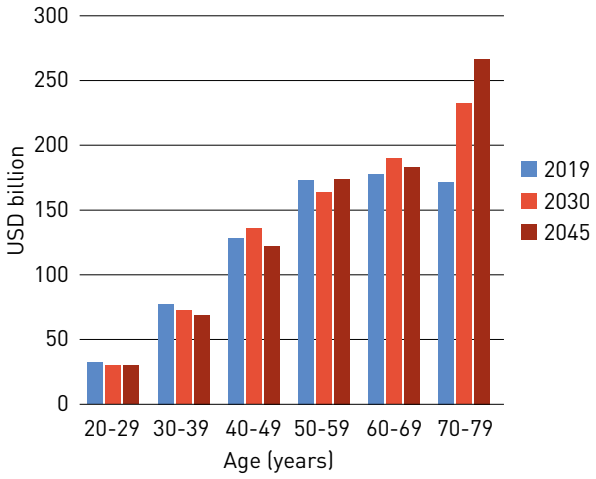


Figure 3.15 **Total diabetes-related health expenditure (USD billion) by sex in 2019, 2030 and 2045**

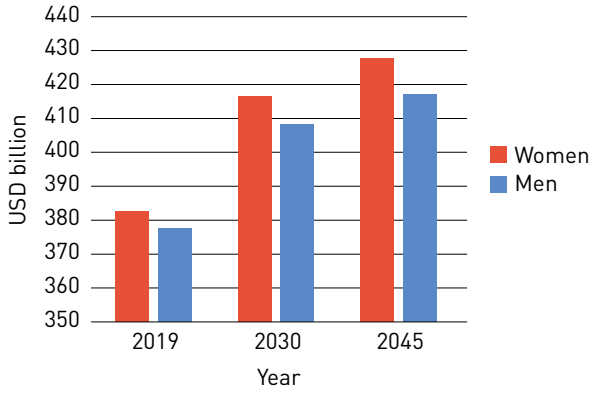


Table 3.25 **Total, direct and indirect costs of diabetes (2015) by country income level[19]**

Country income level	High-income	Middle-income	Low-income
Number of countries	53	202	29
Total costs, USD billion	804.36 (780.19–836.03)[i]	504.89 (477.41–544.16)	2.51 (2.32–3.05)
Indirect costs, USD billion	293.66 (284.93–308.33)	160.20 (150.74–176.65)	0.95 (0.87–1.15)
Indirect as % of total	36.5	31.7	37.8

i 95% confidence intervals are reported in brackets.

Indirect costs of diabetes

Bommer et al's overall estimate of the indirect costs of diabetes[19] is that these constitute 34.7% of their total global estimate of the costs of diabetes (in 2015) of USD 1.31 trillion. Table 3.25 shows indirect costs as a proportion of the total for high-, middle- and low-income countries with little difference between these groupings. There is substantial variation, however, in the ways in which these indirect costs are made up.

The four sources of indirect costs considered by Bommer et al[19] are: labour-force drop out; mortality; absenteeism; and presenteeism. Of these, the first two dominate the global picture with 48.5% and 45.5% contributions, respectively. In high-income countries, these are much the same (59.2% and 35.5%). However, mortality contributes 63.6% of indirect costs in middle-income countries and 90.6% in low-income countries. Absenteesim and presenteeism together contribute 6% globally and less than 3% in low-income countries.

References

1. Saeedi P, Petersohn I, Salpea P, Malanda B, Karuranga S, Unwin N, et al. Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: results from the International Diabetes Federation Diabetes Atlas, 9th edition. *Diabetes Res Clin Pract.* 2019 (in press); DOI:https://doi.org/10.1016/j.diabres.2019.107843
2. Dall TM, Yang W, Halder P, Pang B, Massoudi M, Wintfeld N, et al. The economic burden of elevated blood glucose levels in 2012: diagnosed and undiagnosed diabetes, gestational diabetes mellitus, and prediabetes. *Diabetes Care.* 2014 Dec;37(12):3172–9; DOI:10.2337/dc14-1036.
3. Magliano D, Islam R, Barr E, Gregg E, Pavkov M, Harding J, et al. Trends in incidence of total or type 2 diabetes: systematic review. *British Medical Journal*. 2019; 366:l5003; DOI:10.1136/bmj.l5003.
4. Karpati T, Cohen-Stavi CJ, Leibowitz M, Hoshen M, Feldman BS, Balicer RD. Towards a subsiding diabetes epidemic: trends from a large population-based study in Israel. *Popul Health Metr.* 2014;12(1):32; DOI:10.1186/s12963-014-0032-y.
5. DIAMOND Project Group. Incidence and trends of childhood Type 1 diabetes worldwide 1990-1999. *Diabet Med.* 2006 Aug;23(8):857–66; DOI:10.1111/j.1464-5491.2006.01925.x
6. Patterson CC, Harjutsalo V, Rosenbauer J, Neu A, Cinek O, Skrivarhaug T, et al. Trends and cyclical variation in the incidence of childhood type 1 diabetes in 26 European centres in the 25 year period 1989-2013: a multicentre prospective registration study. *Diabetologia.* 2019;62(3):408–17; DOI:10.1007/s00125-018-4763-3.
7. Fazeli Farsani S, van der Aa MP, van der Vorst MMJ, Knibbe C a. J, de Boer A. Global trends in the incidence and prevalence of type 2 diabetes in children and adolescents: a systematic review and evaluation of methodological approaches. *Diabetologia.* 2013 Jul;56(7):1471–88; DOI:10.1007/s00125-013-2915-z.
8. Nolan CJ, Damm P, Prentki M. Type 2 diabetes across generations: from pathophysiology to prevention and management. *Lancet*. 2011 Jul 9;378(9786):169–81; DOI:10.1016/S0140-6736(11)60614-4.
9. Darnton-Hill I, Nishida C, James WPT. A life course approach to diet, nutrition and the prevention of chronic diseases. *Public Health Nutr.* 2004 Feb;7(1A):101–21.
10. Association AD. Economic costs of diabetes in the U.S. in 2017. *Diabetes Care*. 2018 May 1;41(5):917–28; DOI:10.2337/dci18-0007.
11. Peters ML, Huisman EL, Schoonen M, Wolffenbuttel BHR. The current total economic burden of diabetes mellitus in the Netherlands. *Neth J Med.* 2017 Sep;75(7):281–97.
12. Yang W, Zhao W, Xiao J, Li R, Zhang P, Kissimova-Skarbek K, et al. Medical care and payment for diabetes in China: enormous threat and great opportunity. *PLoS ONE.* 2012;7(9):e39513; DOI:10.1371/journal.pone.0039513.
13. International Diabetes Federation. *IDF Diabetes Atlas, 8th edition.* Brussels; 2017.
14. International Diabetes Federation. *IDF Diabetes Atlas, 7th edition.* Brussels; 2015.
15. International Diabetes Federation. *IDF Diabetes Atlas, 6th edition.* Brussels; 2013.
16. International Diabetes Federation. *IDF Diabetes Atlas, 5th edition.* Brussels; 2011.
17. International Diabetes Federation. *IDF Diabetes Atlas, 4th edition.* Brussels; 2009.
18. International Diabetes Federation. *IDF Diabetes Atlas, 3rd edition.* Brussels; 2006.
19. Bommer C, Heesemann E, Sagalova V, Manne-Goehler J, Atun R, Bärnighausen T, et al. The global economic burden of diabetes in adults aged 20-79 years: a cost-of-illness study. *Lancet Diabetes Endocrinol.* 2017;5(6):423–30. DOI:10.1016/S2213-8587(17)30097-9.

4 DIABETES BY REGION

Verónica Emilia Tapia Abril from Cuenca, Equador, living with latent adult autoimmune diabetes (LADA)

Key messages

The number of people with diabetes in the IDF Africa Region is expected to increase by 48% by 2030 and by 143% by 2045, the highest predicted increase of all the IDF Regions.

The IDF Europe Region has the highest number of children and adolescents (0–19 years) with type 1 diabetes – 296,500 in total.

The IDF Middle East and North Africa Region has the highest age-adjusted diabetes prevalence of all IDF Regions – almost 12%.

43% of the global diabetes-related health expenditure occurs in the North America and Caribbean Region.

In the IDF South and Central America Region, 44% of deaths due to diabetes occur in people under the age of 60 years.

In the IDF South-East Asia Region, 57% of adults aged 20–79 years with diabetes are undiagnosed.

The highest number of deaths due to diabetes in 2019 occurred in the IDF Western Pacific Region – well over 1 million.

AFRICA

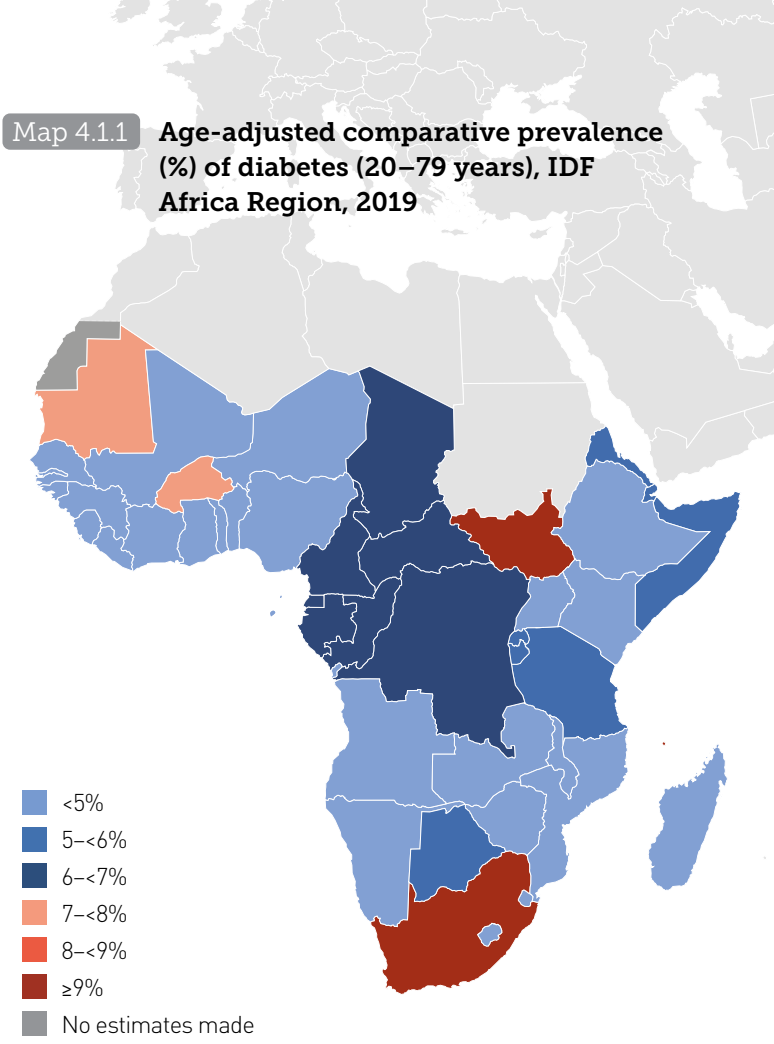
Over half (60%) of adults aged 20–79 years with diabetes are **undiagnosed,** the highest proportion of undiagnosed diabetes of all IDF Regions.

Almost **three-quarters of deaths** due to diabetes each year occur in people **under the age of 60 years** – the highest proportion in this age group in the world.

Estimates were made for 47 sub-Saharan African countries and territories in the IDF Africa (AFR) Region. For this edition of the *IDF Diabetes Atlas*, a total of 22 data sources (from 17 countries) were selected. About two third (64%) of the countries in the IDF AFR Region lack high-quality in-country data sources. Only three countries (Ethiopia, Kenya and Uganda) had studies conducted within the past five years. Comoros, Kenya, Seychelles and Zimbabwe had data sources based on oral glucose tolerance tests (OGTT).

Diabetes prevalence figures for other countries in the Region were based on studies using fasting blood glucose and self-reported diagnostic criteria. Throughout the Region, data on the incidence of type 1 diabetes in children and adolescents are scarce. To calculate estimates for type 1 diabetes in children and adolescents, for example, data sources from Ethiopia, Mauritius, Rwanda and Tanzania were identified and extrapolated. Due to the small number of data sources available, estimates for the Region must be interpreted with caution, particularly mortality and health expenditure estimates.

Map 4.1.1 **Age-adjusted comparative prevalence (%) of diabetes (20–79 years), IDF Africa Region, 2019**



IDF Africa Region at a glance

	2019	2030	2045
Adult population (20–79 years)	501.3 million	703.9 million	1.1 billion
Diabetes (20–79 years)			
Regional prevalence	3.9% (2.1–7.1%)[i]	4.1% (2.3–7.5%)	4.4% (2.5–8.0%)
Age-adjusted comparative prevalence	4.7% (3.2–8.1%)	5.1% (3.4–8.8%)	5.2% (3.5–9.1%)
Number of people with diabetes	19.4 million (10.6–35.8 million)	28.6 million (16.0–53.1 million)	47.1 million (27.4–86.0 million)
Number of deaths due to diabetes	366,200 (200,054–627,374)	-	-
Diabetes-related health expenditure (20–79 years)			
Total health expenditure, USD	9.5 billion	12.7 billion	17.4 billion
Impaired glucose tolerance (20–79 years)			
Regional prevalence	9.0% (5.2–20.1%)	9.5% (5.6–21.0%)	10.3% (6.0–22.5%)
Age-adjusted comparative prevalence	10.1% (5.6–22.7%)	10.5% (5.7–24.1%)	10.7% (5.6–24.9%)
Number of people with impaired glucose tolerance	45.3 million (26.0–100.7 million)	66.8 million (39.1–147.7 million)	110.2 million (64.6–241.9 million)
Undiagnosed diabetes (20–79 years)			
Regional prevalence	59.7%	-	-
Number of people with undiagnosed diabetes	11.6 million (6.6–21.0 million)	-	-
Type 1 diabetes (0–19 years)			
Number of children and adolescents with type 1 diabetes	25,800	-	-
Number of newly diagnosed children and adolescents each year	10,300	-	-

i 95% confidence intervals are reported in brackets.

Figure 4.1.1 **Prevalence (%) estimates of diabetes by age and sex, IDF Africa Region, 2019**

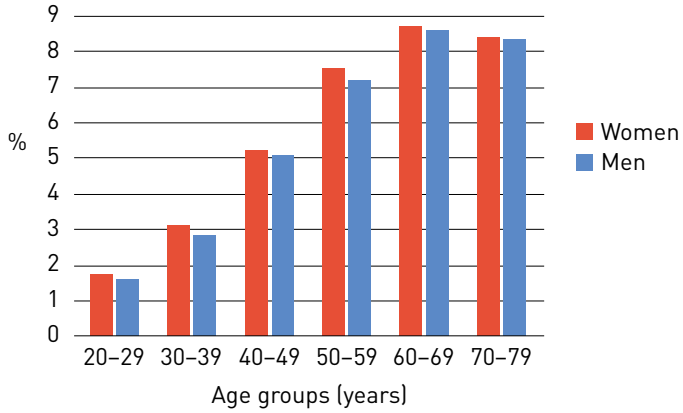
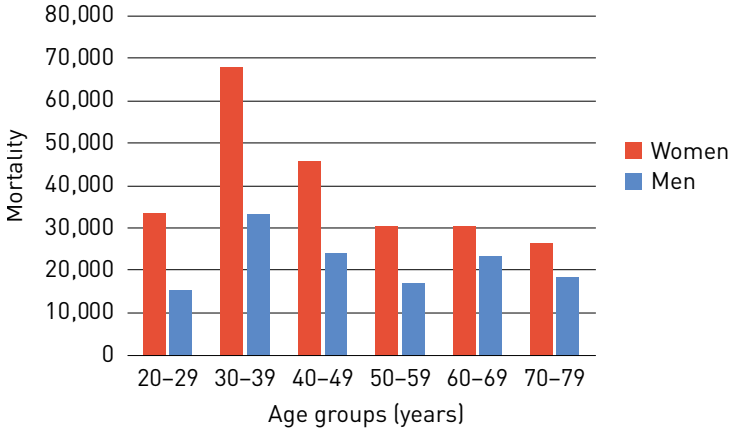


Figure 4.1.2 **Mortality due to diabetes by age and sex, IDF Africa Region, 2019**



Prevalence

An estimated 19.4 million adults aged 20–79 years have diabetes in the AFR Region, representing a regional prevalence of 3.9%. AFR currently has the lowest prevalence among all the IDF Regions, likely due to lower levels of urbanisation, under-nutrition and under-reporting. In the AFR Region, 45.9% of people with diabetes live in low-income countries and 54.1% in middle-income countries. The highest prevalence (8.8%) of diabetes in the Region is among adults aged between 65 and 69 years.

The proportion of undiagnosed diabetes is highest in the AFR Region, where more than half (59.7%) of people living with diabetes are unaware of their condition. Diabetes prevalence is higher in urban (5.9%) than in rural areas (2.4%).

The highest age-adjusted comparative prevalence of diabetes in adults aged 20–79 years in the AFR Region is in South Africa (12.7%), followed by Seychelles (12.3%) and Comoros (12.3%). Some of the most populous countries in the AFR Region have the highest number of people with diabetes, including South Africa (4.6 million), Nigeria (2.7 million), Democratic Republic of Congo (1.8 million) and Ethiopia (1.7 million). More than half (55.8%) of all 20–79 year-old adults with diabetes in the Region live in one of these four countries.

As urbanisation increases and populations age, type 2 diabetes will pose an ever-growing challenge. The AFR Region is estimated to have the highest future increase in the number of people with diabetes compared to other parts of the world. By 2030 there will be 28.6 million (47.5% increase) and by 2045 47.1 million (142.9% increase) adults aged 20–79 years with diabetes, more than double the number in 2019 and the highest increase compared to other IDF Regions.

The AFR Region is also predicted to have the highest increase in the number of people with impaired glucose tolerance (IGT) by 2030 (an increase of 47.5% over the 2019 estimate) and by 2045 (an increase of 143.3%).

An estimated 25,800 children and adolescents under the age of 20 years are living with type 1 diabetes in the AFR Region and this is likely to be an underestimate.

Mortality

In 2019, 366,200 deaths (6.8% of all-cause mortality) in the AFR Region are attributable to diabetes with the highest percentage (9.1%) of all-cause mortality due to diabetes in the age group 30–39 years. Furthermore, 73.1% of all deaths attributable to diabetes occurred in people under 60 years, the highest proportion in the world.

Of the total number of deaths attributable to diabetes, large proportions occur in low- and middle-income countries (41.8% and 58.2%, respectively). The highest number of deaths due to diabetes is estimated for South Africa, where, in 2019, 89,800 deaths are attributable to diabetes. Diabetes-attributable mortality in the Region is almost 1.8 times higher in women (234,500) than in men (131,700).

Health expenditure

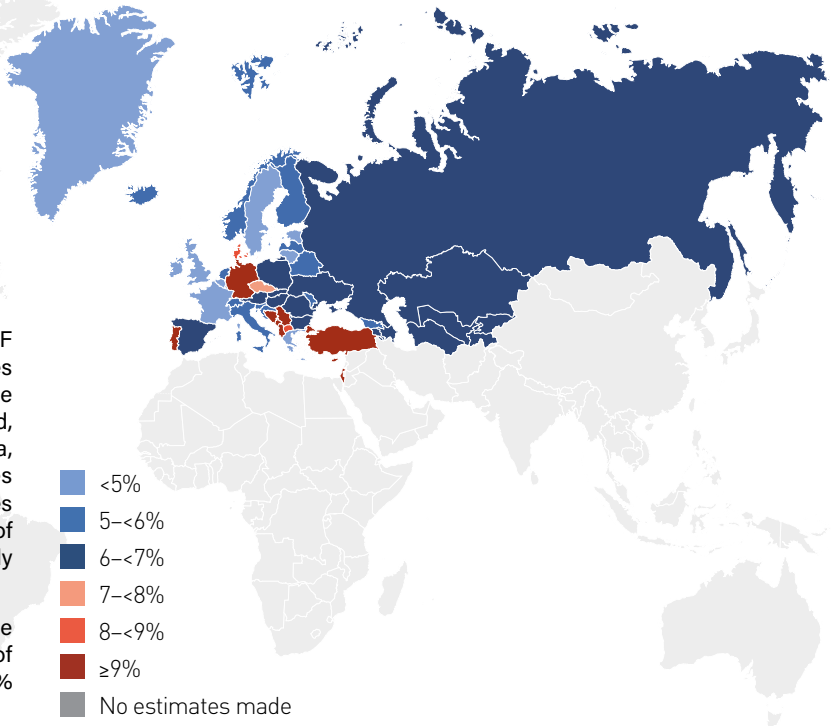
In 2019, USD 9.5 billion was spent on diabetes-related health expenditure in the AFR Region. This is the second lowest of all seven IDF Regions, representing 1.2% of the total spent worldwide, despite the Region being home to 4.2% of people with diabetes. Projections for annual diabetes-related health expenditure in 2030 and 2045 are USD 12.7 billion and USD 17.4 billion, respectively.

The countries in the AFR Region with the largest mean health expenditure per person with diabetes are Namibia (USD 1,872), Botswana (USD 1,418) and Equatorial Guinea (USD 1,306), while those with the lowest mean expenditure are the Central African Republic (USD 72), Niger (USD 88) and Burundi (USD 98).

Countries in the AFR Region with the largest percentage of health expenditure due to diabetes in 2019 are South Africa and Gabon where, respectively, 23.0% and 17.5% of the total health budget is spent on diabetes.

EUROPE

Map 4.2.1 **Age-adjusted comparative prevalence (%) of diabetes (20–79 years) in IDF Europe Region, 2019**



19% of live births are **affected by hyperglycaemia in pregnancy.**

31% of diabetes-related deaths are in people **under the age of 60 years.**

Estimates were made for 57 countries and territories in the IDF Europe (EUR) Region. A total of 73 data sources from 39 countries were used to generate diabetes estimates among adults in the Region. Estimates for 12 countries (Georgia, Germany, Greenland, Israel, Italy, Luxembourg, Macedonia, Malta, Norway, Romania, Russian Federation and Uzbekistan) were based on studies conducted within the past five years. Diabetes prevalence figures for the remaining countries may be underestimated due to lack of recent data or data that, although available for all ages, is not readily accessible by age and sex.

The EUR Region had the most complete and reliable data for type 1 diabetes in children and adolescents, with over three quarters of countries reporting incidence rates of type 1 diabetes and over 60% of publications classified as high quality.

IDF Europe Region at a glance

	2019	2030	2045
Adult population (20–79 years)	665.4 million	673.8 million	664.5 million
Diabetes (20–79 years)			
Regional prevalence	8.9% (7.0–12.0%)[i]	9.8% (7.6–13.1%)	10.3% (7.9–13.5%)
Age-adjusted comparative prevalence	6.3% (4.9–9.2%)	7.3% (5.6–10.3%)	7.8% (6.0–10.8%)
Number of people with diabetes	59.3 million (46.3–80.2 million)	66.0 million (51.3–87.9 million)	68.1 million (52.6–89.6 million)
Number of deaths due to diabetes	465,900 (360,934–590,729)	-	-
Diabetes-related health expenditure (20–79 years)			
Total health expenditure, USD	161.4 billion	168.5 billion	159.6 billion
Impaired glucose tolerance (20–79 years)			
Regional prevalence	5.5% (3.1–11.2%)	5.9% (3.3–11.5%)	6.1% (3.5–11.7%)
Age-adjusted comparative prevalence	4.4% (2.6–9.3%)	4.9% (2.9–9.8%)	5.1% (3.1–10.1%)
Number of people with impaired glucose tolerance	36.6 million (20.4–74.5 million)	39.7 million (22.5–77.4 million)	40.3 million (22.9–77.4 million)
Undiagnosed diabetes (20–79 years)			
Regional prevalence	40.7%	-	-
Number of people with undiagnosed diabetes	24.2 million (18.8–32.4 million)	-	-
Type 1 diabetes (0–19 years)			
Number of children and adolescents with type 1 diabetes	296,500	-	-
Number of newly diagnosed children and adolescents each year	31,100	-	-

i 95% confidence intervals are reported in brackets.

Figure 4.2.1 **Prevalence (%) estimates of diabetes by age and sex, IDF Europe Region, 2019**

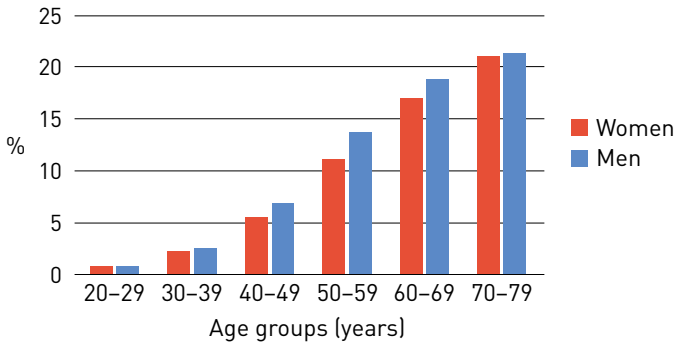
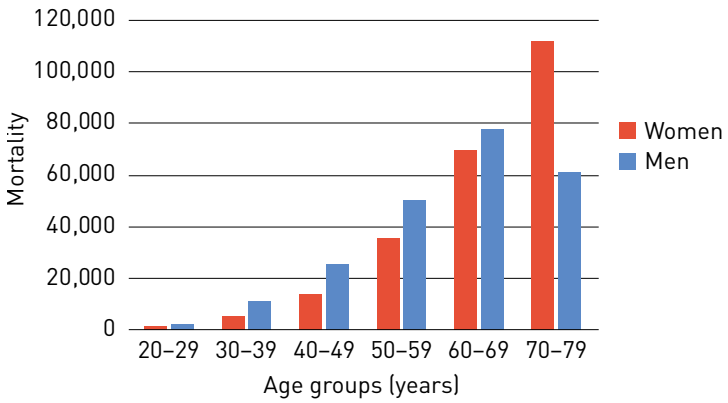


Figure 4.2.2 **Mortality due to diabetes by age and sex, IDF Europe Region, 2019**



Prevalence

The number of adults aged 20–79 years with diabetes in the EUR Region is estimated to be 59.3 million, representing 8.9% of the regional population in this age group. This includes 24.2 million adults with undiagnosed diabetes. While the EUR Region has the second lowest age-adjusted comparative diabetes prevalence (6.3%) among the IDF Regions, there are still many countries with relatively high diabetes prevalence. In Europe, 72.7% of the population live in cities and the diabetes prevalence is higher in urban (9.3%) than rural (7.8%) settings. More than half (58.6%) of adults with diabetes in the Region are living in high-income countries.

Among countries in the EUR Region, Turkey has the highest age-adjusted comparative prevalence (11.1%) followed by Germany (10.4%) and Portugal (9.8%). Germany ranks first for the highest number of people with diabetes (9.5 million), followed by Russian Federation (8.3 million) and Turkey (6.6 million). A further 36.6 million adults aged 20–79 years, 5.5% of the regional population in this age group are estimated to have impaired glucose tolerance (IGT) in 2019. By 2030, it is predicted that there will be 66 million adults with diabetes and 39.7 million with IGT in the Region. Predictions for 2045 suggest that this will increase further to 68.1 million people with diabetes and 40.3 million with IGT. Aging is an especially important risk factor for type 2 diabetes in the EUR Region, where 43.7% of the general population is between 50–79 years and this proportion is expected to increase to 47.7% by 2030 and to 50.1% by 2045. To a large degree, the high prevalence of type 2 diabetes and IGT is a consequence of the aging of the population in the Region.

Compared to other IDF Regions, EUR has the highest number of children and adolescents (0–19 years) with type 1 diabetes with 296,500 affected. The Region also has one of the highest incidence rates of type 1 diabetes in children and adolescents with an estimated 31,100 new cases per year. The Nordic countries of Sweden, Finland and Norway are in the top five worldwide in terms of the incidence of type 1 diabetes in this age group. The United Kingdom has the highest number of new cases of children and adolescents with type 1 diabetes – approximately 4,300 in 2019.

Mortality

In the EUR Region, it is estimated that almost 465,900 deaths in adults aged 20–79 years are attributable to diabetes and its complications in 2019 (8.5% of all-cause mortality). About 31.4% of these deaths are estimated to be in people under 60 years of age, which partly reflects the age distribution of the population, but also may be related to improved survival rates due to overall high quality healthcare of people with diabetes in the EUR Region. The highest percentage (10.8%) of deaths due to diabetes from all cause mortality is seen in the age group 50–59 years Among different income groups, the highest number of diabetes-related deaths (59.0%) is seen in middle-income countries, including the Russian Federation, Turkey and Ukraine.

There are slightly more deaths due to diabetes and its complications in women compared to men: 237,900 and 228,000 respectively. This can be explained by the slightly higher levels of diabetes in women (29.9 million) than men (29.4 million), and more women (342.8 million) than men (322.6 million) in the population. The Russian Federation has the highest number of deaths attributable to diabetes (110,500).

Health expenditure

In 2019, the total diabetes-related health expenditure in the EUR Region is estimated to be USD 161.4 billion. The Region has the third largest expenditure on diabetes of all IDF Regions, accounting for 21.2% of the global spend on diabetes. As a result of the intensity of diabetes treatment in the Region, diabetes is responsible for a large share of total health expenditure, ranging from 4.2% in Ireland to 23.8% in Turkey. For adults aged 20–79 years, diabetes-related health expenditure is projected to reach USD 168.5 billion in 2030 and USD 159.6 billion in 2045.

Regarding mean annual health expenditure per person with diabetes, the largest estimates in the EUR Region are for Switzerland (USD 11,916), Norway (USD 9,061) and Luxembourg (USD 7,978). The lowest estimates are for Tajikistan (USD 145), Kyrgyzstan (USD 194) and Ukraine (USD 341).

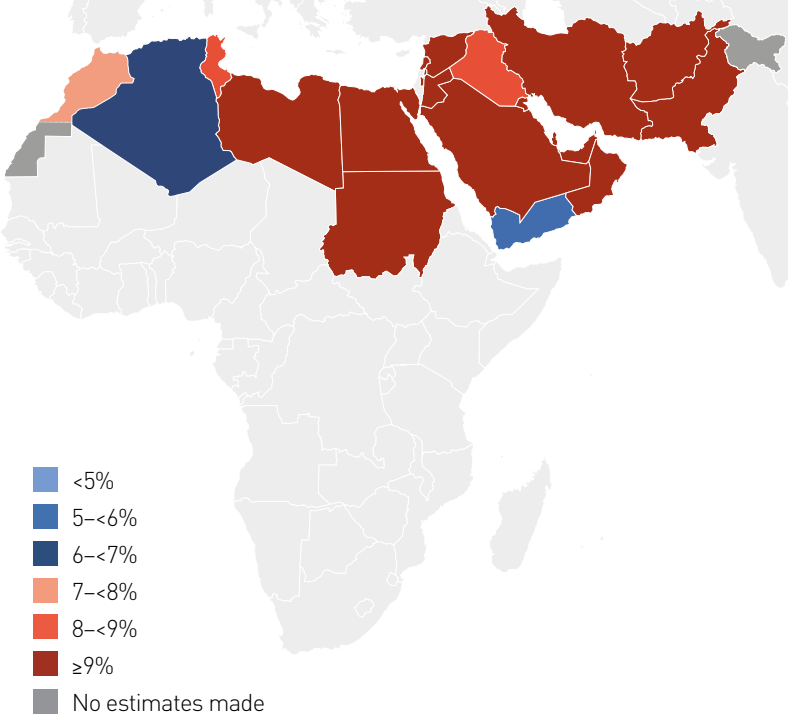
MIDDLE EAST AND NORTH AFRICA

53% of diabetes-related deaths **are in people under the age of 60 years.**

Close to 45% (24 million) of adults aged 20–79 years with diabetes are **undiagnosed.**

Estimates were made for 21 countries and territories in the IDF Middle East and North Africa (MENA) Region. A total of 33 data sources from 17 countries were used to estimate diabetes prevalence in 20–79 year-old adults in the Region. Jordan, Pakistan and Sudan had national studies conducted within the past five years. Algeria, Jordan, Oman, Pakistan, Saudi Arabia, State of Palestine, Sudan and United Arab Emirates had estimates based on oral glucose tolerance tests (OGTT). Diabetes prevalence for the remaining countries may be underestimated. The MENA Region has studies of type 1 diabetes incidence data in the 0–19 age-group covering over half the countries in the Region (12 countries).

Map 4.3.1 **Age-adjusted comparative prevalence (%) of diabetes (20–79 years) in IDF Middle East and North Africa Region, 2019**



IDF Middle East and North Africa Region at a glance

	2019	2030	2045
Total number of adult population in MENA (20–79 years)	426.3 million	533.8 million	686.7 million
Diabetes (20–79 years)			
Regional prevalence	12.8% (7.2–17.6%)[i]	14.2% (8.1–19.5%)	15.7% (8.8–21.5%)
Age-adjusted comparative prevalence	12.2% (8.3–16.1%)	13.3% (9.1–17.6%)	13.9% (9.5–18.3%)
Number of people with diabetes	54.8 million (30.7–75.1 million)	76.0 million (43.0–104.1 million)	107.6 million (60.6–147.4 million)
Number of deaths due to diabetes	418,900 (248,731–533,758)	-	-
Diabetes-related health expenditure (20–79 years)			
Total health expenditure, USD	24.9 billion	32.5 billion	38.6 billion
Impaired glucose tolerance (20–79 years)			
Regional prevalence	8.3% (5.2–12.0%)	8.9% (5.6–12.8%)	9.4% (5.9–13.6%)
Age-adjusted comparative prevalence	9.2% (6.2–13.3%)	9.7% (6.5–14.1%)	9.9% (6.6–14.5%)
Number of people with impaired glucose tolerance	35.5 million (22.2–51.1 million)	47.3 million (30.0–68.4 million)	64.5 million (40.3–93.7 million)
Undiagnosed diabetes (20–79 years)			
Regional prevalence	44.7%	-	-
Number of people with undiagnosed diabetes	24.5 million (13.7–33.4 million)	-	-
Type 1 diabetes (0–19 years)			
Number of children and adolescents with type 1 diabetes	149,400	-	-
Number of newly diagnosed children and adolescents each year	20,800	-	-

i 95% confidence intervals are reported in brackets.

Figure 4.3.1 **Prevalence (%) estimates of diabetes by age and sex, IDF Middle East and North Africa Region, 2019**

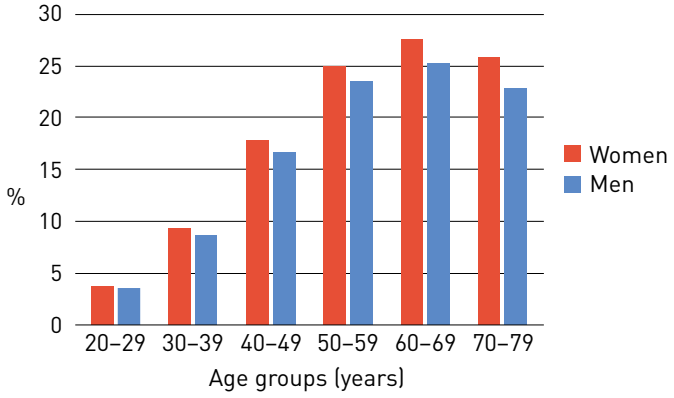
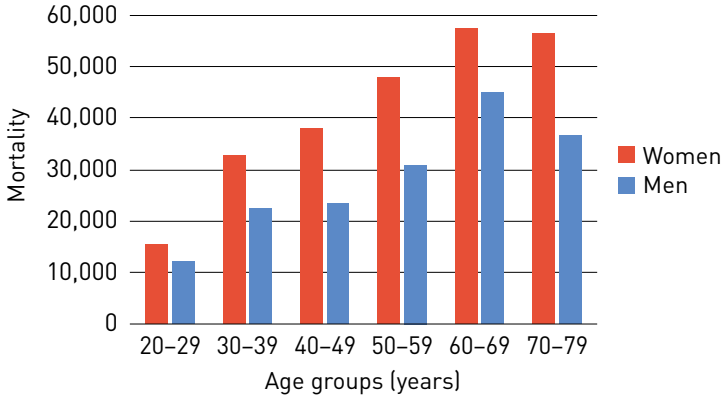


Figure 4.3.2 **Mortality due to diabetes by age and sex, IDF Middle East and North Africa Region, 2019**



Prevalence

In 2019, approximately 54.8 million adults aged 20–79 years, or 12.8% of the regional population in this age group, have diabetes. This includes 24.5 million adults with undiagnosed diabetes. The Region has the highest age-adjusted diabetes prevalence (12.2%) of all the IDF Regions.

It is estimated that the number of people with diabetes in the Region will increase by 38.8% by 2030 and by 96.5% by 2045, the second highest increase of all the IDF Regions.

Although 55.3% of all adults in the Region live in urban areas, 60.6% of adults with diabetes live in urban settings. The majority (87.2%) of adults with diabetes in the Region live in low- or middle-income countries.

Countries with the highest age-adjusted comparative diabetes prevalence in the MENA Region are Sudan (22.1%) and Pakistan (19.9%). Countries with the largest number of adults with diabetes aged 20–79 years are Pakistan (19.4 million), Egypt (8.9 million) and Iran (Islamic Republic of) (5.4 million).

A further 35.5 million adults aged 20–79 years in the Region, or 8.3% of the regional population in this age group, are estimated to have impaired glucose tolerance (IGT).

Algeria (33,100), Morocco (30,200) and Saudi Arabia (27,800) are the countries in the Region with the highest estimated number of children and adolescents (0–19 years) with type 1 diabetes in 2019. They also have the highest number of new cases of type 1 diabetes in children and adolescents: Algeria (4,200 per year), Saudi Arabia (3,700) and Morocco (3,600).

Mortality

Diabetes and its complications were responsible for an estimated 418,900 deaths in adults aged 20–79 years in 2019 (16.2% of all-cause mortality), with the highest percentage (22.4%) in the age group 30–39 years. About 53.3% of all deaths from diabetes in MENA occurred in people under 60 years, making it the Region with the second highest proportion of diabetes-related deaths under 60 years of age. Most of the diabetes-attributable deaths occurred in middle-income countries, which account for 86.7% of all diabetes-related deaths in the Region.

There is a higher mortality due to diabetes in women than men, with 248,300 and 170,600 estimated deaths respectively. This may be due to a slightly higher number of women with diabetes than men; 27.6 million and 27.1 million, respectively. The largest diabetes-attributable mortality is found in Pakistan, with 159,000 deaths in 2019.

Health expenditure

In 2019, diabetes-related health expenditure in the MENA Region totalled USD 24.9 billion and this is expected to increase by 30.3% to USD 32.5 billion by 2030. Total annual diabetes-related health expenditure is projected to reach USD 38.6 billion in 2045.

The proportion of health expenditure dedicated to diabetes corresponds, overall, to 15.2% of the Regional total. Countries in which the largest share of health expenditure relates to diabetes are Sudan (20.7%), Lebanon (20.4%) and Pakistan (19.7%). Oman has the lowest percentage of total health expenditure (6.8%) spent on diabetes in the Region.

There is a great disparity regarding the annual amount spent per person with diabetes in the MENA Region. The highest is estimated to be in Qatar (USD 1,751) and Lebanon (USD 1,548), while Pakistan has the lowest (USD 83).

NORTH AMERICA AND CARIBBEAN

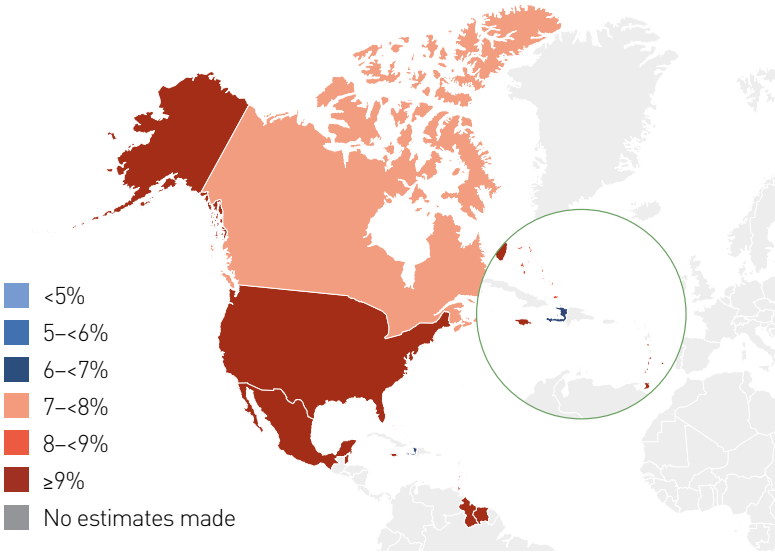
The North America and Caribbean Region has the highest age-adjusted prevalence of **impaired glucose tolerance** of all IDF Regions – over 12%.

The North America and Caribbean Region has the second highest number of **children and adolescents** with type 1 diabetes – almost **225,000 in total.** The United States of America accounts for almost 78% (175,900) of the total.

Estimates were made for Canada, Mexico, the United States of America and 21 Caribbean countries and territories in the IDF North America and Caribbean (NAC) Region. Estimates for diabetes in adults in the Region were taken from 27 data sources, representing 15 of the 24 countries. Suriname and the United States had studies conducted within the past five years. Belize, Haiti, Mexico and the US Virgin Islands had studies that used oral glucose tolerance tests (OGTT) but were performed between 1994 and 2009.

Prevalence estimates for other countries may be underestimates because they were performed when diabetes prevalence was lower and/or because of the use of less sensitive detection methods (e.g HbA1c and self-reporting). Estimates for type 1 diabetes in children and adolescents were derived from studies in eight countries of the NAC Region.

Map 4.4.1 **Age-adjusted comparative prevalence (%) of diabetes (20–79 years) in IDF North America and Caribbean Region, 2019**



IDF North America and Caribbean Region at a glance

	2019	2030	2045
Adult population (20–79 years)	357.1 million	393.5 million	422.6 million
Diabetes (20–79 years)			
Regional prevalence	13.3% (10.5–15.8%)[i]	14.2% (11.0–16.9%)	15.0% (11.4–17.7%)
Age-adjusted comparative prevalence	11.1% (9.0–14.5%)	12.3% (10.0–15.9%)	13.0% (10.5–16.5%)
Number of people with diabetes	47.6 million (37.4–56.4million)	56.0 million (43.4–66.5 million)	63.2 million (48.1–74.9 million)
Number of deaths due to diabetes	301,700 (245,733–347,435)	-	-
Diabetes-related health expenditure (20–79 years)			
Total health expenditure, USD	324.5 billion	338.8 billion	346.7 billion
Impaired glucose tolerance (20–79 years)			
Regional prevalence	15.5% (13.1–17.9%)	16.3% (13.7–18.7%)	16.7% (14.1–19.2%)
Age-adjusted comparative prevalence	12.3% (10.2–14.4%)	13.2% (11.0–15.5%)	13.8% (11.5–16.1%)
Number of people with impaired glucose tolerance	55.5 million (46.8–63.8 million)	64.0 million (54.0–73.6 million)	70.7 million (59.6–81.2 million)
Undiagnosed diabetes (20–79 years)			
Regional prevalence	37.8%		
Number of people with undiagnosed diabetes	18.0 million (14.1–21.3 million)	-	-
Type 1 diabetes (0–19 years)			
Number of children and adolescents with type 1 diabetes	224,900	-	-
Number of newly diagnosed children and adolescents each year	21,900	-	-

i 95% confidence intervals are reported in brackets.

Figure 4.4.1 **Prevalence (%) estimates of diabetes by age and sex, IDF North America and Caribbean Region, 2019**

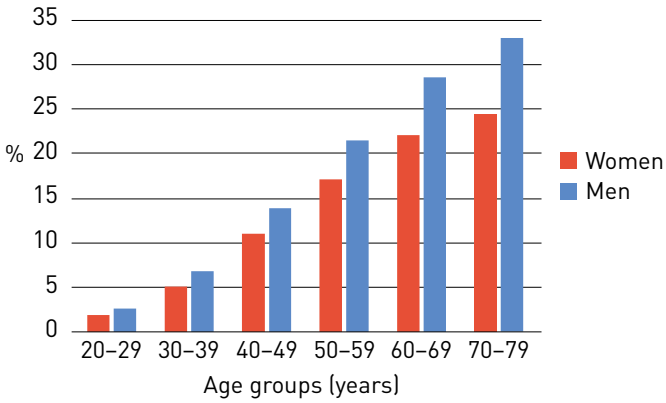
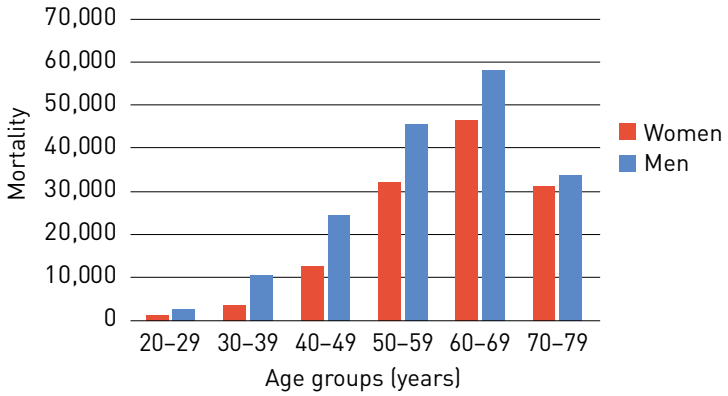


Figure 4.4.2 **Mortality due to diabetes by age and sex, IDF North America and Caribbean Region, 2019**



Prevalence

With 13.3% of adults aged 20–79 years affected by diabetes, an estimated 47.6 million people with diabetes live in the Region, of whom 18.0 million (37.8%) are undiagnosed. The vast majority of people with diabetes live in urban areas (83.5%) and high-income countries (71.5%).

Since most of the people (96.7%) in the NAC Region live in Canada, Mexico and the United States of America, these countries also have the highest numbers of adults with diabetes; United States of America (31.0 million), followed by Mexico (12.8 million) and Canada (2.8 million). The highest age-adjusted prevalence in the NAC Region are found in Belize (17.1%) and British Virgin Islands (14.2%).

The majority (79.2%) of the countries and territories in the Region have an age-adjusted comparative diabetes prevalence above the global average (8.3%), with Canada, Cayman Islands, Sint Maarten, Bermuda and Haiti being the exceptions at 7.6%, 6.8%, 6.8%, 6.7% and 6.6%, respectively.

A further 55.5 million people, or 15.5% of adults aged 20–79 years in the NAC Region, have impaired glucose tolerance (IGT). By 2030, it is predicted that 56.0 million adults in the NAC Region will have diabetes and an additional 64.0 million will have IGT. By 2045 these numbers are expected to increase to 63.2 million adults with diabetes and 70.7 million people with IGT.

There are an estimated 224,900 children and adolescents with type 1 diabetes in NAC, with 21,900 newly diagnosed each year. The United States of America is home to the world's largest number of children and adolescents with type 1 diabetes (175,900) and accounts for 78.2% of the total number of type 1 diabetes in children and adolescents in the Region.

Mortality

The total number of deaths attributed to diabetes in adults aged 20–79 years in NAC for 2019 is 301,700 (13.8% of deaths due to all causes). Of these, the highest proportion (20.0%) occurred in the age group 50–59 years. More than half (67.2%) of these deaths occurred in high-income countries. More men (174,700) than women (127,000) died from diabetes-related causes in the Region in 2019. Diabetes-related mortality in the NAC Region was not limited to older age groups, with 44.0% of deaths occurring in adults under the age of 60 years. Diabetes-related deaths in the United States of America is estimated to be 189,000 in 2019, one of the highest numbers of deaths due to diabetes worldwide.

Health expenditure

In 2019, USD 324.5 billion was spent on diabetes in the Region. This was greater than for any other IDF Region, corresponding to 42.7% of the total global health expenditure on diabetes. USD 294.6 billion was spent in the United States of America alone. Mean annual expenditure per person with diabetes was highest in the United States of America (USD 9,506), followed by Canada (USD 4,397). The lowest in the Region was Haiti (USD 142).

In the NAC Region, 9.3% of the total health expenditure was attributable to diabetes. Countries with the largest share were Mexico (27.8%), Belize (25.2%), and Dominica (23.0%), while Canada had the lowest proportion (7.4%).

SOUTH AND CENTRAL AMERICA

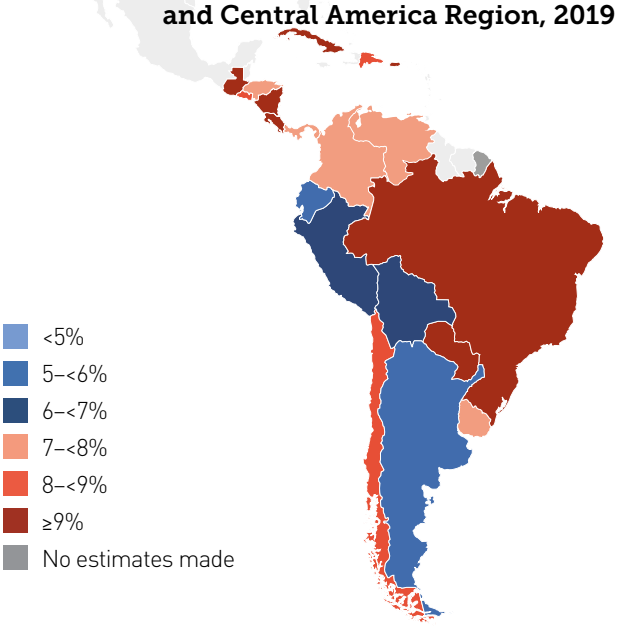
42% (13 million) of adults aged 20–79 years with diabetes are **undiagnosed.**

34 million adults aged 20–79 years have **impaired glucose tolerance,** 10% of the regional population in this age group.

Estimates were made for 19 countries and territories in the IDF South and Central America (SACA) Region. Estimates for diabetes prevalence in adults aged 20–79 years were taken from 27 data sources from 16 countries.

Only Uruguay had a study conducted within the past five years. Estimates for Argentina, Bolivia, Brazil, Guatemala, Honduras and Nicaragua were based on studies that used oral glucose tolerance tests (OGTT). Diabetes prevalence figures for other countries may be underestimated. Estimates of the number of children and adolescents with type 1 diabetes in SACA were derived from studies in 12 countries.

Map 4.5.1 **Age-adjusted comparative prevalence (%) of diabetes (20–79 years) in IDF South and Central America Region, 2019**



IDF South and Central America Region at a glance

	2019	2030	2045
Adult population (20–79 years)	335.1 million	381.0 million	417.0 million
Diabetes (20–79 years)			
Regional prevalence	9.4% (7.8–11.7%)[i]	10.6% (8.8–13.1%)	11.8% (9.7–14.6%)
Age-adjusted comparative prevalence	8.5% (6.7–11.3%)	9.5% (7.4–12.6%)	9.9% (7.8–13.2%)
Number of people with diabetes	31.6 million (26.3–39.2 million)	40.2 million (33.3–49.9 million)	49.1 million (40.3–60.7 million)
Number of deaths due to diabetes (20–79 years)	243,200 (203,845–293,546)		
Diabetes-related health expenditure (20–79 years)			
Total health expenditure, USD	69.7 billion	80.4 billion	85.7 billion
Impaired glucose tolerance (20–79 years)			
Regional prevalence	10.1% (7.3–13.4%)	10.8% (7.9–14.3%)	11.5% (8.5–15.1%)
Age-adjusted comparative prevalence	9.7% (6.9–12.9%)	10.3% (7.5–13.7%)	10.7% (7.8–14.1%)
Number of people with impaired glucose tolerance	33.9 million (24.4–45.0 million)	41.0 million (29.9–54.3 million)	48.1 million (35.5–63.1 million)
Undiagnosed diabetes (20–79 years)			
Regional prevalence	41.9%	-	-
Number of people with undiagnosed diabetes	13.3 million (11.1–16.3 million)	-	-
Type 1 diabetes (0–19 years)			
Number of children and adolescents with type 1 diabetes	127,200	-	-
Number of newly diagnosed children and adolescents each year	12,300	-	-

i 95% confidence intervals are reported in brackets.

Figure 4.5.1 **Prevalence (%) estimates of diabetes by age and sex, IDF South and Central America Region, 2019**

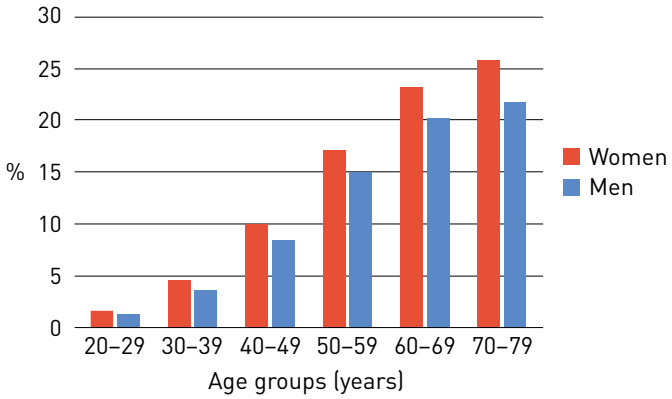
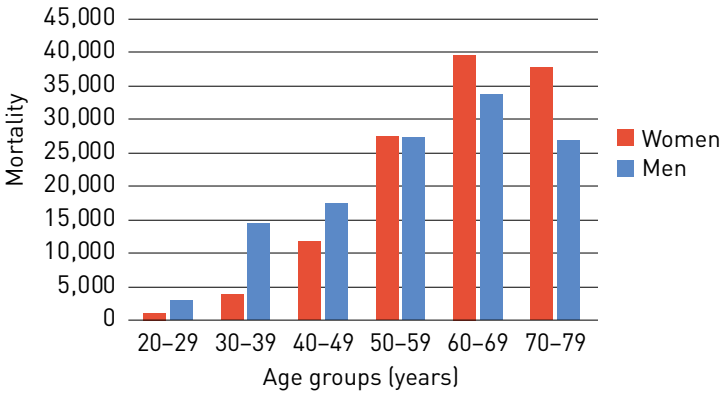


Figure 4.5.2 **Mortality due to diabetes by age and sex, IDF South and Central America Region, 2019**



Prevalence

An estimated 31.6 million adults aged 20–79 years in the SACA Region, or 9.4% of the regional population in this age group, have diabetes in 2019. Of these, 13.3 million (41.9%) are undiagnosed. About 85.5% of adults with diabetes live in urban settings and 87.5% live in middle-income countries.

Puerto Rico has the highest age-adjusted comparative prevalence of diabetes (13.7%) in adults aged 20–79 years in the Region. Brazil has the highest number of adults with diabetes (16.8 million). Diabetes prevalence is higher in women (17.9 million, 10.4%) than in men (13.8 million, 8.4%).

Estimates indicate that another 33.9 million adults aged 20–79 years, or 10.1% of the regional population in this age group, have impaired glucose tolerance (IGT) in 2019. The number of people with IGT is expected to rise to 41.0 million by 2030 and to 48.1 million by 2045.

An estimated 127,200 children and adolescents under the age of 20 have type 1 diabetes in the Region. Some 95,800 of these children and adolescents live in Brazil, which makes it the country with the third highest number of children and adolescents with type 1 diabetes in the world, after the United States of America and India.

Mortality

In 2019, an estimated 243,200 deaths in adults aged 20–79 years in the SACA Region were the result of diabetes or its complications (12.5% of all-cause mortality), with the highest percentage (16.2%) in the age group 50–59 years. An estimated 43.5% of these deaths occur in people under the age of 60. The number of deaths due to diabetes is higher in men (122,200) than in women (121,000), and there is higher diabetes-related mortality among middle-income countries (217,300) compared to high-income countries (25,900). Over half (55.6%, 135,200) of the diabetes-related deaths in the Region occur in Brazil.

Health expenditure

In 2019, total diabetes-related health expenditure in the SACA Region was USD 69.7 billion, corresponding to 9.2% of the global total. Health expenditure on diabetes in the Region is expected to increase by 15.3% by 2030, reaching USD 80.4 billion, and by 22.9% by 2045, reaching USD 85.7 billion.

In the SACA Region, 19.4% of health expenditure is dedicated to diabetes. Countries with the largest percentage are Cuba (24.3%), Brazil (24.2%), and Costa Rica (21.3%), while the lowest estimates are for Argentina (5.0%) and Uruguay (6.1%).

Mean annual health expenditure per person with diabetes, was highest in Brazil (USD 3,117), and lowest in Nicaragua (USD 564).

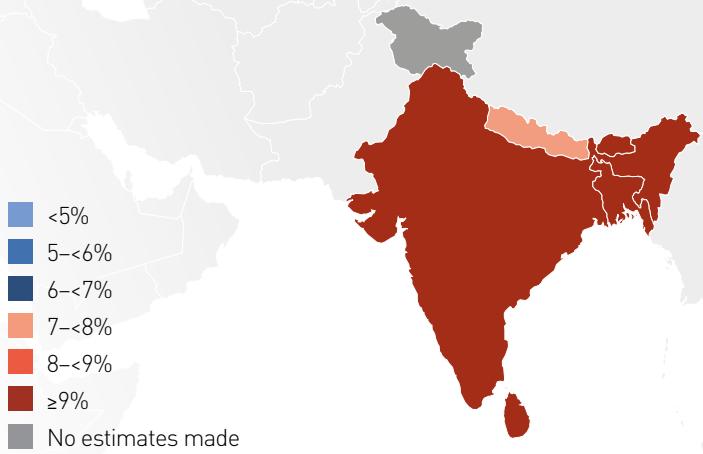
SOUTH-EAST ASIA

24% of live births are affected by hyperglycaemia in pregnancy.

Over **1 million people died due to diabetes** in 2019 – the second highest number of deaths of all IDF Regions.

Estimates were made for the seven countries and territories in the IDF South-East Asia (SEA) Region. All countries except Bhutan had primary data sources, which were used to generate estimates for diabetes in adults aged 20–79 years. A total of 13 data sources from these six countries were used. All data sources that were used to generate estimates are older than five years. Estimates for type 1 diabetes in children and adolescents were based on incidence data from four out of the seven countries in the Region.

Map 4.6.1 **Age-adjusted comparative prevalence (%) of diabetes (20–79 years) in IDF South-East Asia Region, 2019**



IDF South-East Asia Region at a glance

	2019	2030	2045
Adult population (20–79 years)	997.4 million	1.2 billion	1.3 billion
Diabetes (20–79 years)			
Regional prevalence	8.8% (7.1–11.1%)[i]	9.7% (7.9–12.2%)	11.3% (9.2–14.1%)
Age-adjusted comparative prevalence	11.3% (8.0–15.9%)	12.2% (8.6–17.2%)	12.6% (8.9–17.7%)
Number of people with diabetes	87.6 million (70.9–110.9 million)	115.1 million (92.9–144.5 million)	152.8 million (123.4–190.1 million)
Number of deaths due to diabetes (20–79 years)	1,150,300 (939,263–1,400,002)		
Diabetes-related health expenditure (20–79 years)			
Total health expenditure, USD	8.1 billion	10.1 billion	12.3 billion
Impaired glucose tolerance (20–79 years)			
Regional prevalence	3.1% (2.3–6.0%)	3.3% (2.5–6.3%)	3.7% (2.8–6.9%)
Age-adjusted comparative prevalence	7.7% (5.7–11.3%)	7.9% (5.9–11.6%)	8.0% (5.9–11.8%)
Number of people with impaired glucose tolerance	30.6 million (23.0–60.0 million)	39.1 million (29.5–74.8 million)	49.8 million (37.7–92.9 million)
Undiagnosed diabetes (20–79 years)			
Regional prevalence	56.7%	-	-
Number of people with undiagnosed diabetes	49.6 million (40.2–62.8 million)	-	-
Type 1 diabetes (0–19 years)			
Number of children and adolescents with type 1 diabetes	184,100	-	-
Number of newly diagnosed children and adolescents each year	21,300	-	-

i 95% confidence intervals are reported in brackets.

Figure 4.6.1 **Prevalence (%) estimates of diabetes by age and sex, IDF South-East Asia Region, 2019**

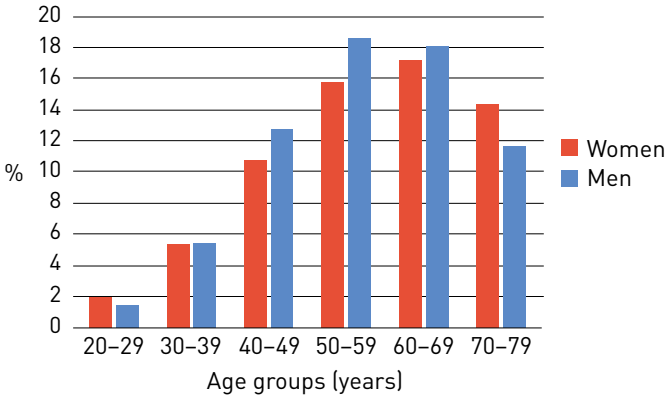
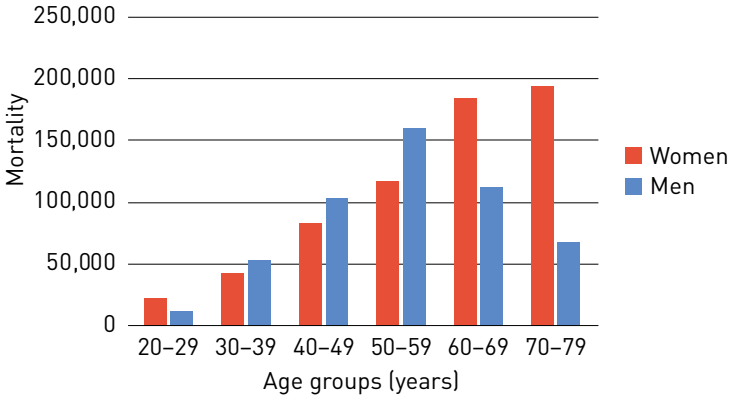


Figure 4.6.2 **Mortality due to diabetes by age and sex, IDF South-East Asia Region, 2019**



Prevalence

Estimates for 2019 indicate that 8.8% of the adult population aged 20–79 years has diabetes. This is equivalent to 87.6 million people, of whom 56.7% are undiagnosed. Although only one-third (34.3%) of adults in the SEA Region live in urban areas in 2019, nearly half (49.4%) of all adults with diabetes can be found in cities. Most people (98.2%) in the SEA Region live in middle-income countries and, as a result, 99.2% of adults with diabetes are in such countries.

Mauritius has the highest (22.0%) age-adjusted comparative diabetes prevalence in adults aged 20–79 years in the Region, followed by Sri Lanka (10.7%) and India (10.4%). India is home to the second largest number (77 million) of adults with diabetes worldwide. Adults with diabetes in India, Bangladesh, and Sri Lanka make up 98.9% of the total adult population with diabetes in the Region. Adults aged 50–70 years have the highest diabetes prevalence among all age groups.

In 2019, a further 30.6 million adults aged 20–79 years have impaired glucose tolerance (IGT) in the SEA Region. The number of people with diabetes in the Region is predicted to reach 115.1 million by 2030 or 9.7% of the adult population aged 20–79 years. By 2045, 152.8 million adults are expected to have diabetes, with an additional 49.8 million with IGT.

It is estimated that 184,100 children and adolescents under the age of 20 years are living with type 1 diabetes in the SEA Region. Approximately 21,300 children and adolescents developed type 1 diabetes in 2019. India is home to the second largest number of children and adolescents aged 0–19 years with type 1 diabetes in the world (171,300), and accounts for the majority of children and adolescents with diabetes in SEA.

Mortality

With 1.2 million deaths in 2019 (14.1% of all-cause mortality), the SEA Region has the second highest number of deaths attributable to diabetes in adults 20–79 years among the IDF Regions. More than half (51.5%) of these deaths occurred in people under the age of 60 years. The age group with the highest (21.3%) proportion of diabetes-related deaths from all cause mortality was 50–59 years. There are more diabetes-related deaths in women (643,400) than in men (507,000) and most of the diabetes-attributable deaths occur in middle-income countries (1,138,700). India was the largest contributor to regional diabetes mortality with more than 1 million estimated deaths attributable to diabetes and related complications.

Health expenditure

Total diabetes-related health expenditure in the SEA Region was USD 8.1 billion in 2019, the lowest total of all IDF Regions. However, it is projected that the Region will experience growth in health expenditure on diabetes in the next decades, reaching USD 10.1 billion in 2030 and USD 12.3 billion in 2045.

In the SEA Region, 8.4% of total health expenditures was allocated to diabetes. The highest percentage was in Mauritius (16.9%), and the lowest was in Nepal (4.2%).

The highest estimate in 2019 for mean annual expenditure per person with diabetes in the Region was USD 1,794 in the Maldives, while the lowest was USD 64 in Bangladesh. In India, which accounts for 87.9% of adults with diabetes in the Region, USD 92 was spent per person.

WESTERN PACIFIC

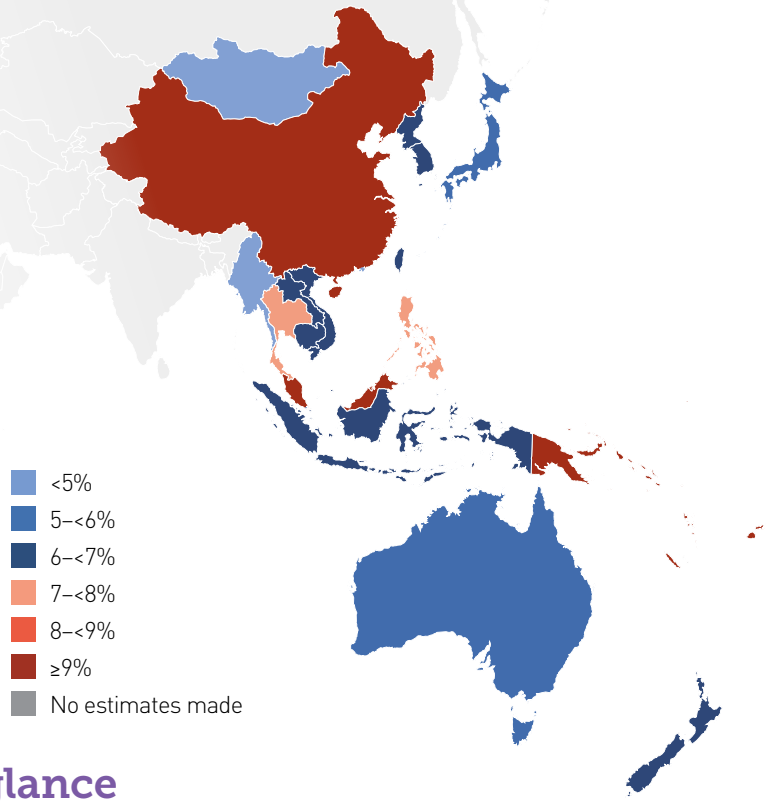
An estimated **163 million adults** aged 20–79 years **have diabetes** in the IDF Western Pacific Region. This is the highest number of all IDF Regions and represents 35% of the world's total number of adults with diabetes in this age group.

Close to **137 million adults** aged 20–79 years have **impaired glucose tolerance,** the highest of all the IDF Regions.

Estimates were made for 36 countries and territories in the IDF Western Pacific (WP) Region. For this edition of the *IDF Diabetes Atlas*, 60 data sources from 28 countries were used to generate estimates of diabetes in adults aged 20–79 years. Estimates for Brunei Darussalam, Myanmar, Republic of Korea and Thailand were based on studies conducted within the past five years. Other studies were performed between 1990 and 2013. Eleven countries in the Region had national studies based on oral glucose tolerance tests (OGTT). Diabetes prevalence figures for other countries may be underestimated.

Estimates for type 1 diabetes in children and adolescents were based on studies conducted in 11 countries of the Region.

Map 4.7.1 **Age-adjusted comparative prevalence (%) of diabetes (20–79 years) in IDF Western Pacific Region, 2019**



IDF Western Pacific Region at a glance

	2019	2030	2045
Adult population (20–79 years)	1.7 billion	1.8 billion	1.8 billion
Diabetes (20–79 years)			
Regional prevalence	9.6% (8.6–11.9%)[i]	11.0% (9.9–13.5%)	11.8% (10.5–14.3%)
Age-adjusted comparative prevalence	11.4% (8.3–15.6)	12.4% (9.0–16.8%)	12.8% (9.3–17.4%)
Number of people with diabetes	162.6 million (146.6–203.0 million)	196.5 million (176.6–241.6 million)	212.2 million (188.3–255.9 million)
Number of deaths due to diabetes	1,265,100 (1,137,890–1,482,903)		
Diabetes-related health expenditure (20–79 years)			
Total health expenditure, USD	162.2 billion	181.8 billion	184.7 billion
Impaired glucose tolerance (20–79 years)			
Regional prevalence	8.0% (5.0–13.0%)	8.7% (5.5–14.1%)	9.2% (5.9–14.9%)
Age-adjusted comparative prevalence	10.4% (7.1–16.0%)	11.0% (7.5–16.8%)	11.3% (7.6–17.2%)
Number of people with impaired glucose tolerance	136.5 million (85.5–221.0 million)	155.9 million (98.7–253.3million)	164.8 million (105.0–267.8 million)
Undiagnosed diabetes (20–79 years)			
Regional prevalence	55.8%	-	-
Number of people with undiagnosed diabetes	90.8 million (81.9–113.1 million)	-	-
Type 1 diabetes (0–19 years)			
Number of children and adolescents with type 1 diabetes	102,200	-	-
Number of newly diagnosed children and adolescents each year	11,200	-	-

i 95% confidence intervals are reported in brackets.

Figure 4.7.1 **Prevalence (%) estimates of diabetes by age and sex, IDF Western Pacific Region, 2019**

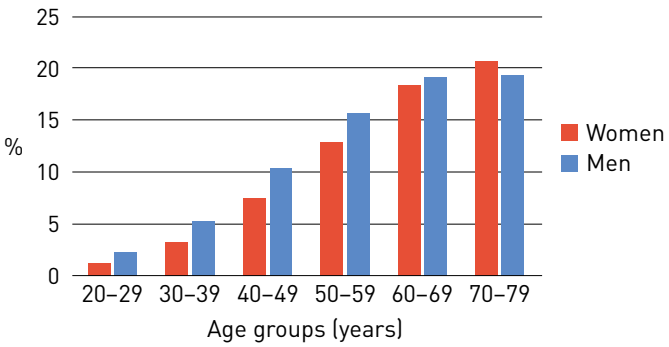
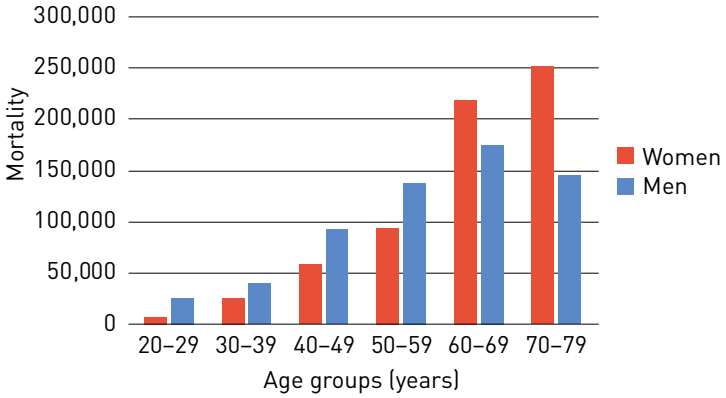


Figure 4.7.2 **Mortality due to diabetes by age and sex, IDF Western Pacific Region, 2019**



Prevalence

In 2019, 9.6% of adults aged 20–79 years are estimated to have diabetes in the WP Region, equivalent to 162.6 million people. Over half (55.8%) of these have undiagnosed diabetes. Over two-thirds (67.4%) of adults with diabetes live in urban areas and 90.5% live in low- and middle-income countries. The Region is home to 35.1% of the total number of adults with diabetes in the world.

The WP Region includes the country with the highest age-adjusted comparative prevalence: Marshall Islands (30.5%); and the country with the highest number of people with diabetes in the world: China (116.4 million).

It is predicted that there will be 196.5 million adults aged 20–79 years with diabetes in the WP Region by 2030 and 212.2 million by 2045, equivalent to 11.0% and 11.8% of the adult population in the Region, respectively.

There are also 136.5 million (8.0%) adults aged 20–79 years with impaired glucose tolerance (IGT) in the Region.

An estimated 102,200 children and adolescents under the age of 20 have type 1 diabetes, with approximately 11,200 diagnosed in 2019. About 54,000 of these children and adolescents are in China, likely due to China's large population rather than to a high incidence rate.

Mortality

In 2019, 1.3 million deaths due to diabetes (11% of deaths from all causes) among adults aged 20–79 years occurred in the WP Region. This is the highest number of deaths attributable to diabetes among all the IDF Regions. The highest proportion (14.3%) of mortality due to diabetes from all-cause mortality is reported in the age group 50–59 years. An estimated 37.7% of diabetes-related deaths occurred in adults under the age of 60 years and more diabetes-related deaths occurred in women (653,600) than in men (611,500). Within the Region, the highest number (1.1 million, 88.9%) of deaths attributable to diabetes occurred in middle-income countries, and 2.0% of all deaths occurred in low-income countries. China alone had 823,800 deaths due to diabetes in 2019, 33.4% occurring in people under the age of 60 years.

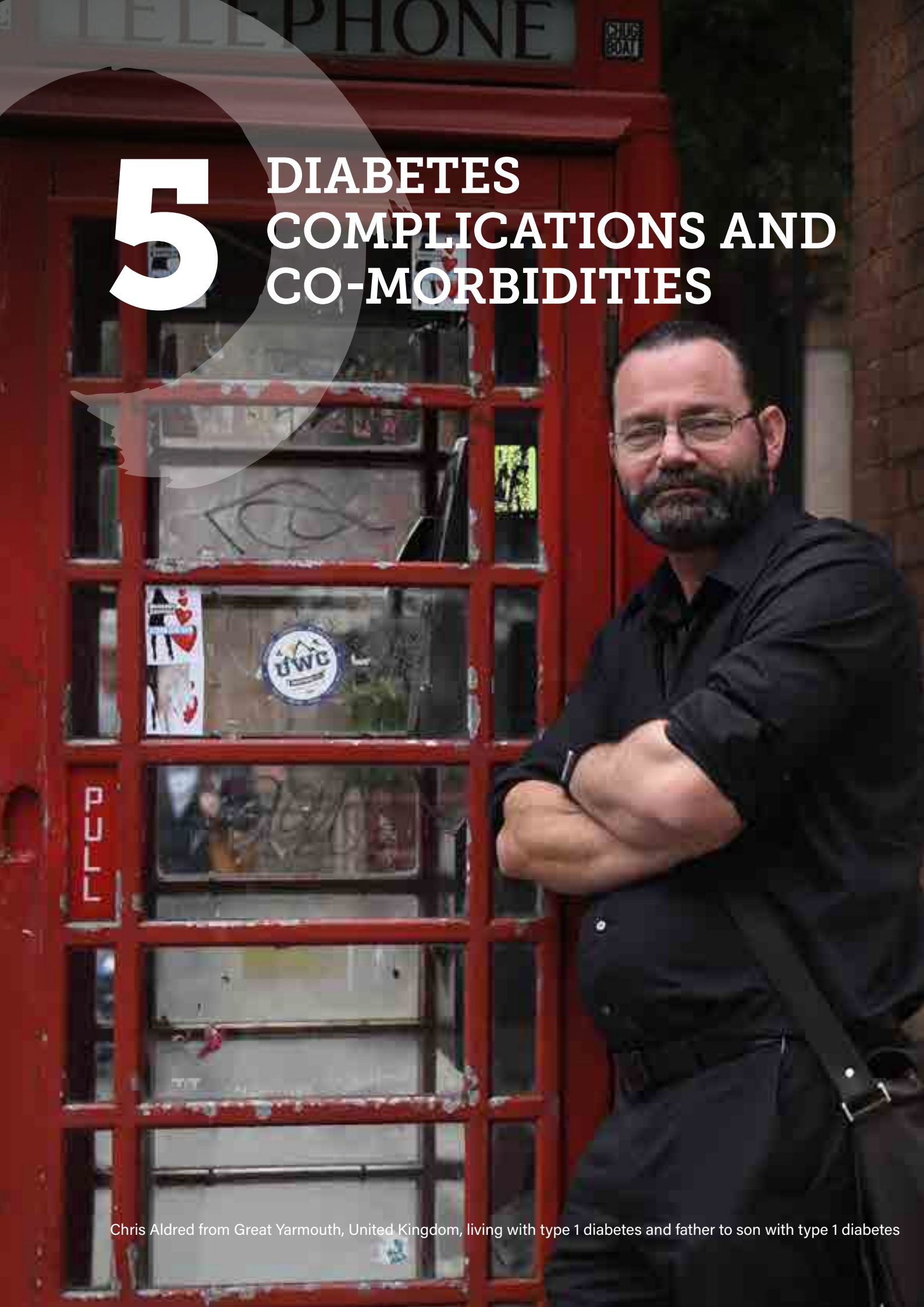
Health expenditure

In 2019, the total diabetes-related health expenditure in the WP Region was USD 162.2 billion. This total is expected to reach USD 181.8 billion in 2030 and USD 184.7 billion in 2045. China spent the most on diabetes in the Region (USD 109 billion), accounting for 67.2% of the regional total.

In the WP Region, 11.1% of health expenditure was spent on diabetes. The country with the highest percentage of diabetes-related health expenditure was Marshall Islands (38.8%), while the lowest was Japan (4.4%).

The highest mean annual expenditure per person with diabetes was in Australia (USD 5,000), while the lowest was in Papua New Guinea (USD 135).

5 DIABETES COMPLICATIONS AND CO-MORBIDITIES



Chris Aldred from Great Yarmouth, United Kingdom, living with type 1 diabetes and father to son with type 1 diabetes

Key messages

Lack of access to insulin, misdiagnosis or delayed diagnosis of type 1 diabetes, result in diabetic ketoacidosis, a common cause of death in children and young people with diabetes.

The long-term complications of diabetes can be present at diagnosis in people with type 2 diabetes and can appear early (around five years) after the onset of type 1 diabetes. Therefore, early detection is essential to prevent disability and death.

Self-management for people with diabetes is an important part of successfully preventing or delaying diabetes complications.

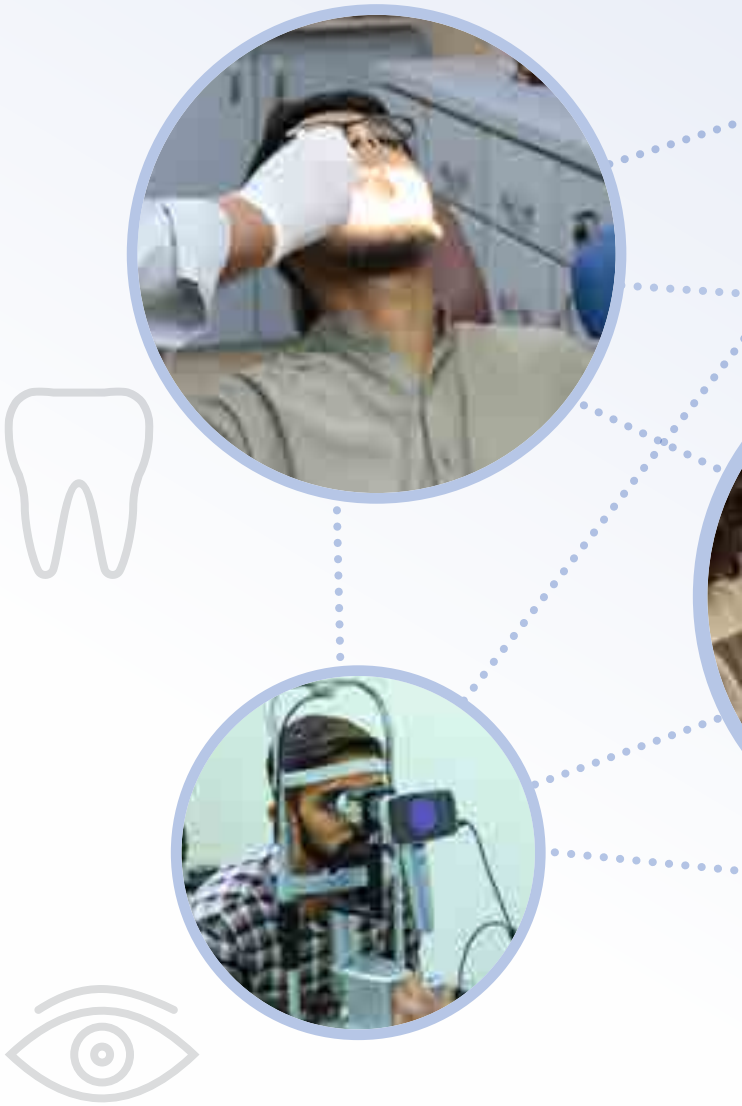
Acute complications

Acute diabetes complications, resulting from extremes of blood glucose levels are common in type 1 diabetes and can occur, with certain medications, in type 2 diabetes and other forms of the condition as well. They can lead to permanent neurological consequences or death.

If the initial diagnosis of type 1 diabetes is delayed, it typically presents with a build-up of ketones in the body, or diabetic ketoacidosis (DKA). It will also appear if blood glucose control is sub-optimal. DKA is a complex metabolic disorder that requires expert guidelines-based management.[1] With such care, outcomes are usually satisfactory, but deaths can still occur, particularly if cerebral oedema develops. There is also disturbing recent evidence that DKA may result in adverse neurocognitive outcomes in the medium term.[1,2] Management of DKA is also a considerable cost to a country's health system – treatment of a single DKA episode in the United Kingdom, for example, has been estimated to cost the health service GBP 1,387 (around USD 1,750).[3]

Hypoglycaemia is common in type 1 diabetes, and also in type 2 diabetes when insulin or sulphonylureas are used, as a fine balance must be achieved between glucose-lowering medicines, food intake and exercise. A rapid-acting carbohydrate such as a sweetened drink, glucose tablets or sweets can treat mild hypoglycaemia. Severe hypoglycaemia occurs when the person with diabetes requires external assistance, and can develop quickly into seizure and coma. Prompt treatment with glucagon or intravenous dextrose or glucose is required.[4] Hypoglycaemia may be implicated in some instances of 'dead-in-bed' syndrome.

These complications are even more dangerous in less-resourced countries. Many health facilities are unable to perform the various laboratory tests needed to diagnose DKA nor to administer the fluids and insulin required by infusion pump. Protocols are available for management in less-resourced settings, such as the IDF Life for a Child and International Society for Pediatric and Adolescents Diabetes (ISPAD) *Pocketbook Guidelines*,[5] and transfer should be arranged to tertiary centres when indicated.



An even greater problem is misdiagnosis of DKA in new-onset type 1 diabetes in children, adolescents and adults. Since type 1 diabetes is uncommon in many less-resourced countries, health professional awareness is low, and glucose testing facilities are limited. As a result, the diagnosis of type 1 diabetes is often mistaken for diagnoses of malaria, pneumonia, gastroenteritis, typhoid, malnutrition, HIV or other conditions.[6,7] If the diagnosis of type 1 diabetes is delayed, DKA will follow and the risk of morbidity and mortality rises. If missed entirely, the person will die. This may be the most common cause of death for children with type 1 diabetes globally.[8]

Health professional and community education are needed to address this and successful programmes have been conducted that have reduced DKA rates at diagnosis. IDF Life for a Child has also made six-icon education posters available in many languages in various countries and online.[9] Severe hypoglycaemia is also dangerous in less-resourced countries, and is likely to be more common where there is food insecurity. Glucagon is rarely available at home or even at hospitals, and access to intravenous glucose is difficult if the health facility is distant or has limited opening hours.

The hyperglycaemic hyperosmolar state (HHS) can also occur in people with type 2 diabetes. The onset of HHS can be insidious but it can progress to profound dehydration and electrolyte losses, with a risk of other complications.[1] Accurate diagnosis and careful treatment is required to achieve good clinical outcomes. Although there are multiple precipitating causes, infections are the most common. Up to 20% of people with HHS do not have a previous diagnosis of diabetes. The elderly, the chronically ill and institutionalised populations are at increased risk for HHS. Overall mortality for HHS is estimated at 5–20%: 10 times higher than that for DKA.[10]

Diabetes and elevated blood glucose are associated with an approximate doubling of cardiovascular diseases risk.

The risk of cardiovascular diseases in people with diabetes can be reduced by lowering high blood pressure and high glucose levels, and using lipid-lowering medications.

Diabetes and cardiovascular diseases

Diabetes, and the continuum of blood glucose levels even below the diabetes diagnostic threshold, are associated with a wide range of cardiovascular conditions that collectively comprise the largest cause of both morbidity and mortality for people with diabetes.[11] Systematic reviews indicate that the relative risk of cardiovascular diseases (CVD) is between 1.6 and 2.6, but that the relative risk is higher among those of younger age and slightly higher in women.[12,13] Across the full spectrum of fasting glucose, haemoglobin A1c (HbA1c), or 2-hour glucose test results, each standard deviation (SD) is associated with a 6–20% increased risk of CVD events (Table 5.1).

These associations have contributed to a prevalence of coronary artery disease of around 21% (range from 12% to 32%) and any CVD of 32% in adults with diabetes living in high- and middle-income countries.[14] Excess glucose has been shown to be associated with about 15% of all deaths due to CVD, kidney disease and diabetes.[15,16] However, the relative risk of CVD may vary across regions and between high- and low-income countries, and there are few specific data on this variability.[17]

Although rates of CVD incidence and related mortality have declined substantially in many countries in recent decades, such data are limited to high-income countries that represent only about 10% of the world, leaving the status of trends and progress in most of the world unclear.[18] The most common and classic types of CVD associated with diabetes are coronary heart disease, cerebrovascular disease, peripheral artery disease, and congestive heart failure, and these are manifested as specific events, hospitalisations, procedures and deaths from acute coronary syndromes, myocardial infarction, ischaemic and haemorrhagic stroke, as well as sudden death. Peripheral artery disease is also a potent cause of lower extremity amputations. Collectively, CVD accounts for between one-third and one-half of all deaths.

Elevated levels of blood glucose, and diabetes itself, lead to increased risk of CVD through multiple mechanisms, including insulin resistance, inflammation, endothelial dysfunction, and the toxic effects of glucose on microvasculature.[19] In addition, elevated blood glucose levels are associated with a common set of other underlying metabolic risk factors, including hypertension, dyslipidaemia, and central obesity. Risk is also strongly affected by smoking and by low levels of physical activity. This wide range of risk factors is accompanied by numerous opportunities to reduce risk. Lowering high blood pressure and high glucose levels and using drugs that lower cholesterol can each significantly reduce the risk of CVD outcomes. These goals can be achieved through implementation of health system-based approaches of team-based care with case managers, clinical registries, tools for decision support, and patient education. In addition, community- and population-wide approaches that facilitate increasing levels of physical activity and diets rich in fresh fruits and vegetables, whole grains, cereal fibres and healthy fats will reduce long-term risk for people with diabetes.

Table 5.1 **Global estimates of the association and impact of diabetes on cardiovascular diseases**

Outcome	Impact	Data systems / study	Reference
Prevalence of cardiovascular diseases	Any cardiovascular disease: 32% Coronary heart disease: 21% Myocardial infarction: 10% Stroke: 7.6%	57 cross-sectional studies	Einarson et al., 2018[14]
Coronary heart disease	160% increased risk	102 prospective studies	Emerging Risk Factors Collaboration, 2010[12]
Ischaemic heart disease	127% increased risk	102 prospective studies	Emerging Risk Factors Collaboration, 2011[13]
Haemorrhagic stroke	56% increases risk	102 prospective studies	
Cardiovascular diseases death	132% increased risk	97 prospective studies	
Years of life lost	5.8 years for men age 50 6.4 years for women age 50	97 prospective studies	

Early diagnosis and timely treatment of diabetic retinopathy can prevent sight impairment and blindness.

Optimised blood glucose and blood pressure management complemented by screening for diabetic retinopathy can reduce the impact of diabetic eye disease.

Internationally agreed standards for screening methods and diagnostic criteria are required to make meaningful comparisons of diabetic retinopathy prevalence between countries, regions and ethnic groups.

Diabetic eye disease

Diabetic eye disease (DED) is a much-feared complication of diabetes, consisting predominantly of diabetic retinopathy (DR), diabetic macular oedema (DMO), cataract and glaucoma, but also double vision and inability to focus. In most countries, DR is acknowledged to be one of the leading causes of blindness in the working age population with devastating personal and socioeconomic consequences, despite being potentially preventable and treatable.[20–30]

Based on an analysis of 35 studies worldwide carried out between 1980 and 2008, the overall prevalence of any DR in people with diabetes using retinal images was estimated to be 35% with vision-threatening DR present in 12%.[31] DR prevalence increased with duration of diabetes in both type 1 and type 2 diabetes, and was associated with deteriorating glycaemic control and the presence of hypertension. DR was more common in people with type 1 diabetes, with differences evident between Asians (20.8%), Caucasians (44.7%) and African Americans (55.7%) with type 2 diabetes.

However, this review did not include data from low- and middle-income countries where diabetes impact is highest and access to DR screening and management is lowest.

A more recent review in 2015[32] further emphasised the considerable heterogeneity in prevalence of DR across the globe and within countries. This was demonstrated, for example, by the United States of America having a wide range of any DR and sight-threatening DR (STDR) prevalence, both in type 1 diabetes (ranging from 36.5% to 93.6%, and 6.7% to 34.9%, respectively) and in type 2 diabetes (from 28.5% to 40.3% and 4.4% to 8.2%, respectively). In general, Asian countries had a lower prevalence of DR (12.1–23.0%) and STDR (4.3–4.6%) with the exception of Singapore, where rates more analogous to those of western countries were observed, while retaining ethnic differences between Malaysians (33.4%), Indians (33.0%) and Chinese (25.4%). In 2015, a community-based national DR screening service in Wales (for people aged 12 years and over) used retinal images to reveal that the prevalence of DR and STDR in type 1 diabetes was 56.0% and 11.2% respectively, and in type 2 diabetes was 30.3% and 2.9% respectively.[33] However, meaningful comparisons between regions and ethnic groups across the globe can only be made following the adoption of internationally agreed screening methods and diagnostic criteria for DR.[34]

In 2019, a systematic review[35] of the incidence of DR based on eight studies that were conducted after 2000 (five from Asia, and one each from North America, Caribbean and sub-Saharan Africa) indicated that the annual incidence of DR ranged from 2.2% to 12.7% and annual progression to STDR ranged from 3.4% to 12.3%. The review emphasised that more high-quality population-based studies are needed to consolidate the evidence base on which to develop related public health strategies, such as screening programmes for DR.

Over the past 20 years or so, systematic screening has been adopted in several countries.[33,36–40] Following the introduction of screening in the United Kingdom DR is no longer the primary cause of blindness in the working age population[41] with further evidence from Wales demonstrating a 40–50% reduction in the incidence of new certification for visual impairment and blindness over eight years.[42] The establishment of successful DR screening programmes benefits from both sociopolitical acceptance and health care professional commitment on a long-term basis. The implementation of DR screening will benefit from a committed champion to oversee, construct and implement integrated care pathways across the spectrum of relevant health care professionals. Consideration should be given to international and national guidelines for diabetes care and examples of best practice in screening for DR elsewhere in the world.[29,30,33,36-40,43,44] Providing information to raise general awareness of the relationship between diabetes and vision impairment and blindness along with specific education for people with diabetes and related health care professionals is an early and mandatory step in overcoming barriers to DR screening.[44] Understanding the economic impact of sight impairment and blindness is essential to appreciate fully the socioeconomic consequences of DR.

The WHO *Universal Eye Health: A Global Action Plan 2014–2019*[29] outlines the need to achieve a reduction in the prevalence of avoidable visual impairment and blindness including that related to diabetes, which is currently among the five most common causes of both moderate or severe visual impairment and blindness. WHO Member States have committed to reducing the prevalence of avoidable visual impairment by 25% by 2019 compared to the baseline established by WHO in 2010. This, however, remains to be achieved. Further research is required to fill the existing knowledge gaps in the natural history of DR to introduce prevention strategies facilitated by improved resource allocation to maintain diabetes-related eye health in the future despite an increasing number of people with diabetes.

The economic impact of DED is considerable since visual impairment and blindness have a devastating impact on quality of life and the economic status of both individuals and the society in which they live. Estimates of related expenditure are available for some countries including Australia, Canada, Hong-Kong, Japan, Singapore, Spain, Sweden, the United Kingdom and the United States of America. All have underlined the heavy and increasing financial impact due to the direct and indirect consequences of DED. Estimates are not available from low- and middle-income countries.

Understanding of the economic impact of sight loss and blindness is essential if the socioeconomic impact is to be fully appreciated and to enable international comparisons. Prevention of DR and progression to STDR will undoubtedly reduce related economic impact.

Diabetes, hypertension, or a combination of both, cause 80% of end-stage renal disease globally.

Both diabetes and chronic kidney disease are strongly associated with cardiovascular diseases. Controlling blood glucose and blood pressure can reduce associated risks.

The most effective strategies to reduce the impact of kidney disease in diabetes are to prevent type 2 diabetes and to diagnose and treat kidney disease early and effectively in people already living with diabetes.

Diabetic kidney disease

Chronic kidney disease (CKD) in people with diabetes can result from diabetic nephropathy or can be the result of other associated conditions such as hypertension, polyneuropathic bladder dysfunction, increased incidence of relapsing urinary tract infections, or macrovascular angiopathy. In the United Kingdom, 25% of people with diabetes[45] and, in the United States of America, 36% of people with diabetes, have CKD, 19% of these at stage 3 or worse.[46] A decline in CKD during type 1 diabetes has recently been reported in the United States of America, but not in type 2 diabetes.[47]

Globally, more than 80% of end-stage renal disease (ESRD) is caused by diabetes or hypertension, or a combination of both. The proportion of ESRD attributed to diabetes varies between 10% and 67%.[46] The prevalence of ESRD is also up to 10 times higher in people with diabetes than in those without.

Diabetes, hypertension and CKD are highly interlinked. In type 2 diabetes, hypertension often precedes CKD and contributes to the progression of nephropathy, whereas in type 1 diabetes, hypertension is more often a consequence of CKD.[48,49] Hyperglycaemia induces hyperfiltration and morphological changes in the kidneys that ultimately lead to an increased urinary albumin excretion (albuminuria), podocyte damage and loss of filtration surface,[47,50] hence the use of albuminuria and glomerular filtration as screening tests in this field.

The most effective strategy to reduce the impact of diabetic kidney disease is to prevent type 2 diabetes and, among those already affected by diabetes, to diagnose and treat CKD in its early stages. Screening for albuminuria, or glomerular filtration rate (GFR), is cost-effective in people with diabetes and hypertension.[51] Screening for albuminuria is recommended yearly after diagnosis of type 2 diabetes, and the same after the first five years in people with type 1 diabetes.[52]

Both diabetes and CKD are strongly associated with CVD and, therefore, controlling blood glucose and blood pressure can reduce the risk of both CVD and CKD. When CKD has advanced to stage 3, special considerations are needed regarding selection and dosage of glucose-lowering drugs and other medications. Once the disease has advanced to stage 4 and 5, referral to a nephrologist is required for planning of renal replacement therapy (initially dialysis), monitoring and management of anaemia, hyperpotassaemia and lack of phosphate. In some cases, consideration of pancreas and kidney transplantation should take place. Currently, only a fraction of people has access to dialysis and renal replacement therapy on a global scale.[53]

Diabetes-related CKD is associated with significant additional health expenditure. In a United States of America study conducted between 1999 and 2002, the mean annual healthcare costs were 49% higher among people with diabetes and clinical nephropathy than among those with no nephropathy. For people with diabetes undergoing dialysis, the mean annual healthcare cost increased 2.8 times compared with ESRD patients not on dialysis.[54]

The most effective strategy to reduce the economic impact (and, more importantly, to improve quality of life) is to prevent type 2 diabetes and, among those already affected with all types of diabetes, to diagnose and treat CKD in its early stages. Based on a United Kingdom study, early therapy can lead to important lifetime cost savings when compared with a later start of the same intervention.[55] A study from Thailand has obtained similar results, with angiotensin-converting-enzyme (ACE) inhibitors used as therapy for the delay of ESRD among patients with albuminuria, producing savings of USD 120,000 per 100 people with diabetes.[56]

Diabetic foot and lower limb complications, which affect 40 to 60 million people with diabetes globally, are an important source of morbidity in people with diabetes. Chronic ulcers and amputations result in a significant reduction in the quality of life and increase the risk of early death.

Less than one-third of physicians recognise the signs of diabetes-related peripheral neuropathy. The resulting missed diagnoses contribute greatly to these high rates of morbidity and mortality.

Nerve and/or vascular damage and diabetic foot complications

Peripheral neuropathy is the most common form of diabetes-related neuropathy. It affects the distal nerves of the limbs, particularly those of the feet. It mainly alters the symmetrical sensory function causing abnormal feelings and progressive numbness. These conditions facilitate the development of ulcers resulting from external trauma and/or abnormal distribution of the internal bone pressure (the so-called 'diabetic foot').

Diabetic foot complications are severe and chronic. They consist of lesions in the deep tissues associated with neurological disorders and peripheral vascular disease (PVD) in the lower limbs. The reported prevalence of diabetes-related peripheral neuropathy ranges from 16% to as much as 87%[57] with painful diabetes-related neuropathy reported in about 26% of adults with diabetes.[58]

Lower limb amputation in people with diabetes is 10 to 20 times more common compared to those without diabetes.[59] It has been estimated that, globally, a lower limb (or part of a lower limb), is lost to amputation every 30 seconds as a consequence of diabetes.[60] Foot ulcers and amputations are more common in low- and middle-income countries than in high-income countries.[61] The annual incidence of foot ulceration among people with diabetes is about 2%. Approximately 1% of people with diabetes suffer lower-limb amputation at some stage.[62,63]

The global prevalence of diabetic foot complications varies between 3% in Oceania to 13% in North America, with a global average of 6.4%. Prevalence is higher for men than for women. Similarly, it is higher among people with type 2 diabetes, compared with those with type 1 diabetes.[64]

People with PVD have an increased risk of diabetic foot amputation, myocardial ischaemia and stroke, with long-term disability, and an increased risk of death.[65,66] Approximately 50% of people with PVD are asymptomatic, while 33% have atypical symptoms. Recent data suggest that PVD affects more than 200 million people globally.[67,68] Using the ankle brachial index (ABI) to identify PVD, estimates show the prevalence of PVD in people over 40 years of age with diabetes is 20%. This prevalence increases to 29% in people over 50 years of age with diabetes.

Intensive blood glucose management (with an HbA1c target of less than 53 mmol/mol (or 7% in Diabetes Control and Complications Trial units)) can lead to a 35% risk reduction of amputation compared to less intensive glycaemic management.[69] In addition, two management strategies should be prioritised:

- Increasing awareness and knowledge among healthcare professionals about the management of diabetic foot complications.
- Conducting regular screening and risk stratification for at-risk feet.

Less than one-third of physicians recognise the manifestations of diabetes-related peripheral neuropathy, even when the patient is symptomatic.[70] Moreover, there is a lack of understanding of the comprehensive management and treatment of diabetic foot complications among healthcare professionals.[71] Comprehensive diabetic foot complications risk assessments and foot care based on prevention, education and support by a multi-disciplinary team reduces foot complications and amputations by up to 85%.[72]

People with diabetes who have foot ulcers bear health expenditures five times higher than those without foot ulcers. Compared to people with diabetes without foot ulcers, the cost of care 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.[73]

Gestational diabetes mellitus is associated with multiple adverse pregnancy outcomes.

Women with gestational diabetes mellitus are at subsequent high risk of type 2 diabetes, especially three to six years after delivery.

Exposure to hyperglycaemia *in utero* predisposes children to a high risk of becoming overweight or obese, resulting in insulin resistance associated with the development of impaired glucose tolerance and type 2 diabetes.

Diabetes-related complications of pregnancy

The most common form of hyperglycaemia during pregnancy is gestational diabetes mellitus (GDM). The definition of GDM originated from a long-term follow-up study by O'Sullivan.[74] This was based on the observation that women with hyperglycaemia in pregnancy (HIP) had a markedly increased risk of diabetes over 15 years after the index pregnancy. Studies in recent decades have also focused on adverse pregnancy outcomes, and numerous studies report that GDM is associated with substantial risk of perinatal morbidities. The recently defined diagnostic cut-off points for the diagnosis of GDM – for fasting, 1-hour and 2-hour plasma levels during an OGTT – were selected based on their associations with adverse pregnancy outcomes.[75] There is strong evidence linking GDM not only to adverse perinatal outcomes but also to long-term health outcomes in mothers and offspring.

A large body of relatively small and un-blinded studies has noted an association between GDM and increased risks of perinatal morbidities in mothers and their infants. These findings were confirmed in a large multinational double-blinded study. The Hyperglycaemia and Adverse Pregnancy Outcomes (HAPO) study found linear associations, without clear threshold points, between plasma glucose

levels at fasting, 1-hour and 2-hour after a 75g glucose load and increased risk of: birth weight ≥90th percentile; cord blood serum C-peptide ≥90th percentile; primary caesarean section; clinical hypoglycaemia; premature delivery; shoulder dystocia and/or other birth injuries; the need for intensive neonatal care; neonatal hyperbilirubinemia; and maternal preeclampsia.[75] Intervention studies have demonstrated that tight control of hyperglycaemia through lifestyle can improve perinatal outcomes in women with GDM (as defined by 1999 WHO criteria)[76] and as defined by the International Association of Diabetes and Pregnancy Study Group's criteria.[77]

GDM is associated with markedly increased risk of type 2 diabetes in women later in their life. Women with prior GDM are at a 7.4-fold risk of type 2 diabetes compared to women with normoglycaemic pregnancy.[78] The risk of type 2 diabetes in women with prior GDM was particularly high at 3–6 years after the index delivery and at an age below 40 years.[79]

There is global variation in the risk of type 2 diabetes after GDM, with women living in Europe, the Middle East and North America being at the highest risk (Table 5.2). It is known that early onset of diabetes predisposes these women at particularly high risk of macrovascular disease and microvascular disease.[80] Indeed, a meta-analysis has already shown that women with prior GDM are at increased risk of CVD with a 1.95-fold odds of developing CVD as compared to women without GDM.[81] However, preliminary data show that lifestyle intervention at postpartum may benefit women who had prior GDM, leading to reduced body weight.[82]

GDM is associated with an increased risk of adverse long-term health outcomes in the offspring. Exposure to hyperglycaemia during pregnancy increases the risk of childhood overweight and obesity. At 10–14 years, offspring exposed to untreated GDM *in utero* have been shown to have increased insulin resistance and, consequently, higher risk of IGT.[83] It has been shown that effective intervention during GDM can improve fasting glucose and insulin resistance in female offspring at 5–10 years of age.[84]

Table 5.2 **Risk and adjusted risk for diabetes in women with prior gestational diabetes mellitus by years after gestational diabetes mellitus, age at follow-up and global regions (data are extracted from Song et al. 2018)[79]**

	Relative risk (95% confidence interval)	Odds ratio (95% confidence interval)[i]
Years after gestational diabetes mellitus		
<3	4.8 (2.2–10.6)	5.4 (3.5–9.3)
3–<6	16.2 (10.0–26.2)	16.6 (16.1–17.0)
6–<10	6.6 (3.6–12.1)	8.2 (4.5–14.9)
≥15	6.0 (1.6–22.5)	7.9 (6.4–9.7)
Age on follow up, years		
<35	6.8 (3.3–14.1)	17.5 (16.3–18.8)
35–<40	14.7 (8.9–24.4)	18.2 (16.7–19.8)
≥40	5.5 (1.4–20.7)	10.4 (8.5–12.7)
Region		
NAC	6.1 (2.0–18.6)	16.2 (15.7–16.7)
SACA	2.0 (0.4–9.4)	3.0 (1.1–7.8)
WP	7.3 (5.7–9.4)	8.3 (6.5–10.6)
SEA	6.2 (0.5–75.2)	5.5 (3.1–9.8)
EUR	11.5 (7.5–17.6)	18.3 (17.0–19.6)
MENA	7.0 (1.2–41.5)	17.9 (16.4–19.5)
AFR	No data	No data

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; OR: odds ratio; RR: relative risk. 95% confidence intervals shown: where these cross 1, no significant relationship has been shown.

i Adjusted for: years after gestational diabetes mellitus, age at pregnancy; age on follow up; body mass index at pregnancy and on follow-up; regions; the Newcastle-Ottawa Scale score; diagnostic criteria for GDM; and parity on follow up.

Children and adolescents with type 1 diabetes or type 2 diabetes are at risk of developing any of the micro- and macro-vascular complications seen in adults with diabetes.

Children and adolescents with diabetes and those in vulnerable families need special attention and support.

Complications in children – type 1 and type 2 diabetes

Children and adolescents (0–19 years of age) with type 1 or type 2 diabetes can develop all the micro- and macro-vascular complications seen in adults with diabetes. Since disease duration is a major risk determinant, micro- and macro-vascular complications may develop at young ages. Therefore, children and adolescents with type 1 diabetes, after five years of disease duration, need routine screening for high blood pressure, albuminuria and retinopathy. For adolescents with type 2 diabetes, screening should begin at diagnosis. Type 2 diabetes diagnosed before the age of 20 years is associated with an accelerated risk of retinopathy, nephropathy and nerve damage compared with type 1 diabetes at a comparable age and duration.[85] Indications demonstrate that survival is shorter among individuals with early onset type 2 diabetes compared with type 1 diabetes.[86]

Children and adolescents in vulnerable families need special attention and support, since children with diabetes in such families have greater risk of failure in daily treatment and have an increased risk of nephropathy[87] and early death.[88]

The economic impact of complications

The health costs of detection and treatment of diabetes-related complications are high. All of the complications of diabetes, both acute and long-term, contribute significantly to the overall economic impact of the condition. This relates both to direct costs, for which the costs of hospitalisation for diabetes complications are a major driver, and to indirect costs since complications are the most significant contributors to premature mortality, disability and absenteeism. Personal concerns about the development of complications in the future and their potential impact on quality of life mean that they are also significant contributors to the intangible costs of the condition – those resulting from worry, anxiety, discomfort, pain, loss of independence and a host of other non-financial but crucially important features of living with diabetes.

These significant economic effects of diabetes-related complications on direct costs have been well known, from early estimates reported from pan-European studies[89] to, for example, the most recent assessment of diabetes health costs for the United States of America.[90] Studies from Germany,[91,92] the United Kingdom,[93] Italy[94] and more focussed work from the United States of America,[95,96] for example, have examined this question in detail. As for other aspects of the economics literature, there is a dearth of diabetes-wide, population-based data from low- and middle-income countries dealing with the costs of specific complications.

It is not the purpose of this section to present detailed conclusions from these studies. It is clear, however, that the treatment of complications is a major contributor to direct costs (53% of them, for example in Germany[92] and, coincidentally, also in the United States of America[95]) and that the main contributors identified (though not always in the same order) are: cardiovascular diseases, diabetes-related foot complications (including amputations), diabetes-related eye disease and diabetes-related kidney disease. Direct 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.[94]

The health costs of treating the complications of diabetes account for over 50% of the direct health costs of diabetes.

Diabetes complications, as frequent causes of disability, premature mortality and absence from work due to sickness, are important drivers of indirect costs.

The early detection and improved management of diabetes complications will have benefits not only for the individuals with diabetes but also for the wider health economy. For example, intensive blood pressure control among people with type 2 diabetes and high blood pressure can be cost-saving compared with standard blood pressure control; screening for diabetic retinopathy is very cost-effective compared with no screening; and comprehensive foot care can save costs by preventing ulcers in people with high risk of ulcers compared with routine foot care.[97] Better care of people with diabetes and subsequent prevention of these late complications promises not only to improve quality of life but also to be highly cost-effective.

The contributions of specific complications of diabetes to indirect costs are largely unknown. However, since premature mortality, disability and absenteeism are overwhelmingly likely to be the result of complications, it follows that these are also likely to be the main drivers of indirect costs. It could be argued that the most important missing information in cost-of-illness studies in diabetes is the contribution of specific complications to indirect costs. Also, Bommer *et al*[98] have commented on the need for more information on the contribution of undiagnosed diabetes to indirect costs since the risk of developing these complications is likely to be higher in those whose diabetes is unrecognised.

Type 2 diabetes and high body mass index are associated with an increased risk of a number of common cancers, with high body mass index associated with almost twice as many cancers as diabetes.

The global rise in elevated body mass index and type 2 diabetes is cause for concern in relation to global cancer impact.

Co-morbidities

Diabetes and cancer

A greater risk of cancer has been detected among adults with type 2 diabetes and those with a high body mass index (BMI), with the strongest associations found for breast and endometrial cancer in women and colorectal and intrahepatic (liver) cholangiocarcinoma in both sexes.[99] The elevated cancer risk for these sites ranges from 20% higher risk (breast cancer) to a nearly two-fold greater risk (endometrial and intrahepatic cholangiocarcinoma).

Pearson-Stuttard *et al*[100] estimated that 5.7% of incident cancers in 2012 were attributable to the combined effects of diabetes and high BMI. Globally, this amounted to just over 800,000 new cases in that year. They defined 'high BMI' as a BMI greater than or equal to 25 kg/m^2 and used age, sex and country specific data for both BMI and diabetes (type 1 diabetes and type 2 combined) from the NCD Risk Factor Collaboration (NCD-RsC) 2016 and 2017.[101,102] High BMI was responsible for around two-thirds (544,300) of these cases. Analysis by cancer site (and assuming that high BMI and diabetes are

Figure 5.1 Annual numbers of cancer cases attributable to diabetes and high BMI by sex

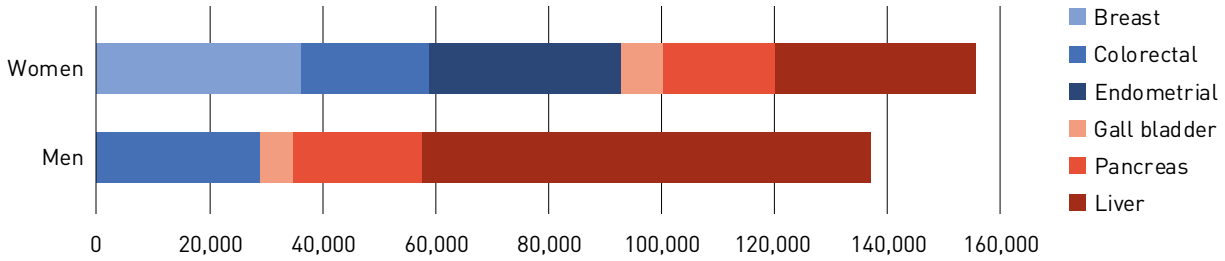
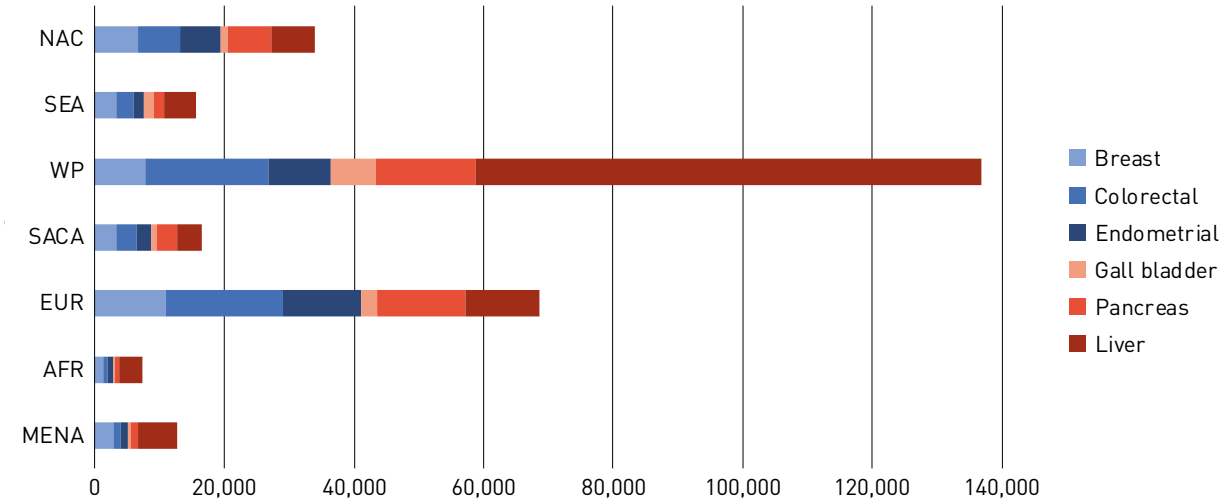


Figure 5.2 Numbers of diabetes-attributable cancers by IDF Region



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.

independent risk factors) revealed that, in women, an estimated 27.3% of liver cancers are attributable to these risk factors (23.3% in men) and around 19% of cases of cancer of the pancreas. The equivalent figure for endometrial cancer in women is 38.4%. More conservative estimates, assuming non-independence of risk, reduced these figures but not substantially. The contributions were calculated by population attributable fraction (PAF). Pearson-Stuttard *et al's* data[100] have been re-analysed by IDF Region. The results are shown graphically in Figures 5.1 and 5.2, which show, respectively, the numbers of attributable cancers for six major sites in women and four in men, and the numbers of attributable cancers at these same six sites by IDF Region.

Not only is the proportion of cancer cases attributable to high BMI and diabetes of considerable public health significance, but the degree of the effect is increasing and is forecast to continue to increase as the prevalence of overweight, obesity and type 2 diabetes continue to rise. Further analyses by Pearson-Stuttard *et al*,[100] show clearly that, in all regions of the world, the proportions of attributable cancers increased when those based on 2002 data were compared with those based on 1980 data (also obtained from NCD-RisC sources,[101,102]) with one in four cases rising to one in three between 2001 and 2012. In some instances, these estimates doubled (e.g. cancers attributable to high BMI in men in the East and South-East Asia region – from 2.3% to 5.6%). The further increases in high BMI and type 2 diabetes since those years, underline the urgent necessity to reduce this wider threat of the so-called 'metabolic syndrome' to public health. In addition, people with diabetes should be strongly encouraged by their healthcare professionals to undergo appropriate cancer screenings as recommended for all people in their age group and sex. Finally, results of some, but not all, epidemiological studies suggest that

diabetes may significantly increase mortality in patients with cancer (e.g. breast and colorectal cancer).

The findings described so far are statistical associations and there is uncertainty about the exact nature of any link between cancer risk and high BMI and diabetes. It has been suggested that cancer and the metabolic syndrome (which includes overweight and abdominal obesity, type 2 diabetes, hypertension and dyslipidaemia) share common risk factors – the 'common soil' hypothesis. Among a number of possibilities, Bellastella *et al.*[103] highlight an unhealthy diet as a possible common risk factor for cancers at some common sites and the metabolic syndrome (and, thus, overweight, obesity and type 2 diabetes). Others include physical inactivity, tobacco use and hyperinsulinaemia. These suggested common risk factors thus further strengthen, if further strengthening were needed, the requirement to encourage and facilitate healthy lifestyle habits. It is also noteworthy that diabetes is associated with a lower risk for prostate cancer. Some metabolic factors associated with diabetes, such as reduced testosterone levels, may be involved.

Most cancer cells express insulin and insulin-like growth factor 1 (IGF-I) receptors. Once activated, these signalling pathways may stimulate multiple cancer phenotypes including proliferation, protection from apoptotic stimuli, invasion and metastasis, potentially enhancing promotion and progression of many types of cancer cells.[104] These mechanisms and other aspects of the relationships between high BMI and/or type 2 diabetes and cancer require further and urgent investigation.

The effects on future cancer risk of different blood glucose lowering therapies in type 2 diabetes is a contentious area. While both hyperglycaemia and hyperinsulinaemia are recognised as potentially increasing the likelihood of cancer development,[105] the effects, in this regard, of insulin therapy in type 2 diabetes and any mitigating effects of metformin are the subject of some debate. Currie *et al* reported an increased risk of serious outcomes, including cancer, in a retrospective analysis of routinely collected data.[106] However, there is strong evidence contrary to this. For example, the ORIGIN (Outcomes Reduction with Insulin Glargine Intervention) randomized controlled trials (RCT) found no effects of therapy with insulin glargine on outcomes for any cancer.[107]

One of the difficulties in interpreting the findings of retrospective analyses of routinely collected data (i.e. as opposed to RCT data) is the likelihood of bias of various kinds being present.[108] Even with the advantage of large size – running to thousands of subjects with millions of data items – the effects of bias and confounding by either unmeasured or poorly recorded items cannot be entirely ruled out.

Metformin, a common oral therapy in type 2 diabetes, has been suggested as protective against the development of cancer, though this finding is not universally accepted. Neither is the use of metformin in the treatment of cancer, irrespective of diabetes being also present.[109] Other investigations aimed at finding such an effect of metformin have failed to find one (e.g. Kowall *et al.*).[110] The majority of studies on glucose-lowering drugs and cancer risk are flawed by severe methodological limitations (e.g. time-related bias). Cancer risk should not be a major factor in choosing between available glucose-lowering drugs for the typical patient. For some individuals at very high risk for cancer occurrence or re-occurrence, however, these issues may require more careful consideration.

Gum disease raises blood glucose levels and may contribute to the development of type 2 diabetes or to poorer glycaemic control in existing diabetes.

Poor oral health and missing teeth lead to poorer diet and nutrition, and poorer quality of life in people with diabetes.

Dental treatment is safe for people with diabetes and good oral health should be part of diabetes management by medical care professionals.

Diabetes and oral health

Diabetes negatively affects all soft and hard tissues surrounding the teeth.[111] Compared to their peers without diabetes, people with diabetes, especially those with sub-optimal glucose control, experience several oral consequences,[112] such as early tooth eruption[113] and more reversible infection of the soft gums (gingivitis) in children and adolescents,[114–118] and adults;[111,119,120] greater prevalence and severity[111,121,122] as well as accelerated progression[123] of irreversible breakdown of the soft and hard (bony) gums (periodontitis);[124] more jaw infection from deep cavities (caries) around root tips;[125–128] loss of many more teeth;[129,130] more infection around dental implants (peri-implantitis);[114,131] more oral yeast infection (thrush, candidiasis);[132] more oral cancer;[133,134] diminished salivary flow (hyposalivation);[135,136] and greater taste alteration[137] – all of which potentially lead to a decreased quality of life.

Diabetes-related neuropathy can lead to hyposalivation[126,138] and burning mouth syndrome (glossodynia).[138] The severity of diabetes-related retinopathy and the severity of periodontitis are associated,[139,140] as are retinal and gingival haemorrhaging.[141] Diabetes-related nephropathy is also associated with periodontitis.[124,140]

The end result of untreated periodontitis is tooth loss. Missing or loose teeth cause both social and psychological harm, and trouble eating anything other than soft foods, some of which are high in fat, sugar and salt.[142–145]

Non-surgical periodontal treatment (deep cleaning) consisting of removing soft (dental plaque) and hard (calculus, tartar) deposits on the teeth can be performed by dental care professionals in general dental surgeries. Several studies around the world report clinically significant reductions in HbA1c levels in type 2 diabetes three months post-treatment,[146–149] with even greater reduction following extractions.[150]

Chairside screening for diabetes in the dental surgery is generally well accepted by dental care providers,[151–153] physicians,[154] medical and dental authorities, professional organizations[155] and dental patients.[156,157] Interestingly, between 30% and 54% of dental patients who state that they do not have diabetes in, for example, Denmark,[158] the United Kingdom,[159] Saudi Arabia,[160] and the United States of America[161–166] were found to have elevated blood glucose levels, including up to 5.1% having previously undiagnosed type 2 diabetes.

The American Diabetes Association (ADA) includes seeing a "Dentist for comprehensive dental and periodontal examination" as part of the routine initial diabetes care management.[167] Based on sound evidence, IDF and the European Federation of Periodontology (EFP) issued in 2018, consensus guidelines for medical and oral healthcare professionals and their patients to promote early diagnosis, prevention and co-management of diabetes and periodontitis.[168] As a result, the 2013 guidelines by the EFP and the American Academy of Periodontology (AAP)[169] and the 2009 *IDF guideline for oral health for people with diabetes* were updated.[170] A brief online questionnaire is available at www.perioscreening.com for people to rapidly assess their risk for having periodontitis.[171]

References

1. Wolfsdorf JI, Glaser N, Agus M, Fritsch M, Hanas R, Rewers A, et al. ISPAD Clinical Practice Consensus Guidelines 2018: Diabetic ketoacidosis and the hyperglycemic hyperosmolar state. *Pediatr Diabetes*. 2018 Oct;19 Suppl 27:155–77; DOI:10.1111/pedi.12701.
2. Cameron FJ, Scratch SE, Nadebaum C, Northam EA, Koves I, Jennings J, et al. Neurological consequences of diabetic ketoacidosis at initial presentation of type 1 diabetes in a prospective cohort study of children. *Diabetes Care.* 2014 Jun;37(6):1554–62; DOI:10.2337/dc13-1904.
3. Dhatariya KK, Parsekar K, Skedgel C, Datta V, Hill P, Fordham R. The cost of treating diabetic ketoacidosis in an adolescent population in the UK: a national survey of hospital resource use. *Diabet Med*. 2019 Aug;36(8):982–987; DOI:10.1111/dme.13893.
4. Abraham MB, Jones TW, Naranjo D, Karges B, Oduwole A, Tauschmann M, et al. ISPAD Clinical Practice Consensus Guidelines 2018: Assessment and management of hypoglycemia in children and adolescents with diabetes. *Pediatr Diabetes*. 2018 Oct;19 Suppl 27:178–92; DOI:10.1111/pedi.12698.
5. IDF Life for a Child Program. Edited by Ogle G, Middlehurst A, Silink M, Hanas R. Pocketbook for management of diabetes in childhood and adolescence in under-resourced countries (2nd Edition). Brussels: International Diabetes Federation; 2017.
6. Makani J, Matuja W, Liyombo E, Snow RW, Marsh K, Warrell DA. Admission diagnosis of cerebral malaria in adults in an endemic area of Tanzania: implications and clinical description. *QJM*. 2003 May;96(5):355–62; DOI:10.1093/qjmed/hcg059.
7. Rwiza HT, Swai AB, McLarty DG. Failure to diagnose diabetic ketoacidosis in Tanzania. *Diabet Med*. 1986 Mar;3(2):181–3; DOI:10.1111/j.1464-5491.1986.tb00738.x.
8. Ali Z, Levine B, Ripple M, Fowler DR. Diabetic ketoacidosis: a silent death. *Am J Forensic Med Pathol*. 2012 Sep;33(3):189–93; DOI:10.1097/PAF.0b013e31825192e7.
9. IDF Life for a Child Program. *Education resources – DKA prevention campaign.* Brussels: International Diabetes Federation. Available from: https://lfacinternational.org/education/dka/.
10. Pasquel FJ, Umpierrez GE. Hyperosmolar hyperglycemic state: a historic review of the clinical presentation, diagnosis, and treatment. *Diabetes Care.* 2014 Nov;37(11):3124–31; DOI:10.2337/dc14-0984.
11. Gerstein HC. Diabetes: Dysglycaemia as a cause of cardiovascular outcomes. *Nat Rev Endocrinol*. 2015 Sep;11(9):508–10; DOI:10.1038/nrendo.2015.
12. Emerging Risk Factors Collaboration, Sarwar N, Gao P, Seshasai SRK, Gobin R, Kaptoge S, et al. Diabetes mellitus, fasting blood glucose concentration, and risk of vascular disease: a collaborative meta-analysis of 102 prospective studies. *Lancet.* 2010 Jun 26;375(9733):2215–22; DOI:10.1016/S0140-6736(10)60484-9.
13. Rao Kondapally Seshasai S, Kaptoge S, Thompson A, Di Angelantonio E, Gao P, Sarwar N, et al. Diabetes mellitus, fasting glucose, and risk of cause-specific death. *N Engl J Med.* 2011 Mar 3;364(9):829–41; DOI:10.1056/NEJMoa1008862.
14. Einarson TR, Acs A, Ludwig C and Panton UH. Prevalence of cardiovascular disease in type 2 diabetes: a systematic literature review of scientific evidence from across the world in 2007–-2017. *Cardiovasc Diabetol.* 2018 08;17(1):83; DOI:10.1186/s12933-018-0728-6.

15. International Diabetes Federation. *IDF Diabetes Atlas, 7th edition.* Brussels; 2015.
16. Global Burden of Metabolic Risk Factors for Chronic Diseases Collaboration. Cardiovascular disease, chronic kidney disease, and diabetes mortality burden of cardiometabolic risk factors from 1980 to 2010: a comparative risk assessment. *Lancet Diabetes Endocrinol.* 2014 Aug;2(8):634–47; DOI:10.1016/S2213-8587(14)70102-0.
17. Alegre-Díaz J, Herrington W, López-Cervantes M, Gnatiuc L, Ramirez R, Hill M, et al. Diabetes and Cause-Specific Mortality in Mexico City. *N Engl J Med.* 2016 17;375(20):1961–71; DOI:10.1056/NEJMoa1605368.
18. Harding JL, Pavkov ME, Magliano DJ, Shaw JE, Gregg EW. Global trends in diabetes complications: a review of current evidence. *Diabetologia.* 2019;62(1):3–16; DOI:10.1007/s00125-018-4711-2.
19. Paneni F, Beckman JA, Creager MA, Cosentino F. Diabetes and vascular disease: pathophysiology, clinical consequences, and medical therapy: part I. *Eur Heart J.* 2013 Aug;34(31):2436–43; DOI:10.1093/eurheartj/eht149.
20. Bunce C, Wormald R. Leading causes of certification for blindness and partial sight in England & Wales. *BMC Public Health.* 2006 Mar 8;6:58; DOI:10.1186/1471-2458-6-58.
21. Bunce C, Xing W, Wormald R. Causes of blind and partial sight certifications in England and Wales: April 2007–March 2008. *Eye (Lond).* 2010 Nov;24(11):1692–9; DOI:10.1038/eye.2010.122.
22. Buch H, Vinding T, La Cour M, Appleyard M, Jensen GB, Nielsen NV. Prevalence and causes of visual impairment and blindness among 9980 Scandinavian adults: the Copenhagen City Eye Study. *Ophthalmology.* 2004 Jan;111(1):53–61; DOI:10.1016/j.ophtha.2003.05.010.
23. Jeppesen P, Bek T. The occurrence and causes of registered blindness in diabetes patients in Arhus County, Denmark. *Acta Ophthalmol Scand*. 2004 Oct;82(5):526–30; DOI:10.1111/j.1600-0420.2004.00313.x.
24. Pezzullo L, Streatfeild J, Simkiss P, Shickle D. The economic impact of sight loss and blindness in the UK adult population. *BMC Health Serv Res*. 2018 30;18(1):63; DOI:10.1186/s12913-018-2836-0.
25. Jiao F, Wong CKH, Tang SCW, Fung CSC, Tan KCB, McGhee S, et al. Annual direct medical costs associated with diabetes-related complications in the event year and in subsequent years in Hong Kong. *Diabet Med*. 2017;34(9):1276–83; DOI:10.1111/dme.13416.
26. Chapman D, Foxcroft R, Dale-Harris L, Ronte H, Bidgoli F, Bellary S. Insights for care: The healthcare utilisation and cost impact of managing Type 2 diabetes-associated microvascular complications. *Diabetes Ther.* 2019 Apr;10(2):575–85; DOI:10.1007/s13300-018-0548-4.
27. Zhang X, Low S, Kumari N, Wang J, Ang K, Yeo D, et al. Direct medical cost associated with diabetic retinopathy severity in type 2 diabetes in Singapore. *PLoS ONE.* 2017;12(7):e0180949; DOI:10.1371/journal.pone.0180949.
28. Cavan D, Makaroff L, da Rocha Fernandes J, Sylvanowicz M, Ackland P, Conlon J, et al. The Diabetic Retinopathy Barometer Study: Global perspectives on access to and experiences of diabetic retinopathy screening and treatment. *Diabetes Res Clin Pract*. 2017;129:16–24; DOI:10.1016/j.diabres.2017.03.023.
29. Yau JWY, Rogers SL, Kawasaki R, Lamoureux EL, Kowalski JW, Bek T, et al. Global prevalence and major risk factors of diabetic retinopathy. *Diabetes Care.* 2012 Mar;35(3):556–64; DOI:10.2337/dc11-1909.
30. World Health Organization. *Universal eye health: A global action plan 2014–2019.* Geneva 2013. Available from: http://www.vision2020australia.org.au/uploads/resource/108/Universal-Eye-Health-A-Global-Action-Plan-2014-2019.pdf.
31. World Health Organization. *TADDS: Tool for assessment of diabetes and diabetic retinopathy*. Geneva; 2015. Available from: https://www.who.int/blindness/publications/TADDS_ENG.pdf.
32. Lee R, Wong TY, Sabanayagam C. Epidemiology of diabetic retinopathy, diabetic macular edema and related vision loss. *Eye Vis (Lond).* 2015;2:17; DOI:10.1186/s40662-015-0026-2.
33. Thomas RL, Dunstan F, Luzio SD, Roy Chowdury S, Hale SL, North RV, et al. Incidence of diabetic retinopathy in people with type 2 diabetes mellitus attending the Diabetic Retinopathy Screening Service for Wales: retrospective analysis. *BMJ.* 2012 Feb 22;344:e874; DOI:10.1136/bmj.e874.
34. Thomas RL, Halim S, Gurudas S, Sivaprasad S, Owens DR. IDF Diabetes Atlas: A review of studies utilising retinal photography on the global prevalence of diabetes related retinopathy between 2015 and 2018. *Diabetes Res Clin Pract.* 2019; DOI:https://doi.org/10.1016/j.diabres.2019.107840.
35. Sabanayagam C, Banu R, Chee ML, Lee R, Wang YX, Tan G, et al. Incidence and progression of diabetic retinopathy: a systematic review. *Lancet Diabetes Endocrinol.* 2019 Feb;7(2):140–9; DOI:10.1016/S2213-8587(18)30128-1.
36. Scanlon PH. The English national screening programme for sight-threatening diabetic retinopathy. *J Med Screen.* 2008;15(1):1–4; DOI:10.1258/jms.2008.008015.
37. Leese GP, Morris AD, Olson J. A national retinal screening programme for diabetes in Scotland. *Diabet Med.* 2003;20(12):962–4; DOI:10.1111/j.1464-5491.2003.01078.x.
38. Olafsdóttir E, Stefánsson E. Biennial eye screening in patients with diabetes without retinopathy: 10-year experience. *Br J Ophthalmol*. 2007;91(12):1599–601; DOI:10.1136/bjo.2007.123810.
39. Agardh E, Tababat-Khani P. Adopting 3-year screening intervals for sight-threatening retinal vascular lesions in type 2 diabetic subjects without retinopathy. *Diabetes Care.* 2011;34(6):1318–9; DOI:10.2337/dc10-2308.
40. Andersen N, Hjortdal JØ, Schielke KC, Bek T, Grauslund J, Laugesen CS, et al. The Danish Registry of Diabetic Retinopathy. *Clin Epidemiol*. 2016;8:613–9; DOI:10.2147/CLEP.S99507.
41. Liew G, Michaelides M, Bunce C. A comparison of the causes of blindness certifications in England and Wales in working age adults (16–64 years), 1999-2000 with 2009-2010. *BMJ Open*. 2014 Feb 12;4(2):e004015; DOI:10.1136/bmjopen-2013-004015.
42. Thomas RL, Luzio SD, North RV, Banerjee S, Zekite A, Bunce C, et al. Retrospective analysis of newly recorded certifications of visual impairment due to diabetic retinopathy in Wales during 2007-2015. *BMJ Open.* 2017 Jul 18;7(7):e015024; DOI:10.1136/bmjopen-2016-015024.
43. International Diabetes Federation. *IDF School of diabetes online short course on diabetic retinopathy*. Available from: https://www.idfdiabeteschool.org/Short-Course/diabetic-retinopathy/en.
44. International Diabetes Federation and The Fred Hollows Foundation. *Diabetes eye health: A guide for health professionals.* Brussels; 2015. Available from: https://www.idf.org/our-activities/care-prevention/eye-health/eye-health-guide.html
45. Adler AI, Stevens RJ, Manley SE, Bilous RW, Cull CA, Holman RR, et al. Development and progression of nephropathy in type 2 diabetes: the United Kingdom Prospective Diabetes

Study (UKPDS 64). *Kidney Int.* 2003 Jan;63(1):225–32; DOI:10.1046/j.1523-1755.2003.00712.x.

46. *2018 USRDS Annual Data Report: Epidemiology of Kidney Disease in the United States.* Bethesda: National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, 2018. Available from: https://www.usrds.org/2018/view/Default.aspx, accessed 16 July 2019.
47. Pavkov ME, Collins AJ, Coresh J, Nelson RG. Kidney disease in diabetes. In: *Diabetes in America, 3rd edition.* Cowie CC, Casagrande SS, Menke A, Cissell MA, Eberhardt MS, Meigs JB, et al, editors. Bethesda: National Institutes of Health; 2018.
48. Coresh J, Astor BC, Greene T, Eknoyan G, Levey AS. Prevalence of chronic kidney disease and decreased kidney function in the adult US population: Third National Health and Nutrition Examination Survey. *Am J Kidney Dis*. 2003 Jan;41(1):1–12; DOI:doi:10.1053/ajkd.2003.50007.
49. Steinke JM. The natural progression of kidney injury in young type 1 diabetic patients. *Curr Diab Rep*. 2009 Dec;9(6):473–9.
50. Fakhruddin S, Alanazi W, Jackson KE. Diabetes-induced reactive oxygen species: mechanism of their generation and role in renal injury. *J Diabetes Res*. 2017;2017:8379327; DOI:10.1155/2017/8379327.
51. Komenda P, Ferguson TW, Macdonald K, Rigatto C, Koolage C, Sood MM, et al. Cost-effectiveness of primary screening for CKD: a systematic review. *Am J Kidney Dis*. 2014 May;63(5):789–97; DOI:10.1053/j.ajkd.2013.12.012.
52. Kidney Disease Outcomes Quality Initiative. KDOQI Clinical practice guidelines and clinical practice recommendations for diabetes and chronic kidney disease. *Am J Kidney Dis.* 2007 Feb;49(2 Suppl 2):S12–-154; DOI:10.1053/j.ajkd.2006.12.005.
53. National Kidney Foundation. K/DOQI clinical practice guidelines for chronic kidney disease: evaluation, classification, and stratification. *Am J Kidney Dis*. 2002 Feb;39(2 Suppl 1):S1–-266.
54. Li R, Bilik D, Brown MB, Zhang P, Ettner SL, Ackermann RT, et al. Medical costs associated with type 2 diabetes complications and comorbidities. *Am J Manag Care*. 2013 May;19(5):421–30; DOI:10.1111/j.1742-1241.2007.01343.x.
55. Palmer AJ, Valentine WJ, Ray JA. Irbesartan treatment of patients with type 2 diabetes, hypertension and renal disease: a UK health economics analysis. *Int J Clin Pract*. 2007 Oct;61(10):1626–33; DOI:10.1111/j.1742-1241.2007.01343.x.
56. Sakthong P, Tangphao O, Eiam-Ong S, Kamolratanakul P, Supakankunti S, Himathongkam6 T, et al. Cost-effectiveness of using angiotensin-converting enzyme inhibitors to slow nephropathy in normotensive patients with diabetes type II and microalbuminuria. *Nephrology*. 2001;6(2):71–7; DOI:10.1046/j.1440-1797.2001.00036.x.
57. Sobhani S, Asayesh H, Sharifi F, Djalalinia S, Baradaran HR, Arzaghi SM, et al. Prevalence of diabetic peripheral neuropathy in Iran: a systematic review and meta-analysis. *J Diabetes Metab Disord*. 2014;13(1):97; 10.1186/s40200-014-0097-y.
58. Davies M, Brophy S, Williams R, Taylor A. The prevalence, severity, and impact of painful diabetic peripheral neuropathy in type 2 diabetes. *Diabetes Care*. 2006 Jul;29(7):1518–22; DOI:10.2337/dc05-2228.
59. Moxey PW, Gogalniceanu P, Hinchliffe RJ, Loftus IM, Jones KJ, Thompson MM, et al. Lower extremity amputations--a review of global variability in incidence. *Diabet Med*. 2011 Oct;28(10):1144–53; DOI:10.1111/j.1464-5491.2011.03279.x.
60. Amoah VMK, Anokye R, Acheampong E, Dadson HR, Osei M, Nadutey A. The experiences of people with diabetes-related lower limb amputation at the Komfo Anokye Teaching Hospital (KATH) in Ghana. *BMC Res Notes*. 2018 Jan 24;11(1):66; DOI:10.1186/s13104-018-3176-1.
61. Mishra SC, Chhatbar KC, Kashikar A, Mehndiratta A. Diabetic foot. *BMJ*. 2017 Nov 16;359:j5064; DOI:10.1136/bmj.j5064.
62. Apelqvist J, Bakker K, van Houtum WH, Nabuurs-Franssen MH, Schaper NC. International consensus and practical guidelines on the management and the prevention of the diabetic foot. International Working Group on the Diabetic Foot. *Diabetes Metab Res Rev*. 2000 Oct;16 Suppl 1:S84–-92.
63. Bobircă F, Mihalache O, Georgescu D, Pătraşcu T. The new prognostic-therapeutic index for diabetic foot surgery – extended analysis. *Chirurgia (Bucur).* 2016 Apr;111(2):151–5.
64. Zhang P, Lu J, Jing Y, Tang S, Zhu D, Bi Y. Global epidemiology of diabetic foot ulceration: a systematic review and meta-analysis†. *Ann Med*. 2017;49(2):106–16; DOI:10.1080/07853890.2016.1231932.
65. Ali Z, Ahmed SM, Bhutto AR, Chaudhry A, Munir SM. Peripheral artery disease in type II diabetes. *J Coll Physicians Surg Pak*. 2012 Nov;22(11):686–9.
66. Akram J, Aamir A, Basit A, Qureshi MS, Mehmood T, Shahid SK, et al. Prevalence of peripheral arterial disease in type 2 diabetics in Pakistan. *J Pak Med Assoc*. 2011 Jul;61(7):644–8.
67. Yost M. *Critical limb ischemia, Volume I.* United States Epidemiology 2016 supplement. Atlanta: The Sage Group; 2016. Available from: http://thesagegroup.us/pages/reports/cli-us-supplement-2016.php, accessed 16 July 2019.
68. Hirsch AT, Criqui MH, Treat-Jacobson D, Regensteiner JG, Creager MA, Olin JW, et al. Peripheral arterial disease detection, awareness, and treatment in primary care. *JAMA*. 2001 Sep 19;286(11):1317–24; DOI:10.1001/jama.286.11.1317.
69. Hasan R, Firwana B, Elraiyah T, Domecq JP, Prutsky G, Nabhan M, et al. A systematic review and meta-analysis of glycemic control for the prevention of diabetic foot syndrome. *J Vas Surg*. 2016 Feb 1;63(2, Supplement):22S-28S.e2; DOI:10.1016/j.jvs.2015.10.005.
70. Melmed S, Polonsky K, Larsen P. *Williams textbook of endocrinology. 13th edition.* Philadelphia: Elsevier; 2015.
71. Cheung C, Alavi A, Botros M. Comment. The diabetic foot: A reconceptualization. *Diabet Foot Can.* 2013;1(1).
72. Basit A, Nawaz A. Preventing diabetes-related amputations in a developing country–steps in the right direction. *Diabetes Voice*. 2013;58:36–9.
73. Driver VR, Fabbi M, Lavery LA, Gibbons G. The costs of diabetic foot: the economic case for the limb salvage team. *J Vasc Surg.* 2010 Sep;52(3 Suppl):17S–22S; DOI:10.1016/j.jvs.2010.06.003.
74. O'Sullivan JB. Body weight and subsequent diabetes mellitus. *JAMA*. 1982 Aug 27;248(8):949–52.
75. HAPO Study Cooperative Research Group, Metzger BE, Lowe LP, Dyer AR, Trimble ER, Chaovarindr U, et al. Hyperglycemia and adverse pregnancy outcomes. *N Engl J Med*. 2008 May 8;358(19):1991–2002; DOI:10.1056/NEJMoa0707943.
76. Crowther CA, Hiller JE, Moss JR, McPhee AJ, Jeffries WS, Robinson JS, et al. Effect of treatment of gestational diabetes mellitus on pregnancy outcomes. *N Engl J Med*. 2005 Jun 16;352(24):2477–86; DOI:10.1056/NEJMoa042973.
77. Yang X, Tian H, Zhang F, Zhang C, Li Y, Leng J, et al. A randomised translational trial of lifestyle intervention using a 3-tier shared care approach on pregnancy outcomes in Chinese women with gestational diabetes mellitus but without diabetes. *J Transl Med*. 2014 Oct 28;12:290; DOI:10.1186/s12967-014-0290-2.

78. Bellamy L, Casas J-P, Hingorani AD, Williams D. Type 2 diabetes mellitus after gestational diabetes: a systematic review and meta-analysis. *Lancet.* 2009 May 23;373(9677):1773–9; DOI:10.1016/S0140-6736(09)60731-5.

79. Song C, Lyu Y, Li C, Liu P, Li J, Ma RC, et al. Long-term risk of diabetes in women at varying durations after gestational diabetes: a systematic review and meta-analysis with more than 2 million women. *Obes Rev*. 2018;19(3):421–9; DOI:10.1111/obr.12645.

80. Huo X, Gao L, Guo L, Xu W, Wang W, Zhi X, et al. Risk of non-fatal cardiovascular diseases in early-onset versus late-onset type 2 diabetes in China: a cross-sectional study. *Lancet Diabetes Endocrinol*. 2016 Feb;4(2):115–24; DOI:10.1016/S2213-8587(15)00508-2.

81. Li J, Song C, Li C, Liu P, Sun Z, Yang X. Increased risk of cardiovascular disease in women with prior gestational diabetes: A systematic review and meta-analysis. *Diabetes Res Clin Pract*. 2018 Jun;140:324–38; DOI:10.1016/j.diabres.2018.03.054.

82. Liu H, Wang L, Zhang S, Leng J, Li N, Li W, et al. One-year weight losses in the Tianjin Gestational Diabetes Mellitus Prevention Programme: A randomized clinical trial. *Diabetes Obes Metab*. 2018;20(5):1246–55; DOI:10.1111/dom.13225.

83. Lowe WL, Scholtens DM, Kuang A, Linder B, Lawrence JM, Lebenthal Y, et al. Hyperglycemia and adverse pregnancy outcome follow-up study (HAPO FUS): maternal gestational diabetes mellitus and childhood glucose metabolism. *Diabetes Care.* 2019 Mar;42(3):372–80; DOI:10.2337/dc18-2021.

84. Landon MB, Rice MM, Varner MW, Casey BM, Reddy UM, Wapner RJ, et al. Mild gestational diabetes mellitus and long-term child health. *Diabetes Care*. 2015 Mar;38(3):445–52; DOI:10.2337/dc14-2159.

85. Dabelea D, Stafford JM, Mayer-Davis EJ, D'Agostino R, Dolan L, Imperatore G, et al. Association of Type 1 diabetes vs Type 2 diabetes diagnosed during childhood and adolescence with complications during teenage years and young adulthood. *JAMA.* 2017 28;317(8):825–35; DOI:10.1001/jama.2017.0686.

86. Al-Saeed AH, Constantino MI, Molyneaux L, D'Souza M, Limacher-Gisler F, Luo C, et al. An inverse relationship between age of Type 2 diabetes onset and complication risk and mortality: the impact of youth-onset Type 2 diabetes. *Diabetes Care*. 2016;39(5):823–9; DOI:10.2337/dc15-0991.

87. Toppe C, Möllsten A, Schön S, Dahlquist G. Socio-economic factors influencing the development of end-stage renal disease in people with Type 1 diabetes - a longitudinal population study. *Diabet Med*. 2017;34(5):676–82; DOI:10.1111/dme.13289.

88. Berhan YT, Eliasson M, Möllsten A, Waernbaum I, Dahlquist G. Impact of parental socioeconomic status on excess mortality in a population-based cohort of subjects with childhood-onset Type 1 diabetes. *Diabetes Care.* 2015 May 1;38(5):827; DOI:10.2337/dc14-1522.

89. Williams R, Van Gaal L, Lucioni C, CODE-2 Advisory Board. Assessing the impact of complications on the costs of Type II diabetes. *Diabetologia*. 2002 Jul;45(7):S13-17; DOI:10.1007/s00125-002-0859-9.

90. American Diabetes Association. Economic Costs of Diabetes in the U.S. in 2017. *Diabetes Care*. 2018 May 1;41(5):917–28; DOI:10.2337/dci18-0007.

91. von Ferber L, Köster I, Hauner H. Medical costs of diabetic complications total costs and excess costs by age and type of treatment results of the German CoDiM Study. *Exp Clin Endocrinol Diabetes Off J Ger Soc Endocrinol Ger Diabetes Assoc*. 2007 Feb;115(2):97–104; DOI:10.1055/s-2007-949152.

92. Kähm K, Laxy M, Schneider U, Rogowski WH, Lhachimi SK, Holle R. Health care costs associated with incident complications in patients with Type 2 diabetes in Germany. *Diabetes Care.* 2018 May;41(5):971–8; DOI:10.2337/dc17-1763.

93. Alva ML, Gray A, Mihaylova B, Leal J, Holman RR. The impact of diabetes-related complications on healthcare costs: new results from the UKPDS (UKPDS 84). *Diabet Med J Br Diabet Assoc*. 2015 Apr;32(4):459–66; DOI:10.1111/dme.12647.

94. Marcellusi A, Viti R, Sciattella P, Aimaretti G, De Cosmo S, Provenzano V, et al. Economic aspects in the management of diabetes in Italy. *BMJ Open Diabetes Res Care*. 2016 Oct;4(1):e000197; DOI:10.1136/bmjdrc-2016-000197.

95. Zhuo X, Zhang P, Hoerger TJ. Lifetime direct medical costs of treating type 2 diabetes and diabetic complications. *Am J Prev Med*. 2013 Sep;45(3):253–61; DOI:10.1016/j.amepre.2013.04.017.

96. Riddle MC, Herman WH. The Cost of Diabetes Care—An Elephant in the Room. *Diabetes Care*. 2018 May;41(5):929–32; DOI:10.2337/dci18-0012.

97. Li R, Zhang P, Barker LE, Chowdhury FM, Zhang X. Cost-effectiveness of interventions to prevent and control diabetes mellitus: a systematic review. *Diabetes Care.* 2010 Aug 1;33(8):1872–94; DOI:10.2337/dc10-0843.

98. Bommer C, Heesemann E, Sagalova V, Manne-Goehler J, Atun R, Bärnighausen T, et al. The global economic burden of diabetes in adults aged 20-79 years: a cost-of-illness study. *Lancet Diabetes Endocrinol*. 2017;5(6):423–30; DOI:10.1016/S2213-8587(17)30097-9.

99. Tsilidis KK, Kasimis JC, Lopez DS, Ntzani EE, Ioannidis JP. Type 2 diabetes and cancer: umbrella review of meta-analyses of observational studies. *BMJ.* 2015 Jan 2;350(1756–1833 (Electronic)):g7607; DOI:10.1136/bmj.g7607.

100. Pearson-Stuttard J, Zhou B, Kontis V, Bentham J, Gunter MJ, Ezzati M. Worldwide burden of cancer attributable to diabetes and high body-mass index: a comparative risk assessment. *Lancet Diabetes Endocrinol*. 2018;6(2):95–104; DOI:10.1016/S2213-8587(18)30150-5.

101. NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in diabetes since 1980: a pooled analysis of 751 population-based studies with 4.4 million participants. *Lancet*. 2016 09;387(10027):1513–30; DOI:10.1016/S0140-6736(16)00618-8.

102. NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128·9 million children, adolescents, and adults. *Lancet.* 2017 Dec 16;390(10113):2627–42; DOI:10.1016/S0140-6736(17)32129-3.

103. Bellastella G, Scappaticcio L, Esposito K, Giugliano D, Maiorino MI. Metabolic syndrome and cancer: "The common soil hypothesis." *Diabetes Res Clin Pract*. 2018 Sep;143:389–97; DOI:10.1016/j.diabres.2018.05.024.

104. Giovannucci E, Harlan DM, Archer MC, Bergenstal RM, Gapstur SM, Habel LA, et al. Diabetes and cancer: a consensus report. *Diabetes Care*. 2010 Jul;33(7):1674–85; DOI:10.2337/dc10-0666.

105. Cignarelli A, Genchi VA, Caruso I, Natalicchio A, Perrini S, Laviola L, et al. Diabetes and cancer: Pathophysiological fundamentals of a "dangerous affair." *Diabetes Res Clin Pract*. 2018 Sep;143:378–88; DOI:10.1016/j.diabres.2018.04.002.

106. Currie CJ, Poole CD, Evans M, Peters JR, Morgan CL. Mortality and other important diabetes-related outcomes with insulin vs other antihyperglycemic therapies in type 2 diabetes. *J Clin Endocrinol Metab*. 2013 Feb;98(2):668–77; DOI:10.1210/jc.2012-3042.

107. Bordeleau L, Yakubovich N, Dagenais GR, Rosenstock J, Probstfield J, Chang Yu P, et al. The association of basal insulin glargine and/or n-3 fatty acids with incident cancers in patients with dysglycemia. *Diabetes Care*. 2014;37(5):1360–6; DOI:10.2337/dc13-1468.

108. Bykov K, He M, Franklin JM, Garry EM, Seeger JD, Patorno E. Glucose-lowering medications and the risk of cancer: A methodological review of studies based on real-world data. *Diabetes Obes Metab*. 2019;21(9): 2029–2038; DOI:10.1111/dom.13766.

109. Currie CJ, Poole CD, Gale E a. M. The influence of glucose-lowering therapies on cancer risk in type 2 diabetes. *Diabetologia*. 2009 Sep;52(9):1766–77; DOI:10.1007/s00125-009-1440-6.

110. Kowall B, Rathmann W, Kostev K. Are sulfonylurea and insulin therapies associated with a larger risk of cancer than metformin therapy? A retrospective database analysis. *Diabetes Care.* 2015 Jan;38(1):59–65; DOI:10.2337/dc14-0977.

111. Kocher T, König J, Borgnakke WS, Pink C, Meisel P. Periodontal complications of hyperglycemia/diabetes mellitus: Epidemiologic complexity and clinical challenge. *Periodontol 2000*. 2018;78(1):59–97; DOI:10.1111/prd.12235.

112. Verhulst MJL, Loos BG, Gerdes VEA, Teeuw WJ. Evaluating all potential oral complications of diabetes mellitus. *Front Endocrinol (Lausanne)*. 2019;10:56; DOI:10.3389/fendo.2019.00056.

113. Lal S, Cheng B, Kaplan S, Softness B, Greenberg E, Goland RS, et al. Accelerated tooth eruption in children with diabetes mellitus. *Pediatrics.* 2008 May;121(5):e1139–-1143; DOI:10.1542/peds.2007-1486.

114. de Araújo Nobre M, Maló P. Prevalence of periodontitis, dental caries, and peri-implant pathology and their relation with systemic status and smoking habits: Results of an open-cohort study with 22009 patients in a private rehabilitation center. *J Dent.* 2017;67:36–42; DOI:10.1016/j.jdent.2017.07.013.

115. Goodson JM, Hartman M-L, Shi P, Hasturk H, Yaskell T, Vargas J, et al. The salivary microbiome is altered in the presence of a high salivary glucose concentration. *PLoS ONE*. 2017;12(3):e0170437; DOI:10.1371/journal.pone.0170437.

116. Janem WF, Scannapieco FA, Sabharwal A, Tsompana M, Berman HA, Haase EM, et al. Salivary inflammatory markers and microbiome in normoglycemic lean and obese children compared to obese children with type 2 diabetes. *PLoS ONE.* 2017;12(3):e0172647; DOI:10.1371/journal.pone.0172647.

117. Lalla E, Cheng B, Lal S, Kaplan S, Softness B, Greenberg E, et al. Diabetes mellitus promotes periodontal destruction in children. *J Clin Periodontol*. 2007 Apr;34(4):294–8; DOI:10.1111/j.1600-051X.2007.01054.x.

118. Novotna M, Podzimek S, Broukal Z, Lencova E, Duskova J. Periodontal diseases and dental caries in children with Type 1 diabetes mellitus. *Mediators Inflamm*. 2015;2015:379626; DOI:10.1155/2015/379626.

119. Eke PI, Wei L, Borgnakke WS, Thornton-Evans G, Zhang X, Lu H, et al. Periodontitis prevalence in adults ≥ 65 years of age, in the USA. *Periodontol 2000*. 2016;72(1):76–95; DOI:10.1111/prd.12145.

120. Oyarzo N, Riveros M, Andaur C, Liberona J, Cortés V. Periodontal inflammation correlates with systemic inflammation and insulin resistance in patients with recent diagnosis of type 2 diabetes. *ARS MEDICA Revista de Ciencias Médicas*. 2019 Jan 28;44(1):6–12; DOI:10.11565/arsmed.v44i1.1524.

121. Al Qahtani NA, Joseph B, Deepthi A, Vijayakumari BK. Prevalence of chronic periodontitis and its risk determinants among female patients in the Aseer Region of KSA. *Journal of Taibah University Medical Sciences*. 2017 Jun 1;12(3):241–8; DOI:10.1016/j.jtumed.2016.11.012.

122. Eke PI, Thornton-Evans GO, Wei L, Borgnakke WS, Dye BA, Genco RJ. Periodontitis in US Adults: National Health and Nutrition Examination Survey 2009-2014. *J Am Dent Assoc.* 2018 Jul;149(7):576-588.e6; DOI:10.1016/j.adaj.2018.04.023.

123. Lang NP, Suvan JE, Tonetti MS. Risk factor assessment tools for the prevention of periodontitis progression a systematic review. *J Clin Periodontol*. 015 Apr;42(Suppl 16):S59–70; DOI:10.1111/jcpe.12350.

124. Tasdemir Z, Özsarı Tasdemir F, Gürgan C, Eroglu E, Gunturk I, Kocyigit I. The effect of periodontal disease treatment in patients with continuous ambulatory peritoneal dialysis. *Int Urol Nephrol*. 2018 Aug;50(8):1519–28; DOI:10.1007/s11255-018-1913-y.

125. Cintra LTA, Estrela C, Azuma MM, Queiroz ÍO de A, Kawai T, Gomes-Filho JE. Endodontic medicine: interrelationships among apical periodontitis, systemic disorders, and tissue responses of dental materials. *Braz Oral Res*. 2018 Oct 18;32(suppl 1):e68; DOI:10.1590/1807-3107bor-2018.vol32.0068.

126. Mauri-Obradors E, Estrugo-Devesa A, Jané-Salas E, Viñas M, López-López J. Oral manifestations of diabetes mellitus. A systematic review. *Med Oral Patol Oral Cir Bucal*. 2017 Sep 1;22(5):e586–94; DOI:10.4317/medoral.21655.

127. Segura-Egea JJ, Martín-González J, Cabanillas-Balsera D, Fouad AF, Velasco-Ortega E, López-López J. Association between diabetes and the prevalence of radiolucent periapical lesions in root-filled teeth: systematic review and meta-analysis. *Clin Oral Investig*. 2016 Jul;20(6):1133–41; DOI:10.1007/s00784-016-1805-4.

128. Segura-Egea JJ, Martín-González J, Castellanos-Cosano L. Endodontic medicine: connections between apical periodontitis and systemic diseases. *Int Endod J.* 2015 Oct;48(10):933–51; DOI:10.1111/iej.12507.

129. Luo H, Pan W, Sloan F, Feinglos M, Wu B. Forty-year trends in tooth loss among American adults with and without diabetes mellitus: an age-period-cohort analysis. *Prev Chronic Dis*. 2015 Dec 3;12:E211; DOI:10.5888/pcd12.150309.

130. Patel MH, Kumar JV, Moss ME. Diabetes and tooth loss: an analysis of data from the National Health and Nutrition Examination Survey, 2003-2004. *J Am Dent Assoc*. 2013 May;144(5):478–85; DOI:10.14219/jada.archive.2013.0149.

131. Monje A, Catena A, Borgnakke WS. Association between diabetes mellitus/hyperglycaemia and peri-implant diseases: Systematic review and meta-analysis. *J Clin Periodontol*. 2017 Jun;44(6):636–48; DOI:10.1111/jcpe.12724.

132. Olczak-Kowalczyk D, Pyrżak B, Dąbkowska M, Pańczyk-Tomaszewska M, Miszkurka G, Rogozińska I, et al. Candida spp. and gingivitis in children with nephrotic syndrome or type 1 diabetes. *BMC Oral Health*. 2015 May 8;15:57; DOI:10.1186/s12903-015-0042-6.

133. Gong Y, Wei B, Yu L, Pan W. Type 2 diabetes mellitus and risk of oral cancer and precancerous lesions: a meta-analysis of observational studies. *Oral Oncol*. 2015 Apr;51(4):332–40; DOI:10.1016/j.oraloncology.2015.01.003.

134. Shin YJ, Choung HW, Lee JH, Rhyu IC, Kim HD. Association of Periodontitis with Oral Cancer: A Case-Control Study. *J Dent Res*. 2019 May;98(5):526–33; DOI:10.1177/0022034519827565.

135. Carramolino-Cuéllar E, Lauritano D, Silvestre F-J, Carinci F, Lucchese A, Silvestre-Rangil J. Salivary flow and xerostomia in patients with type 2 diabetes. *J Oral Pathol Med*. 2018 May;47(5):526–30; DOI:10.1111/jop.12712.

136. López-Pintor RM, Casañas E, González-Serrano J, Serrano J, Ramírez L, de Arriba L, et al. Xerostomia, hyposalivation, and salivary flow in diabetes patients. *J Diabetes Res*. 2016;2016:4372852; DOI:10.1155/2016/4372852.

137. Molania T, Alimohammadi M, Akha O, Mousavi J, Razvini R, Salehi M. The effect of xerostomia and hyposalivation on the quality of life of patients with type II diabetes mellitus. *Electron Physician*. 2017 Nov;9(11):5814–9; DOI:10.19082/5814.

138. Borgnakke WS, Anderson PF, Shannon C, Jivanescu A. Is there a relationship between oral health and diabetic neuropathy? *Curr Diab Rep*. 2015 Nov;15(11):93; DOI:10.1007/s11892-015-0673-7.

139. Veena HR, Natesh S, Patil SR. Association between Diabetic Retinopathy and Chronic Periodontitis—A Cross-Sectional Study. *Med Sci (Basel)* 2018 Dec;6(4):104; DOI:10.3390/medsci6040104

140. Khanuja PK, Narula SC, Rajput R, Sharma RK, Tewari S. Association of periodontal disease with glycemic control in patients with type 2 diabetes in Indian population. *Front Med*. 2017 Mar;11(1):110–9; DOI:10.1007/s11684-016-0484-5.

141. Hujoel PP, Stott-Miller M. Retinal and gingival hemorrhaging and chronic hyperglycemia. *Diabetes Care*. 2011 Jan;34(1):181–3; DOI:10.2337/dc10-0901.

142. Borgnakke W, Genco R, Eke P, Taylor G. Chapter 31: Oral health and diabetes. In: *Diabetes in America. 3rd ed.* (NIH Pub No. 17-1468). Bethesda: National Institutes of Health/National Institute of Diabetes and Digestive and Kidney Diseases (NIH/NIDDK); 2018. Available from: https://www.niddk.nih.gov/about-niddk/strategic-plans-reports/diabetes-in-america-3rd-edition, accessed 28 July 2019.

143. Borgnakke W, Genco R. Chapter 6: Associations between periodontal disease and hyperglycemia/diabetes. In: *The oral-systemic health connection: a guide to patient care.* Chicago: Quintessence; 2019.

144. Liljestrand JM, Havulinna AS, Paju S, Männistö S, Salomaa V, Pussinen PJ. Missing teeth predict incident cardiovascular events, diabetes, and death. *J Dent Res.* 2015 Aug;94(8):1055–62; DOI:10.1177/0022034515586352.

145. Similä T, Auvinen J, Puukka K, Keinänen-Kiukaanniemi S, Virtanen JI. Impaired glucose metabolism is associated with tooth loss in middle-aged adults: The Northern Finland Birth Cohort Study 1966. *Diabetes Res Clin Pract*. 2018 Aug;142:110–9; DOI:10.1016/j.diabres.2018.05.035.

146. Botero JE, Rodríguez C, Agudelo-Suarez AA. Periodontal treatment and glycaemic control in patients with diabetes and periodontitis: an umbrella review. *Aust Dent J*. 2016;61(2):134–48; DOI:10.1111/adj.12413.

147. Teshome A, Yitayeh A. The effect of periodontal therapy on glycemic control and fasting plasma glucose level in type 2 diabetic patients: systematic review and meta-analysis. *BMC Oral Health.* 2016 Jul 30;17(1):31; DOI:10.1186/s12903-016-0249-1.

148. Faggion CM, Cullinan MP, Atieh M. An overview of systematic reviews on the effectiveness of periodontal treatment to improve glycaemic control. *J Periodont Res*. 2016 Dec;51(6):716–25; DOI:10.1111/jre.12358.

149. Hasuike A, Iguchi S, Suzuki D, Kawano E, Sato S. Systematic review and assessment of systematic reviews examining the effect of periodontal treatment on glycemic control in patients with diabetes. *Med Oral Patol Oral Cir Bucal*. 2017 Mar 1;22(2):e167–76; DOI:10.4317/medoral.21555.

150. Khader YS, Al Habashneh R, Al Malalheh M, Bataineh A. The effect of full-mouth tooth extraction on glycemic control among patients with type 2 diabetes requiring extraction of all remaining teeth: a randomized clinical trial. *J Periodont Res*. 2010 Dec;45(6):741–7; DOI:10.1111/j.1600-0765.2010.01294.x.

151. Greenberg BL, Glick M, Frantsve-Hawley J, Kantor ML. Dentists' attitudes toward chairside screening for medical conditions. *J Am Dent Assoc*. 2010 Jan;141(1):52–62; DOI:10.14219/jada.archive.2010.0021.

152. Greenberg BL, Glick M. Providing health screenings in a dental setting to enhance overall health outcomes. *Dent Clin North Am*. 2018;62(2):269–78; DOI:10.1016/j.cden.2017.11.006.

153. Greenberg BL, Glick M. Assessing systemic disease risk in a dental setting: a public health perspective. *Dent Clin North Am*. 2012 Oct;56(4):863–74; DOI:10.1016/j.cden.2012.07.011.

154. Greenberg BL, Thomas PA, Glick M, Kantor ML. Physicians' attitudes toward medical screening in a dental setting. *J Public Health Dent*. 2015;75(3):225–33; DOI:10.1111/jphd.12093.

155. Friman G, Hultin M, Nilsson GH, Wårdh I. Medical screening in dental settings: a qualitative study of the views of authorities and organizations. *BMC Res Notes*. 2015 Oct 19;8:580; DOI:10.1186/s13104-015-1543-8.

156. Greenblatt AP, Estrada I, Schrimshaw EW, Metcalf SS, Kunzel C, Northridge ME. Acceptability of Chairside Screening for Racial/Ethnic Minority Older Adults: A Qualitative Study. *JDR Clin Trans Res*. 2017 Oct;2(4):343–52; DOI:10.1177/2380084417716880.

157. Sansare K, Raghav M, Kasbe A, Karjodkar F, Sharma N, Gupta A, et al. Indian patients' attitudes towards chairside screening in a dental setting for medical conditions. *Int Dent J.* 2015 Oct;65(5):269–76; DOI:10.1111/idj.12175.

158. Holm N-CR, Belstrøm D, Østergaard JA, Schou S, Holmstrup P, Grauballe MB. Identification of individuals with undiagnosed diabetes and pre-diabetes in a Danish cohort attending dental treatment. *J Periodontol.* 2016 Apr;87(4):395–402; DOI:10.1902/jop.2016.150266.

159. Wright D, Muirhead V, Weston-Price S, Fortune F. Type 2 diabetes risk screening in dental practice settings: a pilot study. *Br Dent J.* 2014;216(7):E15; DOI:10.1038/sj.bdj.2014.250.

160. AlGhamdi AST, Bukhari SMN, Elias WY, Merdad K, Sonbul H. Dental clinics as potent sources for screening undiagnosed diabetes and prediabetes. *Am J Med Sci*. 2013 Apr;345(4):331–4; DOI:10.1097/MAJ.0b013e318287c96c.

161. Estrich CG, Araujo MWB, Lipman RD. Prediabetes and diabetes screening in dental care settings: NHANES 2013 to 2016. *JDR Clin Trans Res*. 2019 Jan;4(1):76–85; DOI:10.1177/2380084418798818.

162. Franck SD, Stolberg RL, Bilich LA, Payne LE. Point-of-care HbA1c screening predicts diabetic status of dental patients. *J Dent Hyg*. 2014 Feb;88(1):42–52.

163. Genco RJ, Schifferle RE, Dunford RG, Falkner KL, Hsu WC, Balukjian J. Screening for diabetes mellitus in dental practices: a field trial. *J Am Dent Assoc*. 2014 Jan;145(1):57–64; DOI:10.14219/jada.2013.7.

164. Herman WH, Taylor GW, Jacobson JJ, Burke R, Brown MB. Screening for prediabetes and type 2 diabetes in dental offices. *J Public Health Dent*. 2015;75(3):175–82; DOI:10.1111/jphd.12082.

165. Kalladka M, Greenberg BL, Padmashree SM, Venkateshaiah NT, Yalsangi S, Raghunandan BN, et al. Screening for coronary heart disease and diabetes risk in a dental setting. *Int J Public Health*. 2014 Jun;59(3):485–92; DOI:10.1007/s00038-013-0530-x.

166. Lalla E, Cheng B, Kunzel C, Burkett S, Lamster IB. Dental findings and identification of undiagnosed hyperglycemia. *J Dent Res*. 2013 Oct;92(10):888–92: DOI:10.1177/0022034513502791.

167. American Diabetes Association. 4. Comprehensive Medical Evaluation and Assessment of Comorbidities: Standards of Medical Care in Diabetes-2019. *Diabetes Care*. 2019 Jan;42(Suppl 1):S34–45; DOI:10.2337/dc19-S004.

168. Sanz M, Ceriello A, Buysschaert M, Chapple I, Demmer RT, Graziani F, et al. Scientific evidence on the links between periodontal diseases and diabetes: Consensus report and guidelines of the joint workshop on periodontal diseases and diabetes by the International Diabetes Federation and the European Federation of Periodontology. *Diabetes Res Clin Pract*. 2018 Mar;137:231–41; DOI:10.1016/j.diabres.2017.12.001.

169. Chapple ILC, Genco R, working group 2 of the joint EFP/AAP workshop. Diabetes and periodontal diseases: consensus report of the Joint EFP/AAP Workshop on Periodontitis and Systemic Diseases. *J Periodontol*. 2013 Apr;84(4 Suppl):S106–112; DOI:10.1902/jop.2013.1340011.

170. International Diabetes Federation. *Oral health for people with diabetes*. International Diabetes Federation. Brussels, Belgium; 2009. Available from: https://www.idf.org/e-library/guidelines/83-oral-health-for-people-with-diabetes, accessed 28 July 2019.

171. Verhulst MJL, Teeuw WJ, Bizzarro S, Muris J, Su N, Nicu EA, et al. A rapid, non-invasive tool for periodontitis screening in a medical care setting. *BMC Oral Health*. 2019 May 23;19(1):87.

6 ACTION ON DIABETES

Pei Yan Heng from Singapore, living with type 2 diabetes

Key messages

No effective and safe intervention currently exists to prevent type 1 diabetes.

There is firm evidence that primary prevention of type 2 diabetes can be effective.

Regular monitoring of the risk factors for diabetes complications and early intervention results in reduced hospitalisations and improved clinical outcomes.

Availability of diabetes medicines is globally variable, with poorer populations having less availability than those in higher income settings.

Despite being available for almost 100 years, insulin remains unaffordable and unavailable to many people with diabetes who require it.

Preventing diabetes: prospects for the prevention or delay of type 1 and type 2 diabetes

Prevention of type 1 diabetes

No effective and safe intervention currently exists to prevent type 1 diabetes despite a large number of clinical trials aimed at arresting the on-going autoimmune destruction of pancreatic beta cells.[1] Nevertheless, there is some evidence that overweight and a high growth rate in children are weak risk factors,[2] indicating that a healthy lifestyle that avoids both over-eating and a sedentary lifestyle is recommended for high-risk groups such as the siblings of children with type 1 diabetes. However, this is just one of a number of factors that have also been implicated. These include not being breast-fed,[3] being the first-born,[4] being born by caesarean section[5] and having an older[6] or obese[7,8] mother.

Although a 'cure' for type 1 diabetes is being actively sought, preventing or delaying it in those known to be at risk or, in those already diagnosed, slowing down the auto-immune destruction of beta cells and protecting those cells that are still active are likely to be more attainable goals in the foreseeable future. Neither has been convincingly achieved as yet. However, several studies are underway using interventions such as oral insulin in people known to have markers of islet autoimmunity, trialling drugs already used, for example in psoriasis, to prolong beta cell life and the use of peptide immunotherapies to 'retrain' killer T cells, the lymphocytes that are intimately involved in the underlying mechanism of type 1 diabetes.

> **No effective and safe intervention** currently exists to **prevent type 1 diabetes.**

Several developments have increased the importance of preventing type 1 diabetes. Firstly, the incidence and prevalence of childhood-onset type 1 diabetes have been increasing over the past several decades in many countries, with an approximate 2–4% annual increase in incidence,[9] clearly indicating the strong impact of changing environmental factors since genetic traits cannot change that quickly. In some countries, the condition is also occurring at a much earlier age, with a markedly increased age-incidence in the 1–5 year age range,[10] thus adding to the considerable impact already mentioned (in Chapter 3) on individuals and their families. On the other hand, there are indications that the increase in incidence after childhood is declining, suggesting that at least some of the environmental triggers of the disease tend to operate in younger age groups.[11]

Secondary prevention interventions to robustly arrest disease progression and prevent or delay clinically defined (and already insulin-dependent type 1 diabetes) may require combining therapies that target multiple pathways such as beta cell-specific autoimmunity, inflammation, beta cell survival and/or metabolic regulation.

Tertiary prevention approaches (i.e. interventions to effectively prevent the long-term complications resulting from the metabolic disturbances of diabetes) already exist. The costs of some of these are high, although the longer-term economic benefits almost always out-weigh these initial costs. IDF and its Member Associations need to continue concerted advocacy for increased resources to be dedicated to these interventions as well as promoting further research into the 'upstream' activities of primary and secondary prevention.

Key to the monitoring of future prevention efforts for type 1 diabetes will be the availability of better data on the incidence and prevalence of the condition. This will support much more effective action on type 1 diabetes in terms of prevention as well as treatments, research investment and policy making. To this end, IDF is working with the Juvenile Diabetes Research Foundation (JDRF) on the concept of a Type 1 Diabetes Global Index, harnessing and augmenting the data in the *IDF Diabetes Atlas* to bring more focused attention and evidence-based decision making to programme investment and policy making.

> **A cure for type 1 diabetes** is being actively sought. **However, preventing or delaying** it in those known to be at risk or slowing its progression in those already diagnosed are likely to be more attainable goals in the foreseeable future.

Prevention of type 2 diabetes

Randomised controlled trials (RCTs), conducted over the past two decades, show unequivocally that the prevention (or, at least, delay) of type 2 diabetes is possible in many ethnic groups by lifestyle modification (LSM) or administration of some pharmacological agents.[12–14] RCTs from different countries that have either considered LSM alone or with pharmacological agents[15–26] are listed in Tables 6.1 and 6.2, respectively.

The earliest trial was started in China in 1997[27] and has the longest follow-up period, so far, of 23 years.[28] Extended trials including this Chinese study,[28,29] the Diabetes Prevention Program Outcomes Study (DPPOS)[30] in the United States, and the Finnish Diabetes Prevention Study (FDPS)[31] have indicated that the benefits of LSM can last for periods from 10 to 23 years (the so-called 'legacy effect') (Table 6.1). Recently, the post-trial follow-up of the Indian SMS (short message service) study[32] also showed that the effect of LSM persisted for an additional three years after cessation of the active phase of the trial. In RCTs, the relative risk reduction with LSM varied among different populations and with different follow-up periods, ranging from 30% to more than 50% (Table 6.1). LSM has proven to be a successful, safe, cost-effective and preferred prevention strategy.[33]

The efficacy of pharmacological agents in preventing type 2 diabetes in high-risk subjects has been evaluated (Table 6.2). The effects of pharmacological agents last as long as the drug is taken. However, many of them also have adverse effects. People with existing angina can experience weight gain and heart failure when taking thiazolidinedione.[43] Metformin can cause diarrhoea, nausea and vomiting.[44,45] The Indian Diabetes

The majority of people with type 2 diabetes **live in low- and middle-income countries.** In these and other countries, priority should be given to **collaborative efforts** for primary prevention of type 2 diabetes and other non-communicable diseases at the societal level.

Prevention Programmes (IDPP-1 and 2)[36,37] have shown that combining LSM with metformin or pioglitazone did not improve the efficacy of LSM.

While the effectiveness of prevention of type 2 diabetes in RCTs is clear, the translation of these findings from targeting people at high-risk into national policies remains a challenge.[13] 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 type 2 diabetes. 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 non-communicable diseases (NCDs) and recommended strategies for implementation.[47] 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.

Public health campaigns alone, while they can increase awareness, have not proven effective in preventing type 2 diabetes.[48] However, global targets and strategies are useful in guiding governments to coordinate an NCDs response, but the 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.

Table 6.1 **Major randomised primary prevention trials in type 2 diabetes using lifestyle modification**

Study (year); country; no. of participants	Intervention	Duration; main outcome (relative risk reduction %)
Da Qing Diabetes Prevention Study (CDQDPS);[27] (1997); China; n = 577 Da Qing Diabetes Prevention Extended Study (CDQDPS);[29] (2008) Da Qing Diabetes Prevention Extended Study (CDQDPS);[28] (2014)	Lifestyle modification	6.0 years; Diet: (31.0) Exercise: (46.0) Diet + exercise: (42.0) 20.0 years; (43.0) 23.0 years; (45.0)
Diabetes Prevention Study;[34] (2001); Finland; n =522 Diabetes Prevention Extended Study;[31] (2013)	Lifestyle modification	3.2 years; Intervention: (58.0) 13.0 years; Intervention: (38.0)
Diabetes Prevention Program;[35] (2002); United States; n= 3234 Diabetes Prevention Program Outcome Study;[30] (2009)	Lifestyle modification, metformin	2.8 years; Intervention: (58.0) 10.0 years; Intervention: (34.0)
Indian Diabetes Prevention Programme-1;[36] (2006); India; n =531	Lifestyle modification, metformin	2.6 years; Intervention: (28.5)
Indian Diabetes Prevention Programme-2;[37] (2009); India; n= 407	Lifestyle modification, pioglitazone	3.0 years; No benefit by adding pioglitazone
Indian SMS Study;[38] (2013); India; n=537	Lifestyle modification, SMS	2.0 years; Intervention: (36.0)
Indian SMS Study Extended Follow-Up;[32] (2018); n=346	Lifestyle modification	3.0 years; Intervention: (30.0)
Diabetes Community Lifestyle Improvement Programme (D-CLIP);[39] (2016)	Lifestyle modification, Metformin	3.0 years; Intervention: (32.0)
Pakistan Diabetes Prevention Study; [40] (2012); Pakistan; n= 317	Lifestyle modification, Metformin	1.5 years; Intervention: (71.0)
Prevention of type 2 diabetes by lifestyle intervention;[41] (2005); Japan; n = 458	Lifestyle modification	4.0 years; Intervention: (67.4)
Zensharen Study for Prevention of Lifestyle Diseases;[42] (2011); Japan; n=641	Lifestyle modification	3.0 years; (44.0)

There are some promising 'best buys' recommended by WHO and backed by evidence. One of these is the imposition of taxes to reduce the purchase of sugar-sweetened beverages.[49] Any reduction of consumption, it is assumed, will make a difference to type 2 diabetes. Further evidence for the efficacy of this intervention is needed, but many countries around the world have adopted such a tax. These are often combined with other public health measures, such as calorie reduction programmes and promotion of physical activity[50] or package labelling.[51] However, in countries such as India, the cost of sugar is subsidised for low-income groups.

In a real-world setting, the best approach seems to be a multi-pronged coordinated strategy. Civil society leaders, such as the NCD Alliance, propose pressuring governments to develop and implement coordinated, multisectoral strategies for tackling NCDs.

> There are **multiple and competing healthcare issues** in all countries. In low- and middle-income countries, these include malnutrition as well as communicable diseases. Stakeholders need to **prioritise health policies and the allocation of resources.**

Table 6.2 Major randomised primary prevention trials in type 2 diabetes using pharmacotherapy

Study; (year); country; No. of participants	Intervention	Duration; main outcome (relative risk reduction %)
Act Now for Prevention of Diabetes;[17] (2011); United States; n=602	Pioglitazone	2.4 years; (72.0)
Troglitazone in the Prevention of Diabetes (TRIPOD);[15] United States; n = 266	Troglitazone	2.5 years ; (50.0)
Diabetes Reduction Assessment with Ramipril and Rosiglitazone Medication;[19] (2006); (DREAM); Global multicentre; n = 5269	Rosiglitazone	3.0 years ; (62.0)
Study to Prevent Non-Insulin Dependent Diabetes Mellitus (STOP-NIDDM);[16] (2002); Global multicentre; n = 1429	Acarbose	3.2 years; (25.0)
Acarbose Cardiovascular Evaluation;[46] Global Multicentre; n = 6526	Acarbose	3.0 years; diabetes incidence was 11.6, 8.2, 2.0, and 4.1% in the control, diet and exercise, acarbose, and metformin groups, respectively.
Voglibose for prevention of type 2 diabetes mellitus;[20] (2009); Japan; n = 1780	Voglibose	3.0 years; (59.5)
Xenical in the Prevention of Diabetes in Obese Subjects (2004) (XENDOS);[24] Sweden; n = 3305	Orlistat	4.0 years; (41.0)
Canadian Normoglycemia Outcomes Evaluation (2011) (CANOE);[26] Canada; n=207	Rosiglitazone, Metformin	3.9 years; (66.0)
Early Diabetes Intervention Trial (EDIT);[18] United Kingdom; n=631	Acarbose, Metformin	3.0 years; (25.0)
Nateglinide and Valsartan in Impaired Glucose Tolerance Outcomes Research (NAVIGATOR);[21] (2010); Global multicentre; n = 9306	Nateglinide and Valsartan	5.0 years; (14.0)
Outcome Reduction with Initial Glargine Intervention (ORIGIN);[22] Global multicentre; n=12,537	Insulin Glargine	6.2 years; (28.0)
Satiety and Clinical Adiposity – Liraglutide Evidence (SCALE);[23] Global multicentre; n=3731	Liraglutide	160 weeks 2.0% of liraglutide vs 6.0% of placebo arm were diagnosed with diabetes

Delivering diabetes care – using data to drive action

Rationale and evidence

Although recent evidence suggests that remission of type 2 diabetes is possible,[52] both type 1 and type 2 diabetes are best regarded, currently at least, as lifelong conditions. Diabetes care is multi-dimensional as a result of complex interactions between environmental, lifestyle, clinical and genetic factors. Each person has a unique profile of risk factors and complications, and access to continuing care, education and medication strongly influence the clinical course. An integral partnership between health professionals and people living with diabetes should safeguard the health and well-being of all patients and families.

Despite the treatments available for diabetes, marked variability in outcomes results from poorly coordinated care with irregular monitoring, insufficient empowerment and sub-optimal use of organ-protective medicines. Considering that global data on the management of type 2 diabetes are scarce, the DISCOVER programme is aiming to record patient, healthcare provider, and healthcare system characteristics, management patterns and factors influencing changes in therapy. It will enable reporting in 35 participating countries on microvascular and macrovascular complications, incidence of hypoglycaemic events, and patient-reported outcomes, a useful addition to knowledge of outcomes of treatment.[53]

The lack of timely and personalised information can delay intervention and reduce motivation to improve self-management.[54] In contrast, structured and team-based care (e.g. with a doctor, nurse, diabetes educator or other healthcare professional) improves clinical outcomes compared to usual care.[55–57] Systematic reviews and meta-analyses support the benefits of self-management and team-based

care. Models focusing on self-management, task-shifting among professionals, ongoing support and the use of role play to promote patient–provider communication can be cost-effective in some settings.[58–62]

Implementation and evaluation

Where team-based care does not currently exist, transferring knowledge using a 'train-the-trainer' approach allows tasks to be shifted to non-medical staff. This facilitates care coordination and systematic data collection for risk stratification and treatment personalisation (Table 6.3).[58] The same data can educate, engage and enable patients to learn how to identify and manage their own risk profiles and achieve their treatment goals. On average, 23 hours of contact (face-to-face, telephone calls, or text messages) with healthcare providers during the first year following diagnosis helps patients better understand their risks, change behaviours and learn new skills to sustain glycaemic control.[58,63]

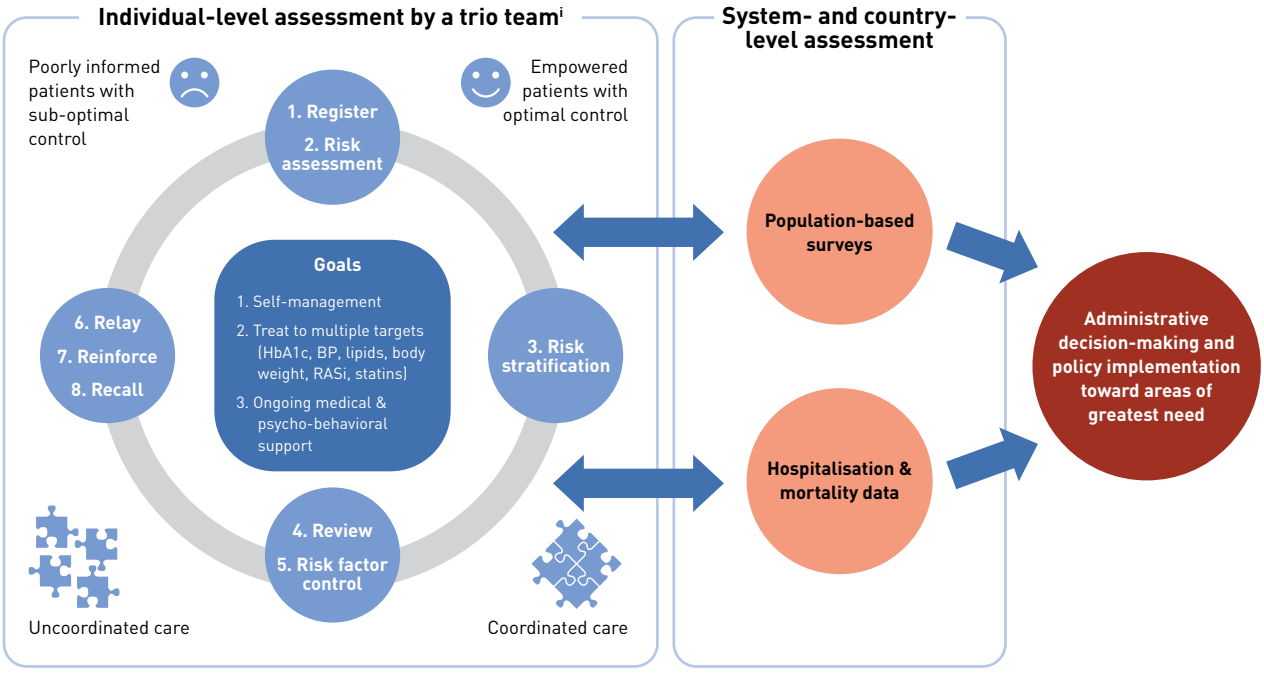
Table 6.3 **Key indicators for data collection to monitor diabetes management quality**

	Ongoing indicators (at least every 12–24 months)			
Baseline	Anthropometric	Laboratory	Clinical	Self-care
• Current age • Diabetes sub-types • Age at diagnosis • Family history • Ethnicity • Body height • Sex and pregnancy risk	• Body weight and height (body mass index) • Waist circumference • Blood pressure	• HbA1c • Total cholesterol • HDL-cholesterol • LDL-cholesterol • Triglycerides • Microalbuminuria (e.g. urine albumin: creatinine ratio) • Estimated glomerular filtration rate (eGFR)	• Visual acuity • Dilated eye examination • Foot examination (skin, vascular and neurological) • Other complications (e.g. stroke, coronary heart disease, heart failure, peripheral arterial disease, end-stage renal disease, autonomic neuropathy, mental health, cancer) • Hospitalisations	• Smoking status • Alcohol consumption • Hypoglycaemia • Self-monitoring (glucose, blood pressure, body weight) • Diet • Exercise • Driving risk • Medication adherence • Insulin technique (where applicable) • Dental

HbA1c: haemoglobin A1c; HDL: high-density lipoprotein; LDLL: low-density lipoprotein

Source: Adapted from Nicolucci A et al.[70]

Figure 6.1 **Effective team-based care enabling risk management at multiple levels for prevention of diabetes-related morbidity and mortality**



i Example of a trio team: healthcare assistants, community health workers and peer supporters.
BP: Blood pressure; HbA1c: Haemoglobin A1c; RASi; Renin-angiotensin system inhibitors.

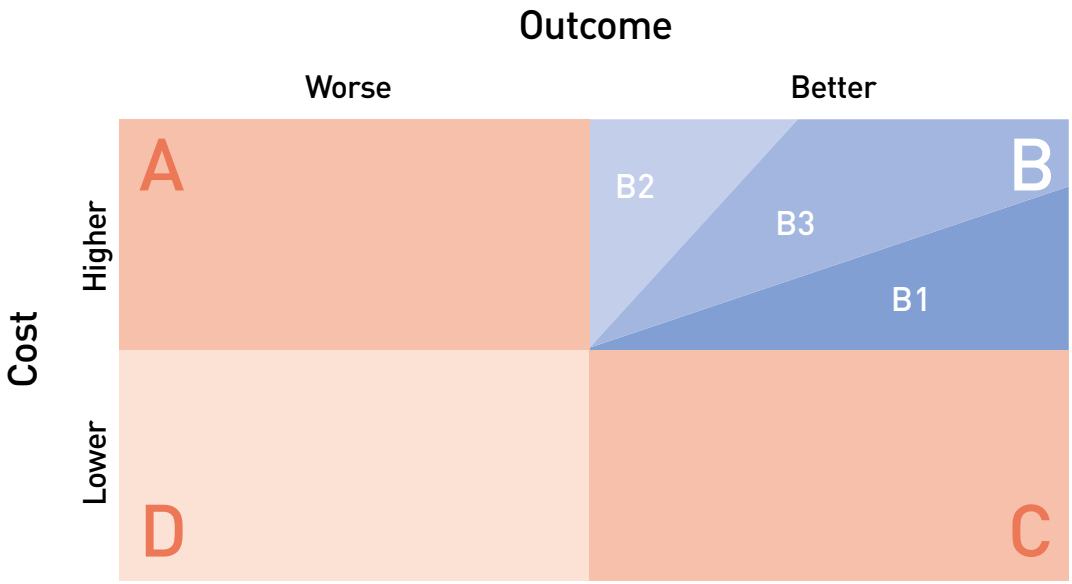
Multi-disciplinary, patient-centred, and well-coordinated approaches improve selfmanagement. **The individualisation of care** leads to the attainment of treatment targets, reduces hospitalisations and adverse clinical events, and can improve quality of life.

Teams can include community health workers and peer supporters trained in skills to meet the physical and psychosocial needs of the person with diabetes.[64,65] Team composition will vary based on national income levels, health expenditure and diabetes awareness. By changing workflow, and using a team-based approach to systematically collect data, establishment of registers can assure quality of care, review, recall and decision support. On a system level, these data can identify gaps, uncover hidden patterns and track performance. High-quality individual data can link to population-level surveys, and hospitalisation and mortality data to reveal relationships between risk factors, care standards and clinical outcomes.[66] Such data can provide valuable insights to inform practices and policies (Figure 6.1).

Given the increasing complexity of pharmaceutical care, there should be a strong emphasis on individualising treatment goals and strategies to maximise benefits and to minimise harm. To implement these clinical guidelines,[67] systemic and financial barriers need to be overcome. This requires governments and payers to invest in high-quality, team-based diabetes care to capitalise on modern technological advancements.[68] To this end, implementation research is urgently needed to generate evidence to inform practices and policies, and make healthcare systems sustainable.[69]

Self-management is the cornerstone of diabetes care. However, the silent nature of type 2 diabetes, with its unpredictable symptoms, is a **major barrier** to motivating behavioural changes by patients and therapeutic decision-making by healthcare providers.

Figure 6.2 **The cost-effectiveness plane: a diagrammatic illustration of the relationship between the costs and effects of interventions (adapted from Williams)[74]**



Cost-effectiveness of interventions

The cost-effectiveness plane is widely used as a diagrammatic illustration of the relationship between the costs and effects of interventions (Figure 6.2). It was initially advocated by economists such as Black[71] and Laupacis.[72]

Of the two intersecting axes, one relates to costs and the other effects (or outcomes). If the existing intervention is visualised at the centre of the diagram, then an intervention that is less effective and more costly (i.e. quadrant A) is clearly unacceptable. One that is more effective and less costly is advantageous (but rare) – quadrant C. An intervention that is less effective and less costly (quadrant D) may be advantageous since it can be employed on a wider scale. Its viability depends principally on the extent of any reduction in effectiveness.

The most frequently encountered combination is a more effective intervention that is also more costly than current practice (quadrant B). This quadrant may be divided into two, three (as here) or four zones in which the trade-offs differ – those that offer better outcomes at comparatively lower additional costs (B1) are clearly worth considering as 'best buys'; those that offer better outcomes but at considerably higher costs (B2) are likely to be regarded as questionable; and there is an intermediate zone (B3) where judgements need to be made.

Organisations such as the UK National Institute of Health and Care Excellence (NICE) has rules of thumb for assessing value for money in terms of the cost per quality-adjusted life year (QALY) for partitioning interventions into the various segments of quadrant B. The previous systematic review by Li et al divided this quadrant into four zones.[73]

The evidence on cost-effectiveness of interventions has been extensively reviewed by Li et al.[73] Both Williams[74] and the update of this review (Marcellusi et al[75] and Zhuo et al)[76] emphasise the lack of information on the effectiveness of interventions in low- and middle-income countries.

> **Regular monitoring** of the risk factors for diabetes complications and **early intervention** result in **reduced hospitalisations** and **improved clinical outcomes.**

Universal health coverage and diabetes: addressing the double challenge of increasing prevalence and economic impact

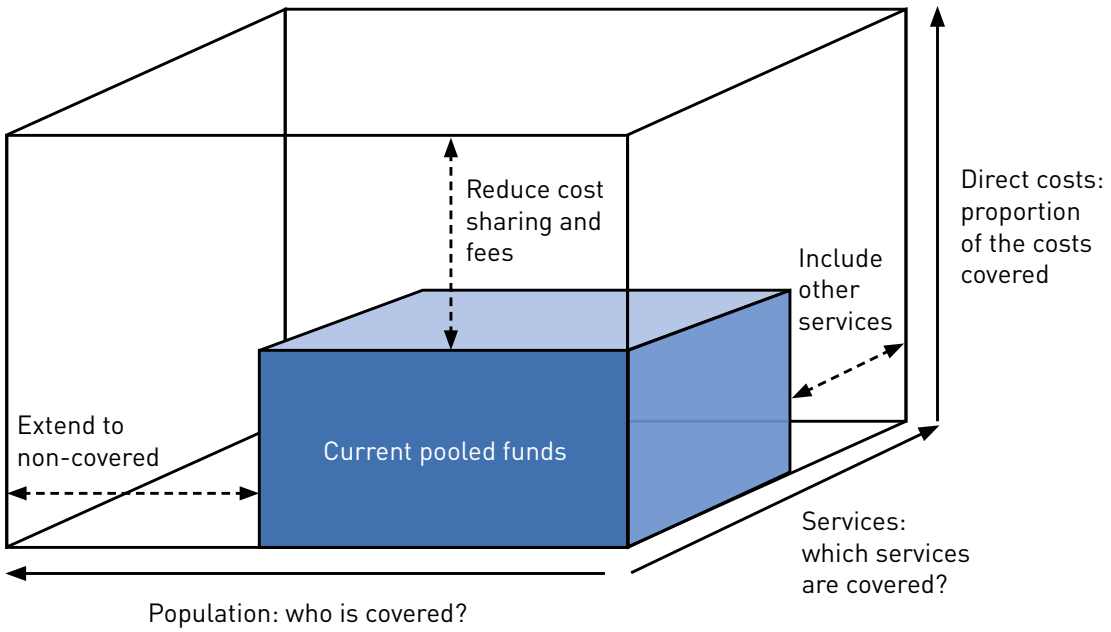
This edition of the *IDF Diabetes Atlas* estimates that 463 million people in 2019 have diabetes and that the annual cost of diabetes care is USD 760 billion. Behind these numbers is the double challenge of addressing the needs of people with diabetes: ensuring that the costs of managing their condition do not lead to increased poverty for individuals, or place undue impact on the resources of the health system.

Within this remarkable number of 463 million, there are many people with diabetes who are unaware that they even have the condition (232 million). Data from sub-Saharan Africa found that most people with diabetes had many unmet needs regarding their diabetes care including access to screening for complications, counselling and medicines.[77] For example global estimates show that one in two people with type 2 diabetes do not have access to the insulin they have been prescribed. This number is higher in low- and middle-income countries: with 86% of people with type 2 diabetes in the African context not being able to access the insulin they need[78] given that current access to insulin in terms of availability and affordability is limited. Using access to medicines as a tracer for

access to diabetes care shows that availability of diabetes medicines is globally variable, with poorer populations having less availability than those in higher income settings.[79]

Availability of medicines is only one factor affecting access – the cost of medications influences whether or not people will be able to afford their treatment. For metformin, it was found that 0.7% of households in high-income countries, and 26.9% of households in low-income countries, could not afford this medicine.[79] The lack of affordability of insulin was higher with 2.8% of households in high-income countries, and 63% of households in low-income countries unable to afford this treatment. Many studies have shown that the cost of diabetes medicines is increasing.[80] The price of medicines is only one element of the overall cost of diabetes care. This, and other aspects of the financial impact, may fall to the individual and/or to the health system, depending on local circumstances. At one extreme, all costs are borne by the individual, whereas at the other extreme all costs are paid by the heath system with little or no financial impact on the individual, at least not at the point of care.

Figure 6.3 **The three dimensions to be considered when moving towards universal health coverage**



Source: Reproduced from WHO[81]

Availability of diabetes medicines is globally variable, with poorer populations having less availability than those in higher income settings. For example, global estimates show that one in **two people with type 2 diabetes** do not have **access to the insulin** they have been prescribed.

Within the Sustainable Development Goals (SDGs) the overarching SDG 3 focuses on achieving health and well-being. Target 3.8 states: "Achieve universal health coverage, including financial risk protection, access to quality essential healthcare services and access to safe, effective, quality and affordable essential medicines and vaccines for all."[82] Universal health coverage (UHC), as proposed by WHO, has as its aim "to ensure that all people obtain the health services they need without suffering financial hardship when paying for them."[83] The model of UHC is often presented as a cube where existing resources can be used to address three dimensions: extend to populations currently not covered; include additional services currently not included; and reduce payments that people need to make for their care (Figure 6.3).[84]

UHC ensures that everyone is assured access to the services and medicines essential for their care. Specifically for diabetes, for example, the *WHO Model Essential Medicines List* prioritises metformin, gliclazide and human insulin over newer and more expensive treatments. Certain medicines – such as insulin analogues, GLP1 analogues, DPP-4 inhibitors and meglitinides[85,86] – may not be included in those that are covered or reimbursed by UHC systems. The global inequity in access to medicines, especially the high cost of insulin, needs action to ensure that access to these lifesaving medicines is no longer a barrier to care and the achievement of UHC. Some costly procedures, such as dialysis, may also not be technically or economically feasible in some settings. For the diabetes community, it is important to ensure that people with diabetes receive the best treatment possible. However, health resources are limited and additional expenditure on diabetes care means that resources may not be available for such items as vaccines, aspects of maternal and child health and interventions relevant to other NCDs, for example.[87] Improving diabetes care, in a context of increasing prevalence and increasing costs of treatment, remains a challenge. Meeting the diabetes care needs of its population adds to the challenge of a country's rational use of limited health finances.

To address this challenge, the six building blocks of the health system[88] – financing; human resources; medicines; information; delivery of services; and governance – need to be strengthened. Health systems need to ensure that diabetes is included in the services provided as part of the UHC package of essential services. Each country needs to align these services with its technical and financial resources. This approach for type 1 diabetes enables the management and provision of different levels of care to be based on the availability of resources.[89] However, overall, governments need to increase the resources available for health, not only for diabetes.

Human resources for diabetes need to be increased. This not only includes specialists, but also generalists, nurses and other health personnel. Diabetes training at medical and nursing schools needs to be increased and include continuing professional development. 'Task shifting' (assigning tasks to less specialised health workers where appropriate) has shown much success for management of conditions such as HIV/AIDS, not only for patient support and education, but also for treatment. In many settings, due to frequent shortages of clinical staff, such an approach for diabetes is essential and urgent.

Improving diabetes care, in a context of increasing prevalence and increasing costs of treatment, **remains a challenge.** Meeting the diabetes care needs of its population adds to the challenge of a country's rational use of limited health finances.

The entry point for diabetes care should be primary healthcare, which provides both preventive and curative services within communities and close to individuals throughout their lifespan. This also ensures that all aspects of the individual receive care, and not just their diabetes. A wide range of policies and government decisions ranging from budgets for health, taxation of unhealthy products and defining UHC packages frames these five elements. WHO has developed a *Global Action Plan on NCDs*,[47] which includes diabetes, and has proposed a wide range of actions that need to be taken, and highlights where national implementation has lagged.[90]

For all these elements, IDF and its Member Associations play a key role in advocating increased attention and resources for diabetes both globally and nationally. This should not compete with, but complement, other health needs as people with diabetes do not only need diabetes care and, globally, health resources are limited for all diseases. Diabetes currently is an example of global inequity: individuals in many high-income countries can access the latest medicines, tools and care at little or no immediate cost, whereas those in low- and middle-income countries still face undue hardship as they cannot access insulin, despite its discovery close to a century ago.

> **Universal health coverage,** enshrined in the aims of the Sustainable Development Goals, in the words of the World Health Organization is: "To ensure that all people obtain the health services they need without suffering financial hardship when paying for them."

Insulin: one hundred years of saving lives but, a century later, barriers to access remain

The therapeutic availability of insulin in 1921, and its first use in humans in 1922, can truly be hailed as a medical miracle.[91–93] This innovation changed the course of type 1 diabetes from a death sentence into a manageable condition. The researchers Frederick Banting (1891–1941) and Charles Best (1899–1978) made this breakthrough while the private sector played a key role in ensuring production and access. Yet, in 2019, as we approach the centenary of insulin's discovery, the challenge of access to insulin persists for many populations globally.

Barriers to access can be simplified into two categories: affordability and availability.[80] There are global and national factors that impact both the affordability and availability of insulin.[94] Price mark-ups within the supply chain also impact prices for individuals. Reports of high and variable prices observed globally influence insulin affordability for both governments and individuals. The prices at which governments buy insulin were found to vary from USD 2.24 to USD 43.51 (median: USD 5.99) for human insulin, and USD 6.88 to USD 81.67 (median USD 34.20) for analogue insulin for a 10ml 100IU vial equivalent.[95]

Some countries provide insulin free of charge to individuals whereas, in other countries, people need to pay for their insulin. In the latter contexts, the median patient price for human insulin was found to be USD 7.64 (Range: USD 2.16–USD 36.70) in the public sector. The median price for analogue insulin in the public sector, human insulin in the private sector and analogue insulin in the private sector wa 5.9, 2.8 and 5.2 times higher, respectively, per 10ml 100IU vial equivalent.

Aside from high prices, many people face barriers due to the lack of availability of insulin. This can result from a variety of factors including the unavailability of insulin in the health system at all, disruptions in the supply of insulin in certain areas of the country or levels of the health system. Looking at the availability across a variety of countries, only six countries in the public sector and two in the private sector had an availability of insulin equal to or higher than 80% of their facilities.[94]

More evidence and awareness now exist regarding access to insulin than in the past. Thus, IDF and the global diabetes community as a whole call for further concrete, sustainable responses from government and industry. Although some companies have various programmes, including differential pricing to address barriers to access, these do not completely address the underlying issues of price. A study based on the cost of production, reported that the use of intermediate acting human insulin should be USD 72 and for long-acting analogues USD 133 per year.[96] These costs are orders of magnitude lower than costs reported in many contexts.

Donation programmes have shown a positive impact[97] in improving survival of children living with type 1 diabetes, but they do not address root causes of inadequate access to insulin and diabetes care. Some low- and middle-income countries should be saluted as, despite a lack of resources, they provide insulin to their populations free of charge.[98]

With the SDG agenda including targets for NCDs, access to medicines and for UHC, the availability of insulin provides a litmus test to the success of this global agenda. In looking at how access to HIV/AIDS medicines has been improved, the diabetes community could learn several lessons.[95] Firstly, there is the need for global advocacy to drive access to insulin and diabetes care. This recommendation needs to hold governments, the private sector and civil society accountable. Governments need to provide resources either through donor governments or as healthcare spending for diabetes. Also, governments should learn from the examples of the low- and middle-income countries that already provide insulin and care to their citizens.

The SDGs also highlight the need for partnership, and the private sector clearly has a role to play in solving global issues. These partnerships must be transparent and equal. The solutions need to go beyond what is currently in place for access to diabetes care, to ensure access to affordable insulin. This needs to be accompanied by governments also assuring regulatory procedures to guarantee quality products on their markets. In 1925, R.D. Lawrence stated: "Now modern discoveries, particularly insulin, have completely changed the outlook." It is unfortunate that 94 years later this changed outlook is not afforded to all those in need of insulin.

IDF activities and materials

As the global voice of people with diabetes, the IDF aims to have a strong presence on the global stage and to increase worldwide recognition of diabetes challenges; to advocate globally for people with diabetes and those at risk; and to empower people affected by diabetes. The mission of IDF is also supported through the development of high-quality programmes and resources that inform and guide policy agendas at the national, regional and global levels, ensuring the continued professional development of diabetes healthcare providers.

Advocating for people with diabetes

IDF's advocacy work is divided into two broad categories: Global advocacy on behalf of people with diabetes, those at risk of developing diabetes and their families; and growth of the global recognition of diabetes as a serious challenge to health and development. Informed and supported by the evidence and policies developed under IDF core programmes and other projects, IDF's advocacy work includes engaging with international bodies, leading political platforms and national governments to affect tangible, beneficial and long-term change for people with diabetes.

In 2018, IDF engaged in intensive advocacy efforts in relation to the United Nations (UN) third high-level meeting (HLM) on NCDs.[a] IDF launched a call for improved action on diabetes prevention, care and education to UN Member States, and developed an advocacy toolkit for its network to bring IDF's global campaign to the national level. The IDF network heavily supported IDF's HLM campaign on social media.

In 2019, IDF ran an advocacy campaign requesting improved access to diabetes medicines and care in the run-up to the UN first HLM on UHC. The campaign, supported by the IDF network, revolved around the WHO target of 80% access to essential NCDs medicines and technologies by 2025, and the achievement of UHC by 2030.

More information

www.idf.org/our-activities/advocacy-awareness.html

a See: https://www.idf.org/our-activities/advocacy-awareness/campaigns/hlm2018.html?id=327.

young leaders in diabetes
A programme of the International Diabetes Federation

Young Leaders in Diabetes – young minds, fresh ideas, real change

The IDF *Young Leaders in Diabetes* (YLD) programme aims to enhance the lives of young people living with diabetes and create leaders within the diabetes community. It is open to people with diabetes between the ages of 18 to 30. YLD is committed to raising awareness of diabetes by being a powerful voice for prevention, education, access to quality care, improved quality of life and ultimately to ending diabetes discrimination.

More information

www.idf.org/our-network/young-leaders

blue circle voices

Blue Circle Voices – representing the global voice of diabetes

Blue Circle Voices (BCV) is an IDF initiative that aims to represent the interests of people living with, or affected by, diabetes, through a worldwide network of members and other stakeholders. The BCV network draws upon the experiences of people with diabetes and acts as their global voice and provides IDF with a better understanding of the needs, challenges and wishes of people living with diabetes – thereby enhancing IDF's ability to represent them. The BCV network supports IDF's global advocacy activities to effect real changes in areas of concern for people with diabetes, and strengthens IDFs presence in global forums.

More information

www.idf.org/our-network/blue-circle-voices.html

Uniting the global diabetes community

IDF Congress

The IDF Congress offers a global platform to discuss a broad range of diabetes issues, from latest scientific advances to cutting-edge information on education, diabetes care, advocacy and awareness. Participants include physicians, scientists, nurses, educators and other healthcare professionals, as well as government representatives, policy-makers, people with diabetes, IDF members and the media. The next IDF Congress will be held in Busan, Korea, on 2–6 December 2019.

The IDF Diabetes Complications Congress, the first of which took place in 2018 in Hyderabad, India, is complemented by a series of live educational events focusing on diabetes complications.

More information

www.idf.org/congress

World Diabetes Day (WDD)

World Diabetes Day (WDD) is celebrated every year on November 14. In 1991, IDF and WHO established WDD in response to growing concerns about the escalating health threat posed by diabetes. World Diabetes Day became an official United Nations Day in 2006. WDD is the world's largest diabetes awareness campaign, and draws attention to issues of paramount importance to the diabetes world and keeps diabetes firmly in the public spotlight. Awareness and communications activities developed for World Diabetes Day are distributed and promoted throughout the month of November – diabetes awareness month. The theme for World Diabetes Day and diabetes awareness month 2018–2019 is *Family and Diabetes*.

More information

www.worlddiabetesday.org

Building the evidence to inform the global response to diabetes

Taking Diabetes to Heart

Taking Diabetes to Heart is a multi-country study designed to assess knowledge and awareness of CVD among people with type 2 diabetes. The results of the study aim to facilitate evidence-based decision-making and encourage intersectoral collaboration to strengthen health systems and to implement cost-effective interventions to improve health outcomes for people with diabetes.

More information

www.idf.org/our-activities/care-prevention/cardiovascular-disease/taking-diabetes-to-heart.html

Diabetic Retinopathy Barometer

The *Diabetic Retinopathy Barometer* is the product of unique collaboration of experts from the International Federation on Ageing (IFA), IDF, and International Agency for the Prevention of Blindness (IAPB). With global and 41 country-level reports supported by regional workshops, it highlights the urgent need for clear patient care pathways and robust, responsive health systems around the world to prevent unnecessary vision loss associated with diabetes.

More information

https://www.idf.org/our-activities/care-prevention/eye-health/dr-barometer.html

Tackling the barriers and gaps in diabetes education

The increasing global prevalence of chronic diseases places enormous and growing demands and responsibilities on health systems. Healthcare professionals play a critical role in improving access to, and the quality of, healthcare for people with diabetes. Preparing the worldwide healthcare workforce to respond to the associated challenges is a crucial objective for IDF.

IDF School of Diabetes

The IDF *School of Diabetes* was launched in 2016 to deliver high quality, evidence-based diabetes education for health professionals, people with diabetes and caregivers worldwide. The online platform has since registered 17,500+ healthcare professionals from 190+ countries. The European Accreditation Council for Continuing Medical Education (EACCME) has accredited the IDF School platform.

The IDF School features three tailor-made online courses (comprised of multiple modules) that target diabetes educators, primary care physicians, general practitioners, and specialists. A series of free short courses focusing on prevention of type 2 diabetes, diabetes-related retinopathy, diabetes and CVD are also available in multiple languages.

Since 2017, the IDF School of Diabetes has implemented capacity-building initiatives, for a group of more than 400 specialists, and more than 700 primary care physicians, across 10 countries (Cambodia, India, Iran, Iraq, Jordan, Laos, Myanmar, Pakistan, United Arab Emirates and Viet Nam), in association with various public and private institutions, with an aim to enhance diabetes care in respective IDF Regions.

More information

www.idfdiabeteschool.org/

Diabetes Education Network for Health Professionals (D-NET)

Launched by the IDF in 2010, the *Diabetes Education Network for Health Professionals* (D-NET) is the first international network for health professionals to enhance their skills in diabetes education, care and management. The online platform offers healthcare professionals the opportunity to share, learn and discuss the latest developments in diabetes care and education. Over the years, D-NET has grown into an online network of more than 17,000 members from 189 countries. The platform provides its members with expert-led discussions, an interactive library, a global event calendar and 'Ask D-NET', a feature where members are able to ask questions and consult with the D-NET community.

More information

www.d-net.idf.org

Kids and Diabetes in Schools (KiDS)

Created in collaboration with the International Society for Paediatric and Adolescent Diabetes (ISPAD), the *KiDS & Diabetes in Schools* (KiDS) project fosters a better understanding of diabetes and provides a safe and supportive environment for children with diabetes. The KiDS project is an educational programme designed for school staff, parents and school-age children. Available in 15 languages, the KiDS information pack aims to educate adults on the management of children with diabetes and to raise awareness of the prevention of type 2 diabetes in children. IDF subsequently launched the *KiDS Educational Guide on Nutrition and Diabetes in Schools* as a complimentary resource. In November 2018, the European Federation of Pharmaceutical Industries and Associations (EFPIA) awarded the KiDS Project in Poland the Health Collaboration Award in the Prevention and Awareness category for "creating a programme that had clear benefits to society".

More information

kids.idf.org

International Diabetes Federation
Centres of Excellence in Diabetes Care
2018-2019

IDF Centres of Education and Excellence in Diabetes Care

IDF designates diabetes institutions and organisations to form part of an international voluntary network to initiate, coordinate, facilitate and conduct high-quality education for multi-disciplinary healthcare professionals in diabetes and other related chronic diseases.

During the IDF Congress in 2017, 38 institutes were designated as *IDF Centres of Education* and 27 as *IDF Centres of Excellence in Diabetes Care* for the period 2018–2019. Since then, additional institutes have been recognised as meeting the high global standards and selection criteria set by IDF. Further rounds of applications will be opened and new centres will contribute to the implementation of the *IDF Strategic Implementation Plan*.

Learn more about both networks:

More information

IDF Centres of Education:
www.idf.org/our-activities/education/centres.html

IDF Centres of Excellence in Diabetes Care:
www.idf.org/our-activities/education/centres-excellence-care.html

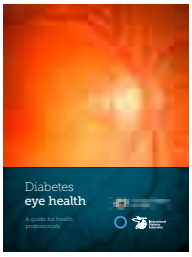
Setting the global standard for care

Integrated Care for Diabetes and Eye Health: A Global Compendium of Good Practice

Integrated Care for Diabetes and Eye Health: A Global Compendium of Good Practice was developed by IDF, the Fred Hollows Foundation, and other leading agencies. Leading non-governmental agencies in diabetes and eye health sectors undertook this advocacy project from 2017 to 2018. The compendium documents real-world case studies from 17 countries that highlight initiatives to promote integrated care for diabetes-related retinopathy through health promotion, prevention, early intervention and treatment in a range of contexts and resource settings. The primary audiences for this document are decision-makers and practitioners who work with people with diabetes.

More information

https://www.idf.org/our-activities/care-prevention/eye-health/dr-compendium.html



Diabetes Eye Health: A Guide for Health Professionals

IDF in partnership with the Fred Hollows Foundation, developed a publication entitled *Diabetes Eye Health: A Guide for Health Professionals*. It is the first document of its kind on diabetes eye health written for health practitioners at the front-line of diabetes management. The purpose of the guide is to highlight the rising prevalence of diabetic-related eye disease, particularly diabetic retinopathy, and outline the actions that can be taken to address it. The guide offers practical, evidence-based advice to healthcare professionals on how to include eye health in their ongoing management of people with diabetes.

More information

https://www.idf.org/our-activities/care-prevention/eye-health/eye-health-guide.html

Delivering diabetes care where it is needed most

Securing immediate access to essential medicines is a priority when people with diabetes are forced to flee their homes. The supply must be uninterrupted and provided at no or very low cost, so that medicines remain affordable for those who need them most. All too often, the response to a humanitarian crisis overlooks the care of people with diabetes.

IDF Humanitarian Projects

IDF is involved in a number of humanitarian projects to provide improved care and access to essential medicines to under-served communities. IDF works with a range of partners to deliver essential medicines and support to people who have difficulty accessing care due to disruption to medication distribution or because of their economic circumstances and/or their care settings do not provide the minimum standards of care they require.

The IDF *Life for a Child* (LFAC) programme was set up in 2000 to provide sufficient insulin and syringes, blood glucose monitoring equipment, appropriate clinical care and diabetes education for children living with diabetes. IDF is now working to identify new target countries that will be supported through a Brussels-based child support programme. The programme will work closely with IDF Member Associations to deliver care to vulnerable children in countries where needs are not yet met.

IDF advocacy activities align with our humanitarian efforts to encourage governments to ramp up support for people living with diabetes and those at high risk. IDF looks to raise awareness of the challenges of managing and preventing diabetes in humanitarian settings, encouraging action, improving health services and ensuring access to essential care and medicines to displaced people and refugees.

Prevention and screening for diabetic retinopathy

The IDF eye screening initiative targets low-income countries and remote areas without eye screening services. IDF is disseminating 100 fundus cameras to 56 sites identified by IDF Member Associations to help integrate eye-health screening into primary care services. This project will provide diabetes centres and healthcare professionals with the necessary medical equipment to screen for diabetic retinopathy and to take preventative action on this common and costly complication.

REFERENCES

1. Atkinson MA, Eisenbarth GS, Michels AW. Type 1 diabetes. *Lancet*. 2014 Jan 4;383(9911):69–82; DOI:10.1016/S0140-6736(13)60591-7.
2. Dahlquist G. Can we slow the rising incidence of childhood-onset autoimmune diabetes? The overload hypothesis. *Diabetologia*. 2006 Jan;49(1):20–4; DOI:10.1007/s00125-005-0076-4.
3. Cardwell CR, Stene LC, Ludvigsson J, Rosenbauer J, Cinek O, Svensson J, et al. Breast-feeding and childhood-onset type 1 diabetes: a pooled analysis of individual participant data from 43 observational studies. *Diabetes Care*. 2012 Nov;35(11):2215–25; DOI:10.2337/dc12-0438.
4. Cardwell CR, Stene LC, Joner G, Bulsara MK, Cinek O, Rosenbauer J, et al. Birth order and childhood type 1 diabetes risk: a pooled analysis of 31 observational studies. *Int J Epidemiol*. 2011 Apr;40(2):363–74; DOI:10.1093/ije/dyq207.
5. Cardwell CR, Stene LC, Joner G, Cinek O, Svensson J, Goldacre MJ, et al. Caesarean section is associated with an increased risk of childhood-onset type 1 diabetes mellitus: a meta-analysis of observational studies. *Diabetologia*. 2008 May;51(5):726–35; DOI:10.1007/s00125-008-0941-z.
6. Cardwell CR, Stene LC, Joner G, Bulsara MK, Cinek O, Rosenbauer J, et al. Maternal age at birth and childhood type 1 diabetes: a pooled analysis of 30 observational studies. *Diabetes.* 2010 Feb;59(2):486–94; DOI:10.2337/db09-1166.
7. Lindell N, Carlsson A, Josefsson A, Samuelsson U. Maternal obesity as a risk factor for early childhood type 1 diabetes: a nationwide, prospective, population-based case-control study. *Diabetologia*. 2018 Jan;61(1):130–7; DOI:10.1007/s00125-017-4481-2.
8. Waernbaum I, Dahlquist G, Lind T. Perinatal risk factors for type 1 diabetes revisited: a population-based register study. *Diabetologia*. 2019 Jul;62(7):1173–84.
9. Hamman RF, Bell RA, Dabelea D, D'Agostino RB, Dolan L, Imperatore G, et al. The SEARCH for Diabetes in Youth Study: Rationale, Findings, and Future Directions. *Diabetes Care*. 2014 Dec;37(12):3336–44; DOI:10.1007/s00125-019-4874-5.
10. Patterson CC, Dahlquist GG, Gyürüs E, Green A, Soltész G, EURODIAB Study Group. Incidence trends for childhood type 1 diabetes in Europe during 1989–2003 and predicted new cases 2005–20: a multicentre prospective registration study. *Lancet*. 2009 Jun 13;373(9680):2027–33; DOI:10.1016/S0140-6736(09)60568-7.
11. Dahlquist GG, Nyström L, Patterson CC, Swedish Childhood Diabetes Study Group, Diabetes Incidence in Sweden Study Group. Incidence of type 1 diabetes in Sweden among individuals aged 0-34 years, 1983-2007: an analysis of time trends. *Diabetes Care*. 2011 Aug;34(8):1754–9; DOI:10.2337/dc11-0056.
12. Backholer K, Peeters A, Herman WH, Shaw JE, Liew D, Ademi Z, et al. Diabetes prevention and treatment strategies: are we doing enough? *Diabetes Care*. 2013;36(9):2714–9; DOI:10.2337/DC12-2501.
13. Cefalu WT, Buse JB, Tuomilehto J, Fleming GA, Ferrannini E, Gerstein HC, et al. Update and next steps for real-world translation of interventions for Type 2 diabetes prevention: reflections from a Diabetes Care Editors' Expert Forum. *Diabetes Care*. 2016;39(7):1186–201; DOI:10.2337/dc16-0873.
14. Ramachandran A, Snehalatha C. Diabetes prevention programs. *Med Clin North Am*. 2011 Mar;95(2):353–72, viii; DOI:10.1016/j.mcna.2010.11.006.
15. Buchanan TA, Xiang AH, Peters RK, Kjos SL, Marroquin A, Goico J, et al. Preservation of pancreatic beta-cell function and prevention of type 2 diabetes by pharmacological treatment of insulin resistance in high-risk hispanic women. *Diabetes*. 2002 Sep;51(9):2796–803; DOI:10.2337/diabetes.51.9.2796.
16. Chiasson J-L, Josse RG, Gomis R, Hanefeld M, Karasik A, Laakso M, et al. Acarbose for prevention of type 2 diabetes mellitus: the STOP-NIDDM randomised trial. *Lancet*. 2002 Jun 15;359(9323):2072–7; DOI:10.1016/S0140-6736(02)08905-5.
17. DeFronzo RA, Tripathy D, Schwenke DC, Banerji M, Bray GA, Buchanan TA, et al. Pioglitazone for diabetes prevention in impaired glucose tolerance. *N Engl J Med*. 2011 Mar 24;364(12):1104–15; DOI:10.1056/NEJMoa1010949.
18. Holman R, North B, Tunbridge F. Possible Prevention of Type 2 Diabetes with Acarbose or Metformin. *Clinical Science*. 2000 Feb;98(s42):13P.4-13P.
19. DREAM (Diabetes REduction Assessment with ramipril and rosiglitazone Medication) Trial Investigators, Gerstein HC, Yusuf S, Bosch J, Pogue J, Sheridan P, et al. Effect of rosiglitazone on the frequency of diabetes in patients with impaired glucose tolerance or impaired fasting glucose: a randomised controlled trial. *Lancet*. 2006;368(9541):1096–105; DOI:10.1016/S0140-6736(06)69420-8.
20. Kawamori R, Tajima N, Iwamoto Y, Kashiwagi A, Shimamoto K, Kaku K, et al. Voglibose for prevention of type 2 diabetes mellitus: a randomised, double-blind trial in Japanese individuals with impaired glucose tolerance. *Lancet*. 2009 May 9;373(9675):1607–14; DOI:10.1016/S0140-6736(09)60222-1.
21. NAVIGATOR Study Group, Holman RR, Haffner SM, McMurray JJ, Bethel MA, Holzhauer B, et al. Effect of nateglinide on the incidence of diabetes and cardiovascular events. *N Engl J Med*. 2010 Apr 22;362(16):1463–76; DOI:10.1056/NEJMoa1001122.
22. ORIGIN Trial Investigators, Gerstein HC, Bosch J, Dagenais GR, Díaz R, Jung H, et al. Basal insulin and cardiovascular and other outcomes in dysglycemia. *N Engl J Med*. 2012 Jul 26;367(4):319–28; DOI:10.1056/NEJMoa1203858.
23. Pi-Sunyer X, Astrup A, Fujioka K, Greenway F, Halpern A, Krempf M, et al. A Randomized, Controlled Trial of 3.0 mg of Liraglutide in Weight Management. *N Engl J Med*. 2015 Jul 2;373(1):11–22; DOI:10.1056/NEJMoa1411892.
24. Torgerson JS, Hauptman J, Boldrin MN, Sjöström L. XENical in the prevention of diabetes in obese subjects (XENDOS) study: a randomized study of orlistat as an adjunct to lifestyle changes for the prevention of type 2 diabetes in obese patients. *Diabetes Care*. 2004 Jan;27(1):155–61; DOI:10.2337/diacare.27.1.155.
25. Yang W, Lin L, Qi J, Yu Z, Pei H, He G, et al. The preventive effect of acarbose and metformin on the progression to diabetes mellitus in the IGT population: a 3-year multicenter prospective study. *Chin J Endocrinol Metab*. 2001;17(3):131–6.
26. Zinman B, Harris SB, Neuman J, Gerstein HC, Retnakaran RR, Raboud J, et al. Low-dose combination therapy with rosiglitazone and metformin to prevent type 2 diabetes mellitus (CANOE trial): a double-blind randomised controlled study. *Lancet*. 2010 Jul 10;376(9735):103–11; DOI:10.1016/S0140-6736(10)60746-5.
27. Pan XR, Li GW, Hu YH, Wang JX, Yang WY, An ZX, et al. Effects of diet and exercise in preventing NIDDM in people with impaired glucose tolerance. The Da Qing IGT and Diabetes Study. *Diabetes Care*. 1997 Apr;20(4):537–44; DOI:10.2337/diacare.20.4.537.

28. Li G, Zhang P, Wang J, An Y, Gong Q, Gregg EW, et al. Cardiovascular mortality, all-cause mortality, and diabetes incidence after lifestyle intervention for people with impaired glucose tolerance in the Da Qing Diabetes Prevention Study: a 23-year follow-up study. *Lancet Diabetes Endocrinol*. 2014 Jun;2(6):474–80; DOI:10.1016/S2213-8587(14)70057-9.

29. Li G, Zhang P, Wang J, Gregg EW, Yang W, Gong Q, et al. The long-term effect of lifestyle interventions to prevent diabetes in the China Da Qing Diabetes Prevention Study: a 20-year follow-up study. *Lancet*. 2008 May 24;371(9626):1783–9; DOI:10.1016/S0140-6736(08)60766-7.

30. Diabetes Prevention Program Research Group, Knowler WC, Fowler SE, Hamman RF, Christophi CA, Hoffman HJ, et al. 10-year follow-up of diabetes incidence and weight loss in the Diabetes Prevention Program Outcomes Study. *Lancet*. 2009 Nov 14;374(9702):1677–86; DOI:10.1016/S0140-6736(09)61457-4.

31. Lindström J, Peltonen M, Eriksson JG, Ilanne-Parikka P, Aunola S, Keinänen-Kiukaanniemi S, et al. Improved lifestyle and decreased diabetes risk over 13 years: long-term follow-up of the randomised Finnish Diabetes Prevention Study (DPS). *Diabetologia*. 2013 Feb;56(2):284–93; DOI:10.1007/s00125-012-2752-5.

32. Nanditha A, Snehalatha C, Raghavan A, Vinitha R, Satheesh K, Susairaj P, et al. The post-trial analysis of the Indian SMS diabetes prevention study shows persistent beneficial effects of lifestyle intervention. *Diabetes Res Clin Pract*. 2018 Aug;142:213–21; DOI:10.1016/j.diabres.2018.05.042.

33. Herman WH, Hoerger TJ, Brandle M, Hicks K, Sorensen S, Zhang P, et al. The Cost-Effectiveness of Lifestyle Modification or Metformin in Preventing Type 2 Diabetes in Adults with Impaired Glucose Tolerance. *Annals of Internal Medicine*. 2005 Mar 1;142(5):323–32; DOI:10.7326/0003-4819-142-5-200503010-00007.

34. Tuomilehto J, Lindström J, Eriksson JG, Valle TT, Hämäläinen H, Ilanne-Parikka P, et al. Prevention of type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance. *N Engl J Med*. 2001 May 3;344(18):1343–50; DOI:10.1056/NEJM200105033441801.

35. Knowler WC, Barrett-Connor E, Fowler SE, Hamman RF, Lachin JM, Walker EA, et al. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *N Engl J Med*. 2002 Feb 7;346(6):393–403; DOI:10.1056/NEJMoa012512.

36. Ramachandran A, Snehalatha C, Mary S, Mukesh B, Bhaskar AD, Vijay V, et al. The Indian Diabetes Prevention Programme shows that lifestyle modification and metformin prevent type 2 diabetes in Asian Indian subjects with impaired glucose tolerance (IDPP-1). *Diabetologia*. 2006 Feb;49(2):289–97; DOI:10.1007/s00125-005-0097-z.

37. Ramachandran A, Snehalatha C, Mary S, Selvam S, Kumar CKS, Seeli AC, et al. Pioglitazone does not enhance the effectiveness of lifestyle modification in preventing conversion of impaired glucose tolerance to diabetes in Asian Indians: results of the Indian Diabetes Prevention Programme-2 (IDPP-2). *Diabetologia*. 2009 Jun;52(6):1019–26; DOI:10.1007/s00125-009-1315-x.

38. Ramachandran A, Snehalatha C, Ram J, Selvam S, Simon M, Nanditha A, et al. Effectiveness of mobile phone messaging in prevention of type 2 diabetes by lifestyle modification in men in India: a prospective, parallel-group, randomised controlled trial. *Lancet Diabetes Endocrinol*. 2013 Nov;1(3):191–8; DOI:10.1016/S2213-8587(13)70067-6.

39. Weber MB, Ranjani H, Staimez LR, Anjana RM, Ali MK, Narayan KMV, et al. The Stepwise Approach to Diabetes Prevention: Results From the D-CLIP Randomized Controlled Trial. *Diabetes Care*. 2016;39(10):1760–7; DOI:10.2337/dc16-1241.

40. Iqbal Hydrie MZ, Basit A, Shera AS, Hussain A. Effect of Intervention in Subjects with High Risk of Diabetes Mellitus in Pakistan. *J Nutr Metab*. 2012; DOI:10.1155/2012/867604.

41. Kosaka K, Noda M, Kuzuya T. Prevention of type 2 diabetes by lifestyle intervention: a Japanese trial in IGT males. *Diabetes Res Clin Pract*. 2005 Feb;67(2):152–62; DOI:10.1016/j.diabres.2004.06.010.

42. Saito T, Watanabe M, Nishida J, Izumi T, Omura M, Takagi T, et al. Lifestyle modification and prevention of type 2 diabetes in overweight Japanese with impaired fasting glucose levels: a randomized controlled trial. *Arch Intern Med*. 2011 Aug 8;171(15):1352–60; DOI:10.1001/archinternmed.2011.275.

43. Singh S, Loke YK, Furberg CD. Long-term risk of cardiovascular events with rosiglitazone: a metaanalysis. *JAMA*. 2007 Sep 12;298(10):1189–95; DOI:10.1001/jama.298.10.1189.

44. Hirst JA, Farmer AJ, Ali R, Roberts NW, Stevens RJ. Quantifying the effect of metformin treatment and dose on glycemic control. *Diabetes Care*. 2012 Feb;35(2):446–54; DOI:10.2337/dc11-1465.

45. Phung OJ, Sood NA, Sill BE, Coleman CI. Oral anti-diabetic drugs for the prevention of Type 2 diabetes. *Diabet Med*. 2011 Aug;28(8):948–64; DOI:10.1111/j.1464-5491.2011.03303.

46. Wenying Y, Lixiang L, Jinwu Q. The preventive effect of acarbose and metformin on the progression to diabetes mellitus in the IGT population: 3-year multicenter prospective study. *Chin J Endocrin Metab*. 2001 Jan 1;17.

47. World Health Organization. *Global action plan for the prevention and control of NCDs 2013–2020*. Geneva; 2013. Available from: http://www.who.int/nmh/events/ncd_action_plan/en/, accessed 30 October 2019.

48. Wakefield MA, Loken B, Hornik RC. Use of mass media campaigns to change health behaviour. *Lancet*. 2010 Oct 9;376(9748):1261–71; DOI:10.1016/S0140-6736(10)60809-4.

49. Malik VS, Popkin BM, Bray GA, Després J-P, Hu FB. Sugar-sweetened beverages, obesity, type 2 diabetes mellitus, and cardiovascular disease risk. *Circulation*. 2010 Mar 23;121(11):1356–64; DOI:10.1161/CIRCULATIONAHA.109.876185.

50. Department of Health and Social Care; Global Public Health Directorate. *Obesity, Food and Nutrition. Childhood obesity: a plan for action.* HM Government; 2018 Jun. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/718903/childhood-obesity-a-plan-for-action-chapter-2.pdf, accessed 30 October 2019.

51. Kanter R, Vanderlee L, Vandevijvere S. Front-of-package nutrition labelling policy: Global progress and future directions. *Pub Health Nut.* 2018;21(8):1399–408; DOI:10.1017/S1368980018000010.

52. Lean MEJ, Leslie WS, Barnes AC, Brosnahan N, Thom G, McCombie L, et al. Durability of a primary care-led weight-management intervention for remission of type 2 diabetes: 2-year results of the DiRECT open-label, cluster-randomised trial. *Lancet Diabetes Endocrinol*. 2019 May;7(5):344–55; DOI:10.1016/S2213-8587(19)30068-3.

53. Ji L, Bonnet F, Charbonnel B, Gomes MB, Kosiborod M, Khunti K, et al. Towards an improved global understanding of treatment and outcomes in people with type 2 diabetes: Rationale and methods of the DISCOVER observational study program. *J Diabetes Complicat*. 2017 Jul;31(7):1188–96; DOI:10.1016/j.jdiacomp.2017.03.011.

54. Miccoli R, Penno G, Del Prato S. Multidrug treatment of type 2 diabetes: a challenge for compliance. *Diabetes Care*. 2011 May;34 Suppl 2:S231-235; DOI:10.2337/dc11-s235.

55. Chan JC. What can we learn from the recent blood glucose lowering megatrials? *J Diabetes Investig*. 2011 Jan 24;2(1):1–5; DOI:10.1111/j.2040-1124.2010.00063.x.

56. Seidu S, Walker NS, Bodicoat DH, Davies MJ, Khunti K. A systematic review of interventions targeting primary care or community based professionals on cardio-metabolic risk factor control in people with diabetes. *Diabetes Res Clin Pract*. 2016 Mar;113:1–13; DOI:10.1016/j.diabres.2016.01.022.
57. Ueki K, Sasako T, Okazaki Y, Kato M, Okahata S, Katsuyama H, et al. Effect of an intensified multifactorial intervention on cardiovascular outcomes and mortality in type 2 diabetes (J-DOIT3): an open-label, randomised controlled trial. *Lancet Diabetes Endocrinol*. 2017;5(12):951–64; DOI:10.1016/S2213-8587(17)30327-3.
58. Chatterjee S, Davies MJ, Heller S, Speight J, Snoek FJ, Khunti K. Diabetes structured self-management education programmes: a narrative review and current innovations. *Lancet Diabetes Endocrinol*. 2018;6(2):130–42; DOI:10.1016/S2213-8587(17)30239-5.
59. Gaede P, Valentine WJ, Palmer AJ, Tucker DMD, Lammert M, Parving H-H, et al. Cost-effectiveness of intensified versus conventional multifactorial intervention in type 2 diabetes: results and projections from the Steno-2 study. *Diabetes Care*. 2008 Aug;31(8):1510–5; DOI:10.2337/dc07-2452.
60. Jiao FF, Fung CSC, Wan EYF, Chan AKC, McGhee SM, Kwok RLP, et al. Five-Year Cost-effectiveness of the Multidisciplinary Risk Assessment and Management Programme-Diabetes Mellitus (RAMP-DM). *Diabetes Care*. 2018;41(2):250–7; DOI:10.2337/dc17-1149.
61. Lim LL, Lau ESH, Kong APS, Davies MJ, Levitt NS, Eliasson B, et al. Aspects of Multicomponent Integrated Care Promote Sustained Improvement in Surrogate Clinical Outcomes: A Systematic Review and Meta-analysis. *Diabetes Care*. 2018;41(6):1312–20; DOI:10.2337/dc17-2010.
62. Zimbudzi E, Lo C, Misso ML, Ranasinha S, Kerr PG, Teede HJ, et al. Effectiveness of self-management support interventions for people with comorbid diabetes and chronic kidney disease: a systematic review and meta-analysis. *Syst Rev*. 2018 13;7(1):84; DOI:10.1186/s13643-018-0748-z.
63. Norris SL, Lau J, Smith SJ, Schmid CH, Engelgau MM. Self-management education for adults with type 2 diabetes: a meta-analysis of the effect on glycemic control. *Diabetes Care*. 2002 Jul;25(7):1159–71; DOI:10.2337/diacare.25.7.1159.
64. Patil SJ, Ruppar T, Koopman RJ, Lindbloom EJ, Elliott SG, Mehr DR, et al. Peer support interventions for adults with diabetes: a meta-analysis of hemoglobin A1c outcomes. *Ann Fam Med*. 2016;14(6):540–51; DOI:10.1370/afm.1982.
65. Trump LJ, Mendenhall TJ. Community health workers in diabetes care: A systematic review of randomized controlled trials. *Fam Syst Health*. 2017 Sep;35(3):320–40.
66. Chan JCN, So W, Ma RCW, Tong PCY, Wong R, Yang X. The complexity of vascular and non-vascular complications of diabetes: the Hong Kong Diabetes Registry. *Curr Cardiovasc Risk Rep*. 2011 Jun;5(3):230–9; DOI:10.1007/s12170-011-0172-6.
67. International Diabetes Federation. IDF clinical practice recommendations for managing Type 2 diabetes in primary care. Brussels; 2019. Available from: https://www.idf.org/e-library/guidelines/128-idf-clinical-practice-recommendations-for-managing-type-2-diabetes-in-primary-care.html, accessed 30 October 2019.
68. Owolabi MO, Yaria JO, Daivadanam M, Makanjuola AI, Parker G, Oldenburg B, et al. Gaps in guidelines for the management of diabetes in low- and middle-income versus high-income countries: a systematic review. *Diabetes Care*. 2018;41(5):1097–105.
69. Grol R, Grimshaw J. From best evidence to best practice: effective implementation of change in patients' care. *Lancet*. 2003 Oct 11;362(9391):1225–30.
70. Nicolucci A, Greenfield S, Mattke S. Selecting indicators for the quality of diabetes care at the health systems level in OECD countries. *Int J Qual Health Care*. 2006 Sep;18 Suppl 1:26–30; DOI:10.1093/intqhc/mzl023.
71. Black WC. The CE plane: a graphic representation of cost-effectiveness. *Med Decis Making*. 1990 Sep;10(3):212–4; DOI :10.1177/0272989X9001000308.
72. Laupacis A, Feeny D, Detsky AS, Tugwell PX. How attractive does a new technology have to be to warrant adoption and utilization? Tentative guidelines for using clinical and economic evaluations. *CMAJ*. 1992 Feb 15;146(4):473–81.
73. Li R, Zhang P, Barker LE, Chowdhury FM, Zhang X. Cost-effectiveness of interventions to prevent and control diabetes mellitus: a systematic review. *Diabetes Care*. 2010 Aug;33(8):1872–94; DOI:10.2337/dc10-0843.
74. Williams R. The economics of diabetes care: a global perspective. In: *The international textbook of diabetes mellitus* (4th edition). Chichester: Wiley; 2015.
75. Marcellusi A, Viti R, Sciattella P, Aimaretti G, De Cosmo S, Provenzano V, et al. Economic aspects in the management of diabetes in Italy. *BMJ Open Diabetes Research & Care*. 2016 Oct;4(1):e000197; DOI:10.1136/bmjdrc-2016-000197.
76. Zhuo X, Zhang P, Hoerger TJ. Lifetime direct medical costs of treating type 2 diabetes and diabetic complications. *Am J Prev Med*. 2013 Sep;45(3):253–61; DOI:10.1016/j.amepre.2013.04.017.
77. Manne-Goehler J, Atun R, Stokes A, Goehler A, Houinato D, Houehanou C, et al. Diabetes diagnosis and care in sub-Saharan Africa: pooled analysis of individual data from 12 countries. *Lancet Diabetes Endocrinol*. 2016;4(11):903–12; DOI:10.1016/S2213-8587(16)30181-4.
78. Basu S, Yudkin JS, Kehlenbrink S, Davies JI, Wild SH, Lipska KJ, et al. Estimation of global insulin use for type 2 diabetes, 2018-30: a microsimulation analysis. *Lancet Diabetes Endocrinol*. 2019 Jan;7(1):25–33; DOI:10.1016/S2213-8587(18)30303-6.
79. Chow CK, Ramasundarahettige C, Hu W, AlHabib KF, Avezum A, Cheng X, et al. Availability and affordability of essential medicines for diabetes across high-income, middle-income, and low-income countries: a prospective epidemiological study. *Lancet Diabetes Endocrinol*. 2018 Oct;6(10):798–808; DOI:10.1016/S2213-8587(18)30233-X.
80. Beran D, Ewen M, Lipska K, Hirsch IB, Yudkin JS. Availability and affordability of essential medicines: implications for global diabetes treatment. *Curr Diab Rep*. 2018 Jun 16;18(8):48; DOI:10.1007/s11892-018-1019-z.
81. World Health Organization. SDG 3: Ensure healthy lives and promote well-being for all at all ages. Geneva; 2018. Available from: https://www.who.int/sdg/targets/en/, accessed 30 October 2019.
82. World Health Organization. What is universal health coverage? Geneva; 2014. Available from: https://www.who.int/features/qa/universal_health_coverage/en/, accessed 30 October 2019.
83. World Health Organization. *The world health report 2010. Health system financing: the path to universal coverage*. Geneva; 2010. Available from: https://www.who.int/whr/2010/en/, accessed 30 October 2019.
84. World Health Organization. Universal coverage - three dimensions. Available from: https://www.who.int/health_financing/strategy/dimensions/en/, accessed 30 October 2019.
85. Bazargani YT, de Boer A, Leufkens HGM, Mantel-Teeuwisse AK. Selection of essential medicines for diabetes in low and middle income countries: a survey of 32 national essential

medicines lists. *PLoS ONE*. 2014;9(9):e106072; DOI:10.1371/journal.pone.0106072.

86. International Diabetes Federation. Access to medicines and supplies for people with diabetes. Brussels; 2016. Available from: www.idf.org/accesstomedicine, accessed 30 October 2019.
87. Beran D, Hirsch IB, Yudkin JS. Why are we failing to address the issue of access to insulin? a national and global perspective. *Diabetes Care*. 2018;41(6):1125–31; DOI:10.2337/dc17-2123.
88. World Health Organization. *The world health report 2000. Health systems: improving performance.* Geneva; 2000. Available from: https://www.who.int/whr/2000/en/, accessed 30 October 2019.
89. Ogle GD, von Oettingen JE, Middlehurst AC, Hanas R, Orchard TJ. Levels of type 1 diabetes care in children and adolescents for countries at varying resource levels. *Pediatr Diabetes*. 2019 Feb;20(1):93–8; DOI:10.1111/pedi.12801.
90. World Health Organization. Global status report on noncommunicable diseases. Geneva; 2017. Available from: https://www.who.int/nmh/publications/ncd-status-report-2014/en/, accessed 30 October 2019.
91. Bliss M. The discovery of insulin: the inside story. *Publ Am Inst Hist Pharm*. 1997;16:93–9.
92. Bliss M. The history of insulin. *Diabetes Care*. 1993 Dec;16 Suppl 3:4–7; DOI:10.2337/diacare.16.3.4.
93. Bliss M. *The discovery of insulin*. Edinburgh: Paul Harris Publishing; 1983.
94. Beran D, Ewen M, Laing R. Constraints and challenges in access to insulin: a global perspective. *Lancet Diabetes Endocrinol*. 2016 Mar;4(3):275–85; DOI:10.1016/S2213-8587(15)00521-5.
95. Ewen M, Joose H, Ashigbie P, Beran D, Laing R. *Insulin prices profile*. Amsterdam: Health. Action International; 2016.
96. Gotham D, Barber MJ, Hill A. Production costs and potential prices for biosimilars of human insulin and insulin analogues. *BMJ Glob Health*. 2018;3(5):e000850.
97. Hogerzeil HV, Recourt S. The importance of insulin donations for children in 43 low- and middle-income countries. *J Public Health Policy*. 2019; 40(2);253–263; DOI:10.1057/s41271-018-00159-w.
98. ACCISS Study. The road to free insulin: country case studies. 2018. Available from: http://accisstoolkit.haiweb.org/page/systems/free-insulin-case-studies, accessed 18 March 2019.

Appendices

Patricia Gómez Medel (right) from Guadalajara, Mexico, diabetes educator and mother to daughter with type 1 diabetes

Country summary table

World

Country or territory	Number of adults 20–79 years with diabetes in 1,000s (95% confidence interval)	Diabetes national prevalence (%) in adults 20–79 years (95% confidence interval)	Diabetes age-adjusted comparative prevalence (%) in adults 20–79 years (95% confidence interval)
World	462,969.9 (368,714.4–600,603.8)	9.3 (7.4–12.1)	8.3 (6.2–11.8)

Africa

Country or territory	Number of adults 20–79 years with diabetes in 1,000s (95% confidence interval)	Diabetes national prevalence (%) in adults 20–79 years (95% confidence interval)	Diabetes age-adjusted comparative prevalence (%) in adults 20–79 years (95% confidence interval)
Africa	**19,406.8 (10,612.8–35,804.7)**	**3.9 (2.1–7.1)**	**4.7 (3.2–8.1)**
Angola	532.4 (361.8–925.3)	3.9 (2.7–6.8)	4.5 (2.9–8.0)
Benin	44.6 (31.5–149.6)	0.8 (0.6–2.7)	1.0 (0.7–3.1)
Botswana	78.1 (41.1–144.8)	5.5 (2.9–10.2)	5.8 (3.1–10.3)
Burkina Faso	494.2 (142.6–717.1)	5.5 (1.6–8.0)	7.3 (2.1–10.7)
Burundi	123.1 (91.6–234.7)	2.4 (1.8–4.5)	5.1 (3.9–8.4)
Cabo Verde	6.9 (6.2–18.2)	2.1 (1.9–5.5)	2.4 (2.1–5.7)
Cameroon	615.3 (514.7–751.3)	5.2 (4.4–6.4)	6.0 (5.1–7.4)
Central African Republic	101.2 (84.3–124.2)	4.6 (3.9–5.7)	6.0 (5.0–7.3)
Chad	245.0 (204.4–299.9)	3.7 (3.1–4.5)	6.0 (5.0–7.3)
Comoros	34.0 (23.9–54.1)	8.0 (5.6–12.7)	12.3 (8.5–20.0)
Congo	158.6 (133.4–192.6)	6.0 (5.1–7.3)	6.0 (5.1–7.4)
Côte d'Ivoire	237.4 (205.8–574.1)	2.0 (1.7–4.8)	2.4 (2.1–5.7)
Democratic Republic of the Congo	1,805.6 (1,511.0–2,204.2)	4.8 (4.0–5.9)	6.0 (5.0–7.3)
Djibouti	35.8 (26.6–55.3)	6.1 (4.5–9.5)	5.1 (3.9–8.4)
Equatorial Guinea	39.9 (33.4–48.8)	5.5 (4.6–6.7)	6.0 (5.1–7.4)
Eritrea	96.9 (71.4–163.9)	3.8 (2.8–6.5)	5.1 (3.9–8.4)
Eswatini	23.2 (13.7–38.1)	3.1 (1.8–5.2)	4.5 (2.9–8.0)
Ethiopia	1,699.4 (987.2–2,937.1)	3.2 (1.8–5.5)	4.3 (3.1–8.2)
Gabon	79.9 (67.2–97.1)	7.0 (5.9–8.5)	6.0 (5.1–7.4)

Total Regional estimates Countries without in-country data sources on diabetes Countries with in-country data sources on diabetes

Number of adults 20–79 years with undiagnosed diabetes in 1,000s (95% confidence interval)	Mean diabetes-related expenditure (USD) per person with diabetes (20–79 years)	Mean diabetes-related expenditure (ID) per person with diabetes (20–79 years)	Diabetes-related deaths in adults 20–79 years (95% confidence interval)	Number of children and adolescents 0–19 years with type 1 diabetes
231,874.0 (186,350.2–300,301.7)	1,673.1	2,480.5	4,211,276.9	1,110,100

Number of adults 20–79 years with undiagnosed diabetes in 1,000s (95% confidence interval)	Mean diabetes-related expenditure (USD) per person with diabetes (20–79 years)	Mean diabetes-related expenditure (ID) per person with diabetes (20–79 years)	Diabetes-related deaths in adults 20–79 years (95% confidence interval)	Number of children and adolescents 0–19 years with type 1 diabetes
11,580.6 (6,570.7–21,011.8)	**509.0**	**1,295.4**	**366,226.5**	**25,800**
278.8 (189.4–484.5)	530.2	1,038.0	6,987.7 (4,622.3–12,020.8)	186
30.4 (21.5–102.0)	163.8	453.2	692.8 (460.4–2,145.9)	305
40.9 (21.5–75.8)	1,417.6	3,473.2	1,674.5 (903.1–3,452.0)	99
337.2 (97.3–489.2)	177.6	502.4	9,675.2 (2,961.8–13,358.9)	580
84.0 (62.5–160.1)	97.8	263.6	2,699.0 (2,029.0–5,076.7)	343
3.6 (3.2–9.5)	685.1	1,494.4	58.0 (52.8–172.3)	27
322.2 (269.5–393.4)	311.3	821.9	13,744.3 (11,584.7–16,587.6)	743
69.0 (57.5–84.7)	72.0	135.0	3,162.9 (2,671.0–3,802.9)	32
167.2 (139.5–204.6)	135.3	401.8	5,706.5 (4,805.5–6,888.0)	122
17.5 (12.3–27.8)	173.6	341.4	357.4 (243.9–558.6)	41
83.0 (69.8–100.8)	343.2	1,289.3	2,536.0 (2,142.9–3,057.5)	265
124.3 (107.8–300.6)	327.0	783.7	5,207.1 (4,575.1–12,082.7)	359
1,231.8 (1,030.8–1,503.7)	98.9	160.2	28,382.7 (23,606.7–34,845.0)	1,275
18.8 (13.9–28.9)	314.4	548.0	467.6 (353.9–687.9)	12
20.9 (17.5–25.6)	1,305.8	3,898.8	491.5 (416.9–589.5)	23
66.1 (48.7–111.8)	147.8	271.0	1,471.5 (1,099.8–2,449.6)	107
12.2 (7.2–19.9)	886.7	2,660.1	1,123.3 (691.0–1,664.2)	41
1,159.4 (673.4–2,003.7)	113.3	283.3	23,156.8 (13,499.6–39,928.4)	2,127
41.8 (35.2–50.8)	1,015.2	2,565.8	922.6 (764.5–1,143.6)	89

Country or territory	Number of adults 20–79 years with diabetes in 1,000s (95% confidence interval)	Diabetes national prevalence (%) in adults 20–79 years (95% confidence interval)	Diabetes age-adjusted comparative prevalence (%) in adults 20–79 years (95% confidence interval)
Gambia	15.6 (15.1–49.4)	1.6 (1.5–5.0)	1.9 (1.8–6.0)
Ghana	281.1 (217.6–536.6)	1.8 (1.4–3.5)	2.5 (1.9–4.1)
Guinea	127.5 (107.4–279.6)	2.0 (1.7–4.4)	2.4 (2.1–5.7)
Guinea-Bissau	18.6 (15.9–43.0)	2.0 (1.7–4.6)	2.4 (2.1–5.7)
Kenya	552.4 (285.7–1,679.1)	2.2 (1.1–6.6)	3.1 (1.7–10.4)
Lesotho	41.2 (24.3–68.8)	3.4 (2.0–5.6)	4.5 (2.9–8.0)
Liberia	48.1 (41.8–116.3)	2.0 (1.8–4.9)	2.4 (2.1–5.7)
Madagascar	468.8 (295.2–788.8)	3.6 (2.3–6.1)	4.5 (2.9–8.1)
Malawi	268.7 (155.9–436.9)	3.0 (1.8–4.9)	4.5 (2.9–8.1)
Mali	157.6 (133.6–363.2)	1.9 (1.6–4.5)	2.4 (2.1–5.7)
Mauritania	155.1 (42.3–262.1)	6.7 (1.8–11.2)	7.1 (2.0–12.4)
Mozambique	337.5 (234.1–726.4)	2.4 (1.7–5.2)	3.3 (2.3–7.4)
Namibia	53.2 (34.5–91.5)	3.8 (2.5–6.5)	4.5 (2.9–8.0)
Niger	183.3 (148.1–342.4)	2.0 (1.6–3.8)	2.4 (2.1–5.7)
Nigeria	2,743.8 (958.6–9,217.8)	3.0 (1.1–10.1)	3.1 (1.3–8.9)
Rwanda	168.9 (126.2–312.5)	2.7 (2.0–4.9)	5.1 (3.9–8.4)
Sao Tome and Principe	1.9 (1.8–5.3)	2.0 (1.8–5.4)	2.4 (2.1–5.7)
Senegal	153.1 (131.5–363.9)	2.0 (1.7–4.7)	2.4 (2.1–5.7)
Seychelles	9.5 (5.9–12.6)	14.2 (8.9–18.8)	12.3 (7.5–16.7)
Sierra Leone	73.3 (62.2–166.4)	2.0 (1.7–4.5)	2.4 (2.1–5.7)
Somalia	270.9 (200.0–450.6)	4.1 (3.0–6.8)	5.1 (3.9–8.4)
South Africa	4,581.2 (1,368.7–5,250.9)	12.8 (3.8–14.7)	12.7 (3.6–14.6)
South Sudan	493.7 (330.1–603.4)	7.8 (5.2–9.6)	10.2 (6.9–12.7)
Togo	79.6 (67.7–179.5)	2.0 (1.7–4.5)	2.4 (2.1–5.7)
Uganda	296.2 (168.9–633.7)	1.6 (0.9–3.4)	2.5 (1.3–5.6)
United Republic of Tanzania	997.4 (638.8–2,087.1)	3.7 (2.4–7.7)	5.7 (3.8–10.4)
Zambia	273.8 (176.5–457.8)	3.4 (2.2–5.7)	4.5 (2.9–8.0)
Zimbabwe	103.2 (72.5–548.6)	1.2 (0.9–6.5)	1.8 (1.3–8.4)

☐ Countries without in-country data sources on diabetes ■ Countries with in-country data sources on diabetes

Number of adults 20–79 years with undiagnosed diabetes in 1,000s (95% confidence interval)	Mean diabetes-related expenditure (USD) per person with diabetes (20–79 years)	Mean diabetes-related expenditure (ID) per person with diabetes (20–79 years)	Diabetes-related deaths in adults 20–79 years (95% confidence interval)	Number of children and adolescents 0–19 years with type 1 diabetes
10.7 (10.3–33.7)	119.3	420.5	193.3 (187.6–647.3)	88
147.2 (114.0–281.0)	262.2	728.9	5,397.8 (4,220.2–9,940.0)	1,209
87.0 (73.3–190.7)	149.1	435.3	2,070.0 (1,771.1–4,478.8)	344
12.7 (10.8–29.4)	170.2	427.8	364.4 (311.3–842.1)	50
243.5 (126.0–740.3)	324.4	707.8	8,080.5 (3,836.0–25,476.8)	1,694
21.5 (12.7–36.0)	334.6	945.5	1,669.9 (1,021.4–2,558.4)	33
32.8 (28.5–79.4)	309.4	605.2	754.5 (659.5–1,852.9)	178
319.9 (201.4–538.1)	99.5	373.2	5,756.0 (3,384.8–9,705.4)	895
183.4 (106.4–298.0)	117.1	448.8	7,603.5 (4,419.3–11,419.3)	616
107.5 (91.1–247.8)	143.2	386.7	2,669.1 (2,289.2–6,235.3)	306
81.2 (22.2–137.2)	213.0	743.2	1,776.5 (482.1–2,924.9)	130
292.6 (202.9–629.8)	101.8	332.1	9,485.0 (6,753.7–18,082.2)	635
27.9 (18.1–47.9)	1,871.8	4,500.7	1,095.3 (713.2–1,756.5)	127
125.1 (101.1–233.6)	87.7	232.5	3,180.6 (2,617.7–5,837.8)	880
1,317.0 (460.1–4,424.5)	468.6	1,269.3	63,957.7 (22,672.3–160,333.4)	2,954
115.2 (86.1–213.2)	202.1	547.3	2,943.9 (2,195.6–5,430.5)	631
1.0 (0.9–2.8)	587.9	1,103.0	19.3 (17.6–61.2)	11
104.5 (89.7–248.3)	248.5	675.1	1,855.0 (1,619.0–4,682.4)	805
4.4 (2.7–5.8)	605.7	1,139.4	84.0 (50.9–103.8)	4
50.0 (42.4–113.5)	383.4	1,087.8	1,772.5 (1,506.6–4,018.6)	52
184.8 (136.4–307.4)	–	–	3,900.4 (2,897.7–6,418.4)	57
2,398.7 (716.7–2,749.4)	1,245.0	3,115.5	89,834.4 (30,483.6–100,197.1)	1,599
336.9 (225.2–411.6)	–	–	7,017.1 (4,857.1–8,356.6)	208
54.3 (46.2–122.5)	169.0	433.3	1,286.3 (1,107.4–2,858.8)	289
202.1 (115.2–432.3)	191.0	588.0	6,288.0 (3,718.9–13,465.4)	2,253
796.1 (509.9–1,665.9)	170.1	544.2	18,031.7 (11,632.5–34,632.3)	1,984
143.4 (92.4–239.7)	296.8	911.3	8,000.2 (5,258.3–12,133.2)	557
70.4 (49.5–374.3)	540.9	1,064.4	2,621.9 (1,884.4–12,412.2)	464

Europe

Country or territory	Number of adults 20–79 years with diabetes in 1,000s (95% confidence interval)	Diabetes national prevalence (%) in adults 20–79 years (95% confidence interval)	Diabetes age-adjusted comparative prevalence (%) in adults 20–79 years (95% confidence interval)
Europe	**59,322.1 (46,291.2–80,175.3)**	**8.9 (7.0–12.0)**	**6.3 (4.9–9.2)**
Albania	237.6 (187.9–266.6)	11.1 (8.8–12.4)	9.0 (7.1–10.2)
Andorra	6.9 (5.9–8.8)	12.0 (10.3–15.4)	7.7 (6.6–10.5)
Armenia	141.2 (106.1–197.1)	6.8 (5.1–9.5)	6.1 (4.7–8.5)
Austria	641.5 (562.5–920.5)	9.7 (8.5–13.9)	6.6 (5.8–10.1)
Azerbaijan	421.6 (321.4–587.1)	6.1 (4.7–8.5)	6.1 (4.7–8.5)
Belarus	463.3 (396.8–931.9)	6.6 (5.7–13.3)	5.0 (4.2–12.7)
Belgium	561.2 (496.0–709.9)	6.8 (6.0–8.6)	4.6 (3.9–6.0)
Bosnia and Herzegovina	311.4 (249.7–349.1)	11.7 (9.4–13.1)	9.0 (7.1–10.2)
Bulgaria	442.5 (358.6–577.3)	8.3 (6.7–10.8)	6.0 (4.8–8.5)
Channel Islands	6.6 (5.5–9.3)	5.2 (4.4–7.3)	3.9 (3.3–6.0)
Croatia	211.1 (163.0–406.3)	6.8 (5.3–13.2)	5.4 (4.2–9.8)
Cyprus	91.8 (57.7–149.1)	10.4 (6.5–16.9)	9.0 (5.6–15.0)
Czechia	818.6 (583.0–1,051.6)	10.2 (7.2–13.1)	7.0 (5.0–9.3)
Denmark	372.0 (275.4–781.8)	8.8 (6.5–18.5)	8.3 (6.9–13.0)
Estonia	58.7 (41.1–111.0)	6.2 (4.3–11.7)	4.2 (3.0–9.0)
Faroe Islands	2.4 (1.6–3.6)	6.6 (4.6–10.2)	4.7 (3.3–7.7)
Finland	373.9 (269.3–465.9)	9.2 (6.7–11.5)	5.6 (4.0–7.4)
France	3,480.0 (2,852.6–4,262.6)	7.6 (6.2–9.3)	4.8 (3.8–6.3)
Georgia	198.0 (137.3–277.5)	7.1 (4.9–10.0)	5.8 (4.0–8.5)
Germany	9,510.5 (7,811.3–10,576.3)	15.3 (12.6–17.0)	10.4 (8.5–11.6)
Greece	613.9 (499.7–1,141.4)	7.4 (6.0–13.8)	4.7 (3.8–10.0)
Greenland	1.3 (1.1–3.2)	3.2 (2.8–8.0)	2.1 (1.9–6.1)
Hungary	684.5 (495.8–1,211.9)	9.3 (6.7–16.4)	6.9 (5.2–13.6)
Iceland	18.2 (14.3–22.7)	7.6 (6.0–9.5)	5.8 (4.7–7.1)
Ireland	148.2 (117.6–200.3)	4.4 (3.5–6.0)	3.2 (2.5–4.6)
Israel	644.3 (449.5–840.5)	12.2 (8.5–15.9)	9.7 (6.7–12.7)
Italy	3,669.4 (3,371.2–4,127.9)	8.3 (7.7–9.4)	5.0 (4.6–5.7)
Kazakhstan	735.2 (558.2–1,026.9)	6.2 (4.7–8.6)	6.1 (4.7–8.5)
Kyrgyzstan	197.8 (156.6–268.1)	5.4 (4.2–7.3)	6.1 (4.7–8.5)
Latvia	104.3 (84.1–131.2)	7.4 (5.9–9.3)	5.0 (3.9–6.6)

Total Regional estimates Countries without in-country data sources on diabetes Countries with in-country data sources on diabetes

Number of adults 20–79 years with undiagnosed diabetes in 1,000s (95% confidence interval)	Mean diabetes-related expenditure (USD) per person with diabetes (20–79 years)	Mean diabetes-related expenditure (ID) per person with diabetes (20–79 years)	Diabetes-related deaths in adults 20–79 years (95% confidence interval)	Number of children and adolescents 0–19 years with type 1 diabetes
24,157.3 (18,834.7–32,428.4)	**2,724.4**	**3,871.8**	**465,916.4**	**296,500**
102.2 (80.8–114.6)	652.8	1,823.9	2,448.1 (2,044.3–2,674.9)	520
2.5 (2.1–3.2)	4,005.5	5,200.3	32.4 (28.2–39.3)	25
60.7 (45.6–84.8)	890.9	2,176.4	1,815.0 (1,343.8–2,491.0)	481
232.9 (204.3–334.2)	5,259.3	5,940.2	3,030.5 (2,704.1–4,056.7)	2,960
181.3 (138.2–252.5)	693.3	3,086.1	4,449.6 (3,387.5–5,950.1)	1,847
199.2 (170.6–400.7)	945.8	3,423.2	6,809.6 (5,861.7–10,425.5)	1,030
203.8 (180.1–257.8)	5,010.4	5,637.1	3,014.1 (2,718.5–3,705.8)	4,273
133.9 (107.4–150.1)	901.3	2,279.5	3,420.2 (2,891.9–3,725.3)	527
143.7 (116.4–187.4)	1,739.0	4,484.0	6,287.1 (5,296.8–7,577.7)	1,084
2.4 (2.0–3.4)	–	–	–	86
88.7 (68.5–170.6)	1,043.9	2,013.4	1,559.0 (1,220.3–2,931.2)	1,333
33.6 (21.1–54.6)	2,007.5	2,790.1	379.8 (257.2–546.3)	391
297.2 (211.7–381.8)	1,532.0	2,879.7	5,714.6 (4,202.7–7,101.6)	4,108
244.0 (180.6–512.8)	5,521.1	5,051.9	2,044.3 (1,544.7–3,880.2)	3,142
21.3 (14.9–40.3)	1,387.4	2,327.6	566.1 (396.6–953.1)	461
0.7 (0.5–1.1)	–	–	–	26
226.7 (163.3–282.5)	3,774.0	3,769.4	2,025.7 (1,533.8–2,396.2)	7,248
1,307.7 (1,072.0–1,601.9)	4,858.6	5,450.1	18,655.8 (15,645.5–22,184.4)	27,275
85.2 (59.1–119.3)	875.5	2,265.4	2,883.1 (1,865.1–3,684.3)	405
4,528.9 (3,719.7–5,036.4)	4,600.7	5,331.7	50,096.0 (42,558.2–54,861.3)	33,095
222.9 (181.4–414.5)	1,659.9	2,483.7	3,231.6 (2,676.4–5,186.1)	3,122
0.5 (0.4–1.2)	–	–	–	33
114.1 (82.7–202.0)	1,235.3	2,571.5	8,338.2 (6,007.6–12,442.3)	3,527
6.6 (5.2–8.2)	6,403.1	5,367.5	69.0 (56.6–81.8)	123
46.2 (36.7–62.5)	6,597.6	7,347.6	706.0 (585.3–882.6)	3,254
233.9 (163.2–305.2)	3,784.3	3,792.3	2,627.3 (1,973.4–3,225.7)	3,970
1,332.2 (1,224.1–1,498.8)	2,849.1	3,564.8	15,655.7 (14,519.8–17,195.7)	15,977
316.1 (240.0–441.6)	742.2	2,433.5	9,357.5 (7,111.5–12,679.4)	931
85.0 (67.3–115.3)	194.1	638.2	2,263.0 (1,800.8–2,945.5)	361
37.8 (30.5–47.6)	1,047.5	1,905.6	1,064.7 (894.6–1,298.0)	256

Country or territory	Number of adults 20–79 years with diabetes in 1,000s (95% confidence interval)	Diabetes national prevalence (%) in adults 20–79 years (95% confidence interval)	Diabetes age-adjusted comparative prevalence (%) in adults 20–79 years (95% confidence interval)
Liechtenstein	3.4 (2.8–3.7)	12.1 (10.1–13.1)	9.4 (7.8–10.3)
Lithuania	114.3 (99.6–167.6)	5.4 (4.7–7.9)	3.8 (3.3–5.6)
Luxembourg	28.6 (20.2–43.6)	6.5 (4.6–9.9)	5.0 (3.5–7.9)
Malta	40.5 (27.9–56.5)	12.2 (8.4–17.1)	8.3 (6.0–11.4)
Monaco	2.4 (2.0–2.8)	8.3 (6.9–9.9)	2.9 (2.4–3.4)
Montenegro	52.4 (41.2–58.6)	11.5 (9.1–12.9)	9.0 (7.1–10.2)
Netherlands	1,019.1 (765.9–1,376.7)	8.1 (6.1–11.0)	5.4 (3.2–8.7)
North Macedonia	175.1 (131.2–218.2)	11.2 (8.4–13.9)	9.3 (6.8–11.5)
Norway	292.4 (283.2–317.8)	7.5 (7.3–8.2)	5.3 (5.1–6.0)
Poland	2,344.6 (1,702.3–6,313.7)	8.1 (5.9–21.9)	6.1 (4.3–22.3)
Portugal	1,090.1 (787.3–1,353.3)	14.2 (10.2–17.6)	9.8 (6.7–13.2)
Republic of Moldova	193.8 (160.2–255.2)	6.2 (5.2–8.2)	5.7 (4.7–7.5)
Romania	1,278.3 (677.7–1,790.3)	8.8 (4.7–12.3)	6.8 (3.3–9.8)
Russian Federation	8,288.5 (6,302.7–10,367.6)	7.8 (6.0–9.8)	6.1 (4.8–7.8)
San Marino	2.4 (2.1–2.7)	9.6 (8.4–10.8)	5.9 (5.2–6.8)
Serbia	773.7 (616.6–865.3)	12.0 (9.6–13.4)	9.0 (7.1–10.2)
Slovakia	377.5 (256.1–440.4)	9.1 (6.2–10.6)	6.5 (4.5–7.9)
Slovenia	122.5 (99.0–197.5)	7.8 (6.3–12.7)	5.8 (4.8–9.1)
Spain	3,619.1 (2,888.0–5,034.6)	10.5 (8.4–14.6)	6.9 (5.5–10.0)
Sweden	521.2 (442.5–686.3)	7.2 (6.1–9.5)	4.8 (4.1–6.7)
Switzerland	496.9 (493.3–872.2)	7.7 (7.7–13.5)	5.7 (5.6–9.8)
Tajikistan	242.6 (195.0–327.3)	4.8 (3.8–6.4)	6.1 (4.7–8.5)
Turkey	6,592.4 (4,645.1–8,501.1)	12 (8.5–15.5)	11.1 (7.6–14.5)
Turkmenistan	188.3 (144.1–265.4)	5.2 (4.0–7.4)	6.1 (4.7–8.5)
Ukraine	2,492.4 (1,840.2–3,509.5)	7.6 (5.6–10.7)	6.1 (4.7–8.5)
United Kingdom	2,680.5 (2,252.5–3,827.0)	5.6 (4.7–8.0)	3.9 (3.3–6.0)
Uzbekistan	1,121.7 (781.3–1,702.6)	5.4 (3.8–8.2)	6.5 (4.5–9.7)

☐ Countries without in-country data sources on diabetes ■ Countries with in-country data sources on diabetes

Number of adults 20–79 years with undiagnosed diabetes in 1,000s (95% confidence interval)	Mean diabetes-related expenditure (USD) per person with diabetes (20–79 years)	Mean diabetes-related expenditure (ID) per person with diabetes (20–79 years)	Diabetes-related deaths in adults 20–79 years (95% confidence interval)	Number of children and adolescents 0–19 years with type 1 diabetes
1.2 (1.0–1.3)	–	–	13.3 (11.5–14.3)	10
41.5 (36.2–60.9)	1,226.9	2,456.4	1,340.3 (1,181.7–1,940.1)	995
10.4 (7.3–15.8)	7,977.8	8,108.8	128.1 (93.0–177.5)	222
19.2 (13.2–26.8)	2,367.2	3,570.1	185.5 (129.7–248.7)	190
0.9 (0.7–1.0)	3,232.9	3,319.7	12.0 (10.2–13.8)	14
22.5 (17.7–25.2)	–	–	597.3 (499.5–648.6)	281
370.0 (278.1–499.9)	5,379.7	5,957.2	4,934.6 (3,882.3–5,911.7)	7,316
75.3 (56.4–93.8)	689.9	1,966.6	1,962.4 (1,481.5–2,195.6)	337
106.2 (102.8–115.4)	9,061.4	7,516.4	1,211.3 (1,182.2–1,304.2)	3,815
990.6 (719.2–2,667.6)	923.5	2,036.5	18,536.0 (13,918.5–31,079.6)	12,561
475.2 (343.2–589.9)	1,800.2	2,776.8	5,796.5 (4,257.0–6,767.4)	2,522
83.3 (68.9–109.7)	431.9	1,212.3	2,474.0 (2,148.3–3,363.8)	576
264.6 (140.3–370.6)	1,208.3	2,924.3	15,920.0 (9,806.0–20,752.9)	2,847
4,450.9 (3,384.6–5,567.4)	1,278.2	3,622.0	110,530.2 (80,778.9–134,463.0)	35,728
0.9 (0.8–1.0)	3,247.2	4,129.9	9.8 (8.7–10.7)	10
332.7 (265.2–372.1)	1,089.4	2,917.6	9,159.8 (7,704.4–9,956.8)	2,564
91.7 (62.2–106.9)	1,468.4	2,705.2	3,459.4 (2,340.0–3,844.2)	1,370
44.5 (35.9–71.7)	2,070.5	3,129.4	690.7 (559.5–1,066.3)	590
1,009.7 (805.8–1,404.7)	2,651.5	3,616.7	15,394.1 (12,565.4–20,170.7)	15,467
189.2 (160.7–249.2)	6,643.1	6,266.2	2,236.9 (1,915.3–2,752.4)	8,567
180.4 (179.1–316.7)	11,915.6	9,530.3	1,790.5 (1,781.6–3,028.0)	2,075
142.8 (114.8–192.7)	145.1	541.7	2,413.0 (1,964.6–3,019.8)	829
2,522.6 (1,777.7–3,253.4)	1,404.4	3,260.9	43,503.1 (32,518.7–53,327.7)	25,953
81.0 (62.0–114.1)	1,257.8	3,321.5	2,475.7 (1,915.8–3,353.9)	1,750
1,071.7 (791.3–1,509.1)	341.4	1,293.0	37,111.8 (27,070.9–51,554.6)	6,416
495.9 (416.7–708.0)	5,255.0	5,547.1	13,951.2 (11,918.8–18,257.7)	39,130
590.7 (411.4–896.6)	352.0	1,087.2	11,534.9 (8,163.2–16,382.5)	2,534

Middle East and North Africa

Country or territory	Number of adults 20–79 years with diabetes in 1,000s (95% confidence interval)	Diabetes national prevalence (%) in adults 20–79 years (95% confidence interval)	Diabetes age-adjusted comparative prevalence (%) in adults 20–79 years (95% confidence interval)
Middle East and North Africa	**54,777.1 (30,711–75,131.4)**	**12.9 (7.2–17.6)**	**12.2 (8.3–16.1)**
Afghanistan	1,090.8 (768.7–1,286.2)	6.4 (4.5–7.5)	9.2 (6.8–10.9)
Algeria	1,904.7 (1,329.6–2,601.7)	7.2 (5.0–9.8)	6.7 (4.7–9.2)
Bahrain	202.7 (185.2–222.9)	16.3 (14.9–17.9)	15.6 (14.0–17.2)
Egypt	8,850.4 (4,754.1–10,086.5)	15.2 (8.2–17.4)	17.2 (9.2–19.6)
Iran (Islamic Republic of)	5,387.2 (4,226.3–7,052.3)	9.4 (7.4–12.3)	9.6 (7.6–12.4)
Iraq	1,505.0 (1,074.4–1,972.5)	7.6 (5.4–9.9)	8.8 (6.5–11.2)
Jordan	544.2 (459.8–1,006.0)	9.9 (8.3–18.2)	12.7 (8.8–19.4)
Kuwait	681.1 (456.3–780.5)	22.0 (14.7–25.2)	12.2 (8.2–14.1)
Lebanon	529.9 (429.3–656.2)	12.9 (10.5–16)	11.1 (9.0–13.7)
Libya	405.1 (276.3–517.6)	9.7 (6.6–12.4)	10.2 (6.9–12.7)
Morocco	1,735.5 (1,346.3–2,816.0)	7.4 (5.8–12.1)	7.0 (5.4–11.6)
Oman	291.8 (232.6–526.1)	8.0 (6.3–14.3)	10.1 (7.9–16.6)
Pakistan	19,369.8 (7,889.4–30,395.0)	17.1 (7.0–26.8)	19.9 (8.3–30.9)
Palestine	174.3 (111.8–333.4)	6.7 (4.3–12.8)	9.5 (6.4–16.3)
Qatar	347.0 (318.5–381.4)	15.5 (14.2–17.0)	15.6 (14.0–17.2)
Saudi Arabia	4,275.2 (2,580.2–4,774.4)	18.3 (11.1–20.5)	15.8 (10.3–17.7)
Sudan	3,690.3 (1,538.0–4,064.8)	17.9 (7.5–19.8)	22.1 (9.5–24.3)
Syrian Arab Republic	1,186.5 (676.0–1,418.7)	12.3 (7.0–14.7)	13.5 (7.8–16.0)
Tunisia	809.5 (532.5–1,162.1)	10.2 (6.7–14.6)	8.5 (5.7–13.2)
United Arab Emirates	1,223.4 (1,079.1–1,444.4)	15.4 (13.6–18.2)	16.3 (13.6–19.2)
Yemen	572.7 (446.6–1,633.0)	3.9 (3.0–11.1)	5.4 (4.2–15.5)

Total Regional estimates Countries without in-country data sources on diabetes Countries with in-country data sources on diabetes

Number of adults 20–79 years with undiagnosed diabetes in 1,000s (95% confidence interval)	Mean diabetes-related expenditure (USD) per person with diabetes (20–79 years)	Mean diabetes-related expenditure (ID) per person with diabetes (20–79 years)	Diabetes-related deaths in adults 20–79 years (95% confidence interval)	Number of children and adolescents 0–19 years with type 1 diabetes
24,461.2 (13,715.0–33,350.3)	**475.3**	**1,469.6**	**418,865.8**	**149,400**
800.3 (564.1–943.8)	167.5	478.9	18,630.3 (13,299.4–21,610.3)	1,406
1,252.4 (874.2–1,710.6)	795.4	3,053.1	12,657.2 (7,819.8–16,365.8)	33,084
73.1 (66.9–80.4)	1,163.0	1,974.6	537.9 (498.7–584.4)	85
4,815.5 (2,586.7–5,488.1)	279.1	1,099.4	76,262.7 (44,911.6–85,183.2)	11,755
1,876.7 (1,472.4–2,457.0)	1,141.1	4,300.4	33,036.7 (24,729.8–42,220.2)	7,808
708.1 (505.5–928.1)	555.5	–	15,657.7 (10,940.9–20,411.5)	4,978
249.9 (211.1–461.9)	712.5	1,574.5	3,266.0 (2,817.1–5,344.8)	1,218
114.4 (76.7–131.1)	1,089.6	2,957.6	1,692.6 (1,248.4–1,872.9)	4,168
226.7 (183.7–280.7)	1,548.4	2,682.9	5,037.4 (4,348.6–5,867.7)	556
173.3 (118.2–221.4)	–	–	2,789.0 (1,992.0–3,405.1)	1,691
742.5 (576.0–1,204.7)	470.5	1,282.1	8,025.1 (6,350.9–12,568.5)	30,187
127.4 (101.6–229.7)	752.6	3,283.2	964.9 (776.9–1,493.5)	268
8,487.2 (3,457.1–13,319.1)	83.3	299.8	158,973.7 (79,895.6–217,485.7)	1,754
43.8 (28.1–83.8)	–	–	–	677
125.2 (114.9–137.7)	1,751.2	3,763.2	644.4 (601.5–697.9)	1,358
1,668.3 (1,006.8–1,863.0)	1,172.5	3,186.3	15,038.7 (10,548.6–16,321.7)	27,784
1,048.1 (436.8–1,154.4)	362.3	710.3	41,998.2 (21,398.4–45,182.6)	12,594
695.9 (396.5–832.0)	–	–	10,471.1 (6,622.4–12,231.6)	2,550
607.1 (399.3–871.6)	579.2	1,816.3	5,317.0 (3,721.8–7,176.3)	2,194
497.9 (439.2–587.9)	1,237.3	2,381.1	2,092.9 (1,886.2–2,384.1)	400
127.4 (99.4–363.3)	–	–	5,772.3 (4,322.8–15,349.8)	2,926

North America and Caribbean

Country or territory	Number of adults 20–79 years with diabetes in 1,000s (95% confidence interval)	Diabetes national prevalence (%) in adults 20–79 years (95% confidence interval)	Diabetes age-adjusted comparative prevalence (%) in adults 20–79 years (95% confidence interval)
North America and Caribbean	**47,610.3 (37,366.6–56,427.0)**	**13.3 (10.5–15.8)**	**11.1 (9.0–14.5)**
Antigua and Barbuda	9.3 (8.6–10.5)	13.3 (12.3–15.1)	13.1 (12.0–15.0)
Aruba	11.6 (9.7–14.3)	15.0 (12.4–18.4)	11.6 (9.6–14.9)
Bahamas	26.9 (21.8–41.7)	9.4 (7.6–14.5)	8.8 (7.1–13.7)
Barbados	36.4 (32.4–42.1)	17.8 (15.9–20.6)	13.4 (11.9–16.0)
Belize	34.1 (29.6–39.3)	14.9 (12.9–17.1)	17.1 (14.9–19.7)
Bermuda	6.9 (5.9–8.0)	15.8 (13.5–18.5)	6.7 (5.6–8.0)
British Virgin Islands	3.1 (2.3–4.0)	14.7 (10.7–18.9)	14.2 (10.3–18.4)
Canada	2,793.5 (2,671.7–3,787.0)	10.1 (9.7–13.7)	7.6 (7.3–10.8)
Cayman Islands	5.9 (5.3–6.8)	14.2 (12.8–16.5)	6.8 (6.2–8.0)
Curaçao	19.7 (15.5–23.3)	17.0 (13.3–20.1)	11.6 (9.6–14.9)
Dominica	6.3 (5.2–7.8)	12.9 (10.7–15.9)	11.6 (9.7–14.9)
Grenada	6.8 (5.2–9.0)	9.7 (7.5–13.0)	10.7 (8.4–14.2)
Guyana	50.4 (43.1–67.9)	10.5 (9.0–14.2)	11.6 (9.7–14.9)
Haiti	365.6 (246.9–602.4)	5.7 (3.9–9.4)	6.6 (4.5–10.6)
Jamaica	226.5 (181.8–284.8)	11.7 (9.4–14.7)	11.3 (9.1–14.3)
Mexico	12,805.2 (7,208.6–15,375.6)	15.2 (8.6–18.2)	13.5 (8.1–16.7)
Saint Kitts and Nevis	5.3 (3.8–7.2)	14.2 (10.2–19.5)	13.2 (9.4–18.4)
Saint Lucia	14.8 (12.7–19.6)	11.5 (9.8–15.2)	11.6 (9.7–14.9)
Saint Vincent and the Grenadines	8.8 (7.4–11.2)	11.9 (10.0–15.2)	11.6 (9.7–14.9)
Sint Maarten	3.8 (3.4–4.4)	14.2 (12.8–16.5)	6.8 (6.2–8.0)
Suriname	47.9 (32.9–92.2)	13.0 (8.9–25.1)	12.5 (8.5–24.3)
Trinidad and Tobago	121.3 (100.2–161.6)	12.3 (10.2–16.4)	11.0 (9.0–14.9)
United States of America	30,987.9 (26,702.4–35,791.8)	13.3 (11.4–15.3)	10.8 (9.3–12.5)
US Virgin Islands	12.4 (10.4–14.4)	16.8 (14.1–19.5)	12.2 (10.2–14.4)

Total Regional estimates Countries without in-country data sources on diabetes Countries with in-country data sources on diabetes

Number of adults 20–79 years with undiagnosed diabetes in 1,000s (95% confidence interval)	Mean diabetes-related expenditure (USD) per person with diabetes (20–79 years)	Mean diabetes-related expenditure (ID) per person with diabetes (20–79 years)	Diabetes-related deaths in adults 20–79 years (95% confidence interval)	Number of children and adolescents 0–19 years with type 1 diabetes
17,995.7 (14,062.5–21,309.8)	**6,824.4**	**7,245.0**	**301,698.6**	**224,900**
2.8 (2.6–3.2)	747.3	1,170.8	85.8 (80.4–93.3)	11
3.5 (2.9–4.3)	–	–	–	–
8.1 (6.6–12.6)	2,178.6	1,704.9	231.5 (192.5–333.5)	100
9.5 (8.5–11.0)	1,162.8	1,321.7	293.9 (266.3–326.6)	34
14.0 (12.2–16.2)	876.9	1,560.5	322.3 (284.5–360.9)	89
2.1 (1.8–2.4)	–	–	–	3
0.9 (0.7–1.2)	–	–	–	13
841.2 (804.5–1,140.3)	4,397.4	4,653.9	11,789.7 (11,361.6–15,009.0)	21,579
1.8 (1.6–2.1)	–	–	–	4
5.9 (4.7–7.0)	–	–	–	1
2.3 (1.9–2.9)	1,144.0	1,586.3	64.1 (53.3–73.2)	13
2.5 (1.9–3.3)	1,356.1	1,958.0	97.6 (77.3–125.1)	17
18.5 (15.9–25.0)	466.0	808.2	898.9 (783.7–1,093.3)	4
192.6 (130.0–317.3)	141.7	354.2	5,647.5 (4,025.7–8,479.3)	110
55.4 (44.5–69.6)	793.5	1,436.8	2,199.9 (1,784.2–2,600.9)	180
4,949.0 (2,786.1–5,942.7)	1,328.5	2,795.1	89,011.7 (57,398.8–104,680.0)	26,578
1.6 (1.1–2.2)	1,060.2	1,685.3	62.9 (47.2–81.4)	8
5.5 (4.7–7.2)	967.0	1,336.1	144.6 (125.2–171.5)	23
3.2 (2.7–4.1)	621.1	1,016.1	115.0 (97.5–135.6)	16
1.2 (1.0–1.3)	–	–	–	6
17.6 (12.1–34.0)	936.4	2,388.4	573.0 (432.5–829.4)	2
36.5 (30.2–48.6)	1,189.3	2,437.8	1,191.5 (1,008.0–1,521.0)	167
11,816.5 (10,181.6–13,647.4)	9,505.6	9,505.6	188,968.8 (167,714.5–211,520.8)	175,866
3.4 (2.9–4.0)	–	–	–	36

South and Central America

Country or territory	Number of adults 20–79 years with diabetes in 1,000s (95% confidence interval)	Diabetes national prevalence (%) in adults 20–79 years (95% confidence interval)	Diabetes age-adjusted comparative prevalence (%) in adults 20–79 years (95% confidence interval)
South and Central America	**31,638.8 (26,275.9–39,164.7)**	**9.4 (7.8–11.7)**	**8.5 (6.7–11.3)**
Argentina	1,837.4 (1,309.6–2,712.4)	6.3 (4.5–9.3)	5.9 (4.4–8.5)
Bolivia (Plurinational State of)	411.4 (337.5–636.3)	6.3 (5.1–9.7)	6.8 (5.6–10.4)
Brazil	16,780.8 (15,045.1–18,697.9)	11.4 (10.2–12.7)	10.4 (9.2–11.5)
Chile	1,262.2 (1,081.3–1,550.0)	9.8 (8.4–12.0)	8.6 (7.4–10.7)
Colombia	2,836.5 (2,017.4–3,815.2)	8.4 (6.0–11.3)	7.4 (5.1–10.6)
Costa Rica	353.0 (314.0–403.7)	10.2 (9.1–11.7)	9.1 (8.1–10.5)
Cuba	1,134.0 (1,035.3–1,236.5)	13.2 (12.1–14.4)	9.6 (8.8–10.6)
Dominican Republic	578.8 (421.6–747.5)	8.7 (6.3–11.2)	8.6 (6.3–11.1)
Ecuador	579.1 (351.3–904.9)	5.5 (3.3–8.6)	5.5 (3.4–8.9)
El Salvador	346.2 (302.8–448.3)	8.7 (7.6–11.2)	8.8 (7.7–11.3)
Guatemala	782.2 (517.2–1,174.9)	8.2 (5.4–12.4)	10.0 (6.8–14.9)
Honduras	339.2 (235.9–558.3)	6.1 (4.2–10.1)	7.3 (5.0–12.0)
Nicaragua	395.8 (259.1–542.1)	10.2 (6.7–13.9)	11.4 (7.4–15.6)
Panama	206.1 (171.0–295.1)	7.8 (6.4–11.1)	7.7 (6.4–10.7)
Paraguay	372.7 (340.4–411.3)	8.8 (8.1–9.7)	9.6 (8.8–10.6)
Peru	1,385.0 (966.9–2,244.2)	6.7 (4.7–10.8)	6.6 (4.6–10.7)
Puerto Rico	438.7 (368.9–521.3)	16.8 (14.1–19.9)	13.7 (11.5–16.4)
Uruguay	196.0 (148.3–247.1)	8.3 (6.3–10.5)	7.3 (5.7–9.4)
Venezuela (Bolivarian Republic of)	1,403.6 (1,052.2–2,017.7)	6.8 (5.1–9.8)	7.0 (5.0–10.8)

Total Regional estimates Countries without in-country data sources on diabetes Countries with in-country data sources on diabetes

Number of adults 20–79 years with undiagnosed diabetes in 1,000s (95% confidence interval)	Mean diabetes-related expenditure (USD) per person with diabetes (20–79 years)	Mean diabetes-related expenditure (ID) per person with diabetes (20–79 years)	Diabetes-related deaths in adults 20–79 years (95% confidence interval)	Number of children and adolescents 0–19 years with type 1 diabetes
13,270.6 (11,092.1–16,278.4)	**2,339.8**	**4,285.7**	**243,175.0**	**127,200**
597.2 (425.6–881.5)	1,169.4	1,874.7	15,468.2 (10,596.4–21,729.7)	8,618
114.3 (93.8–176.8)	821.0	1,911.7	4,418.3 (3,638.6–6,303.0)	834
7,719.2 (6,920.7–8,601.0)	3,116.7	5,451.1	135,196.7 (122,237.1–149,503.8)	95,846
271.5 (232.6–333.4)	1,405.8	2,363.1	7,744.1 (6,830.1–9,024.0)	6,103
1,111.9 (790.8–1,495.6)	1,217.7	2,972.6	18,452.9 (13,501.6–23,948.0)	1,824
138.4 (123.1–158.3)	2,677.3	3,761.5	1,854.3 (1,683.3–2,059.2)	170
444.5 (405.9–484.7)	2,395.1	6,062.9	8,593.0 (7,896.6–9,279.5)	491
226.9 (165.3–293.0)	1,502.2	3,400.0	6,859.9 (4,950.3–8,722.3)	196
227.0 (137.7–354.7)	1,957.1	3,654.5	3,955.4 (2,319.8–6,216.0)	710
135.7 (118.7–175.7)	1,015.6	2,072.6	2,927.6 (2,564.7–3,706.7)	1,348
306.6 (202.7–460.6)	856.1	1,641.1	7,397.7 (4,966.3–10,327.4)	4,333
133.0 (92.5–218.8)	730.5	1,461.0	1,911.0 (1,309.5–3,067.2)	2,236
155.2 (101.6–212.5)	564.1	1,455.2	2,768.8 (1,848.4–3,685.5)	1,374
67.0 (55.6–95.9)	1,333.0	2,240.9	1,200.9 (997.4–1,718.9)	168
146.1 (133.4–161.2)	1,088.0	2,555.3	3,133.7 (2,890.2–3,395.9)	204
542.9 (379.0–879.7)	1,135.3	2,446.6	9,160.7 (6,458.3–14,235.6)	480
142.6 (119.9–169.4)	–	–	–	1,482
63.7 (48.2–80.3)	1,499.1	2,129.6	1,482.9 (1,112.2–1,814.5)	627
727.1 (545.0–1,045.2)	–	–	10,649.0 (8,043.9–14,808.4)	149

South-East Asia

Country or territory	Number of adults 20–79 years with diabetes in 1,000s (95% confidence interval)	Diabetes national prevalence (%) in adults 20–79 years (95% confidence interval)	Diabetes age-adjusted comparative prevalence (%) in adults 20–79 years (95% confidence interval)
South-East Asia	**87,611.3 (70,868.2–110,876.6)**	**8.8 (7.1–11.1)**	**11.3 (8.0–15.9)**
Bangladesh	8,372.2 (6,952.9–10,727.9)	8.1 (6.7–10.3)	9.2 (7.6–11.8)
Bhutan	46.0 (41.2–54.1)	8.7 (7.8–10.2)	10.3 (9.2–11.9)
India	77,005.6 (62,393.7–96,444.6)	8.9 (7.3–11.2)	10.4 (8.4–13.0)
Maldives	22.8 (20.1–56.1)	7.3 (6.4–17.9)	9.2 (8.1–22.1)
Mauritius	234.9 (94.7–271.3)	25.3 (10.2–29.2)	22.0 (9.1–25.7)
Nepal	696.9 (488.9–1,446.2)	4.0 (2.8–8.2)	7.2 (5.6–11.6)
Sri Lanka	1,232.8 (876.6–1,876.4)	8.7 (6.2–13.3)	10.7 (8.1–15.3)

Total Regional estimates Countries without in-country data sources on diabetes Countries with in-country data sources on diabetes

Number of adults 20–79 years with undiagnosed diabetes in 1,000s (95% confidence interval)	Mean diabetes-related expenditure (USD) per person with diabetes (20–79 years)	Mean diabetes-related expenditure (ID) per person with diabetes (20–79 years)	Diabetes-related deaths in adults 20–79 years (95% confidence interval)	Number of children and adolescents 0–19 years with type 1 diabetes
49,644.5 (40,175.9–62,831.7)	**92.0**	**342.0**	**1,150,344.0**	**184,100**
4,688.4 (3,893.6–6,007.6)	63.9	171.0	109,857.3 (93,448.9–133,214.1)	5,350
24.7 (22.1–29.0)	165.1	531.5	326.7 (300.2–363.7)	105
43,869.0 (35,545.7–54,944.5)	91.6	353.3	1,010,262.1 (825,170.9–1,220,800.5)	171,281
12.2 (10.8–30.1)	1,794.1	2,788.7	111.4 (101.9–234.0)	38
124.8 (50.3–144.1)	506.4	1,105.3	2,648.7 (1,305.5–2,952.8)	40
484.3 (339.7–1,004.9)	80.4	278.7	11,678.9 (8,458.0–20,187.3)	4,621
441.1 (313.7–671.4)	198.3	636.3	15,459.1 (10,478.1–22,249.9)	2,623

Western Pacific

Country or territory	Number of adults 20–79 years with diabetes in 1,000s (95% confidence interval)	Diabetes national prevalence (%) in adults 20–79 years (95% confidence interval)	Diabetes age-adjusted comparative prevalence (%) in adults 20–79 years (95% confidence interval)
Western Pacific	**162,603.5 (146,588.8–203,023.6)**	**9.6 (8.6–11.9)**	**11.4 (8.3–15.6)**
Australia	1,288.3 (1,119.3–1,569.2)	7.3 (6.3–8.8)	5.6 (4.8–7.0)
Brunei Darussalam	40.1 (29.9–52.1)	13.2 (9.8–17.2)	13.3 (9.3–17.6)
Cambodia	430.6 (320.4–851.9)	4.4 (3.3–8.7)	6.3 (4.9–11.0)
China	116,446.9 (108,606.1–145,740.2)	10.9 (10.2–13.7)	9.2 (8.6–11.9)
Democratic People's Republic of Korea	1,392.4 (1,086.4–2,257.7)	7.6 (6.0–12.4)	6.3 (4.8–11.0)
Fiji	87.0 (66.2–151.6)	15.1 (11.5–26.4)	14.7 (11.1–25.7)
French Polynesia	39.4 (32.8–46.2)	20.1 (16.7–23.5)	19.5 (16.4–22.9)
Guam	22.1 (18.6–29.2)	20.2 (17–26.7)	18.7 (15.4–24.5)
Hong Kong	723.4 (613.4–835.4)	12.2 (10.4–14.1)	4.5 (3.8–5.3)
Indonesia	10,681.4 (9,215.0–11,549.7)	6.2 (5.3–6.7)	6.3 (5.4–6.8)
Japan	7,390.5 (6,121.1–9,396.8)	7.9 (6.5–10.0)	5.6 (4.5–8.1)
Kiribati	14.0 (6.6–19.4)	21.1 (9.9–29.1)	22.5 (11.0–31.0)
Lao People's Democratic Republic	191.6 (146.4–361.2)	4.7 (3.6–8.9)	6.3 (4.9–11.0)
Macau	50.9 (43.4–59.0)	9.9 (8.4–11.5)	4.3 (3.6–5.0)
Malaysia	3,652.6 (3,277.6–4,217.2)	16.8 (15.1–19.4)	16.7 (14.9–19.2)
Marshall Islands	10.9 (6.2–14.0)	33.8 (19.1–43.3)	30.5 (17.2–39.3)
Micronesia (Federated States of)	6.2 (4.7–9.1)	10.4 (7.8–15.2)	11.9 (9.2–19.2)
Mongolia	99.3 (34.0–176.7)	5.0 (1.7–8.9)	4.7 (1.7–8.6)
Myanmar	1,282.7 (1,007.1–1,876.4)	3.7 (2.9–5.4)	3.9 (3.0–5.9)
Nauru	1.6 (1.3–2.2)	24.0 (18.6–31.4)	12.0 (9.3–15.7)
New Caledonia	46.6 (34.9–56.8)	24.1 (18.0–29.3)	21.8 (17.3–26.0)
New Zealand	259.8 (234.8–307.8)	7.7 (7.0–9.2)	6.2 (5.6–7.4)
Palau	2.4 (1.9–3.2)	18 (13.7–23.6)	17.9 (13.6–23.4)
Papua New Guinea	713.5 (310.2–973.5)	15.4 (6.7–21.1)	17.9 (7.4–25.0)
Philippines	3,993.3 (3,183.8–5,040.3)	6.3 (5.0–8.0)	7.1 (5.6–8.9)
Republic of Korea	3,689.4 (3,020.3–4,553.2)	9.2 (7.5–11.3)	6.9 (5.8–8.5)
Samoa	7.7 (5.6–16.7)	7.5 (5.3–16.1)	9.2 (6.7–18.9)
Singapore	640.4 (556.8–720.1)	14.2 (12.3–16.0)	5.5 (4.7–6.3)
Solomon Islands	46.9 (25.4–68.6)	14.6 (7.9–21.3)	19.0 (9.4–27.4)

Total Regional estimates Countries without in-country data sources on diabetes Countries with in-country data sources on diabetes

Number of adults 20–79 years with undiagnosed diabetes in 1,000s (95% confidence interval)	Mean diabetes-related expenditure (USD) per person with diabetes (20–79 years)	Mean diabetes-related expenditure (ID) per person with diabetes (20–79 years)	Diabetes-related deaths in adults 20–79 years (95% confidence interval)	Number of children and adolescents 0–19 years with type 1 diabetes
90,764.1 (81,890.2–113,091.2)	**1,019.2**	**1,840.6**	**1,265,051.0**	**102,200**
455.5 (395.7–554.7)	5,000.4	4,528.5	5,174.5 (4,574.7–5,996.8)	12,969
18.7 (14.0–24.3)	702.3	2,016.7	281.3 (204.0–354.7)	13
268.1 (199.5–530.4)	238.7	700.8	7,918.6 (6,070.4–14,331.1)	546
65,179.8 (60,786.8–81,570.8)	936.2	1,790.0	823,779.5 (770,732.4–949,397.0)	54,040
964.3 (752.3–1,563.4)	–	–	25,241.6 (19,751.2–38,330.2)	1,941
46.3 (35.2–80.6)	456.5	793.9	866.7 (670.4–1,300.0)	28
18.4 (15.3–21.6)	–	–	–	8
10.3 (8.7–13.6)	–	–	–	1
466.1 (395.2–538.3)	–	–	–	222
7,870.1 (6,789.6–8,509.8)	365.2	1,183.7	115,632.0 (102,064.3–124,600.8)	8,483
3,441.2 (2,850.0–4,375.1)	3,178.9	3,448.5	71,513.1 (60,934.3–81,732.5)	4,534
7.5 (3.5–10.3)	475.6	632.5	112.0 (63.8–139.8)	3
102.3 (78.2–192.8)	197.3	556.2	3,697.9 (2,902.2–6,279.5)	192
23.8 (20.3–27.6)	–	–	–	19
1,841.3 (1,652.2–2,125.9)	980.4	2,851.9	22,448.5 (20,674.3–24,937.2)	977
5.8 (3.3–7.5)	1,608.0	1,764.8	163.7 (111.2–190.2)	–
3.3 (2.5–4.8)	916.8	1,023.4	58.3 (46.3–77.0)	–
71.3 (24.4–126.9)	524.7	1,737.9	1,229.6 (439.3–2,056.9)	168
684.7 (537.6–1,001.6)	183.4	860.8	31,288.3 (24,187.2–46,455.0)	1,549
0.8 (0.6–1.0)	2,597.3	3,197.9	15.3 (12.7–18.2)	–
21.8 (16.3–26.5)	–	–	–	7
66.8 (60.4–79.1)	4,032.4	3,946.2	1,069.5 (973.5–1,229.8)	2,528
1.1 (0.9–1.5)	1,872.3	2,116.1	15.7 (12.6–19.0)	–
380.9 (165.6–519.7)	134.9	225.7	6,324.1 (3,405.0–8,390.1)	28
2,662.3 (2,122.7–3,360.4)	428.8	1,136.8	38,583.5 (31,242.1–46,657.4)	3,897
1,333.2 (1,091.5–1,645.5)	1,988.8	2,638.7	33,307.7 (27,609.8–38,921.2)	2,721
3.7 (2.7–8.0)	548.8	853.4	79.5 (55.2–142.6)	8
346.0 (300.8–389.0)	2,095.1	3,475.4	4,374.1 (3,917.9–4,772.2)	289
25.0 (13.6–36.6)	263.2	293.0	324.5 (173.0–457.8)	3

Country or territory	Number of adults 20–79 years with diabetes in 1,000s (95% confidence interval)	Diabetes national prevalence (%) in adults 20–79 years (95% confidence interval)	Diabetes age-adjusted comparative prevalence (%) in adults 20–79 years (95% confidence interval)
Taiwan	1,228.8 (1,014.2–2,069.3)	6.6 (5.5–11.2)	6.3 (5.1–9.6)
Thailand	4,284.9 (3,312.2–4,920.3)	8.3 (6.4–9.6)	7.0 (5.4–8.1)
Timor-Leste	32.0 (28.4–36.3)	5.3 (4.7–6.0)	6.7 (5.9–7.6)
Tonga	7.6 (5.1–11.7)	13.1 (8.8–20.2)	15.7 (10.2–23.8)
Tuvalu	1.6 (1.3–1.9)	23.2 (18.6–27.9)	22.1 (17.6–26.6)
Vanuatu	17.0 (13.1–25.1)	10.8 (8.4–16.0)	11.9 (9.2–19.2)
Viet Nam	3,779.6 (3,084.3–5,003.6)	5.7 (4.6–7.5)	6.0 (4.9–8.1)

☐ Countries without in-country data sources on diabetes ■ Countries with in-country data sources on diabetes

Number of adults 20–79 years with undiagnosed diabetes in 1,000s (95% confidence interval)	Mean diabetes-related expenditure (USD) per person with diabetes (20–79 years)	Mean diabetes-related expenditure (ID) per person with diabetes (20–79 years)	Diabetes-related deaths in adults 20–79 years (95% confidence interval)	Number of children and adolescents 0–19 years with type 1 diabetes
525.9 (434.1–885.6)	–	–	–	2,828
1,868.0 (1,444.1–2,145.2)	560.3	1,602.6	40,918.0 (32,254.3–46,403.5)	1,584
17.1 (15.2–19.4)	292.7	446.3	326.4 (289.5–362.9)	52
5.2 (3.5–8.0)	464.7	712.0	69.3 (48.3–95.9)	4
0.9 (0.7–1.0)	1,121.1	1,329.0	13.3 (11.2–15.2)	–
9.1 (7.0–13.4)	280.8	296.1	128.0 (101.9–174.0)	10
2,017.7 (1,646.4–2,670.9)	322.8	934.3	30,096.2 (24,357.4–39,064.5)	2,574

Abbreviations and acronyms

A

AAP	American Academy of Periodontology
ABI	ankle brachial index
ACE	angiotensin-converting enzyme
ADA	American Diabetes Association
ADIPS	Australasian Diabetes in Pregnancy Society
AFR	IDF Africa Region
AHP	analytical hierarchy process

B

BCV	Blue Circle Voices
BMI	body mass index
BP	blood pressure

C

CAD	coronary artery disease
CANOE	Canadian Normoglycemia Outcomes Evaluation
CDQDPS	China Da Qing Diabetes Prevention Study
CKD	chronic kidney disease
CVD	cardiovascular diseases

D

D-CLIP	Diabetes Community Lifestyle Improvement Programme
DED	diabetic eye disease
DIP	diabetes in pregnancy
DKA	diabetic ketoacidosis
DMO	diabetic macular oedema
D-NET	Diabetes Education Network for Health Professionals
DPP-4	dipeptidyl peptidase 4
DPPOS	Diabetes Prevention Program Outcomes Study
DR	diabetic retinopathy
DREAM	Diabetes Reduction Assessment with Ramipril and Rosiglitazone Medication

E

EACCME	European Accreditation Council for Continuing Medical Education
EDIT	Early Diabetes Intervention Trial
EFP	European Federation of Periodontology
EFPIA	European Federation of Pharmaceutical Industries and Associations
eGFR	estimated glomerular filtration rate
ESRD	End-stage renal disease
EUR	IDF Europe Region

F

FBG	fasting blood glucose
FDPS	Finnish Diabetes Prevention Study
FIGO	International Federation of Gynaecology and Obstetrics

G

GDM	gestational diabetes mellitus
GFR	glomerular filtration rate
GLP-1	glucagon-like peptide 1

H

HAPO	hyperglycaemia and adverse pregnancy outcomes
HbA1c	haemoglobin A1c (or glycosylated haemoglobin)
HDL	high-density lipoprotein
HHS	hyperglycaemic hyperosmolar state
HIP	hyperglycaemia in pregnancy
HIV/AIDS	human immunodeficiency virus/acquired immune deficiency syndrome
HLM	high-level meeting

I

IADPSG	International Association of Diabetes and Pregnancy Study Group
ID	international Dollar
IDF	International Diabetes Federation
IDPP	Indian Diabetes Prevention Programme
IFA	International Federation on Ageing
IFG	impaired fasting glucose
IGF-1	insulin-like growth factor 1

IGT	impaired glucose tolerance
IMR	infant mortality rate
ISPAD	International Society for Pediatric and Adolescent Diabetes

J

JDRF	Juvenile Diabetes Research Foundation

K

KiDS	Kids and Diabetes in Schools Project

L

LDL	low-density lipoprotein
LFAC	Life for A Child
LSM	lifestyle modification

M

MENA	IDF Middle East and North Africa Region
mg/dL	milligrams per decilitre
MI	myocardial ischaemia
mmol/L	millimoles per litre
mmol/mol	millimoles per mole
MODY	maturity onset diabetes of the young

N

NAC	IDF North America and Caribbean Region
NAVIGATOR	Nateglinide and Valsartan in Impaired Glucose Tolerance Outcomes Research
NCD	non-communicable disease
NCD-RsC	Non-Communicable Disease Risk Factor Collaboration
NICE	National Institute of Health and Care Excellence

O

OGTT	oral glucose tolerance test
OR	odds ratio
ORIGIN	Outcomes Reduction with Initial Glargine Intervention

P

PAF	population attributable fraction
PVD	peripheral vascular disease

Q

QALY	quality-adjusted life year

R

RASi	renin–angiotensin system inhibitors
RCT	randomised controlled trial
RR	relative risk

S

SACA	IDF South and Central America Region
SCALE	Satiety and Clinical Adiposity – Liraglutide Evidence
SD	standard deviation
SDG	Sustainable Development Goal
SEA	IDF South-East Asia Region
SMS	short message service
STDR	sight-threatening diabetic retinopathy
STEP	WHO STEPwise approach to surveillance
STOP-NIDDM	Study to Prevent Non-Insulin Dependent Diabetes Mellitus

T

TRIPOD	Troglitazone in the Prevention of Diabetes

U

UHC	universal health coverage
UN	United Nations
UNPD	United Nations Population Division
USD	United States dollar

W

WDD	World Diabetes Day
WHO	World Health Organization
WP	IDF Western Pacific Region

X

XENDOS	Xenical in the Prevention of Diabetes in Obese Subjects

Y

YLD	Young Leaders in Diabetes

Glossary

A

ACE inhibitor

Angiotensin-converting enzyme inhibitor, a pharmaceutical drug used primarily for the treatment of hypertension (elevated blood pressure) and congestive heart failure.

Age-adjusted comparative prevalence

Also called comparative prevalence, is the prevalence calculated by adjusting to a standard population age-structure. This reduces the effect of the differences in prevalence that age structures between countries and regions create. This makes this estimate appropriate for making comparisons between countries.

Albuminuria

The presence of albumin (a protein) in the urine, typically as a symptom of kidney disease.

Analytical hierarchy process (AHP) scoring

An approach that quantifies the relative value of a variety of different aspects of study methods.

Attributable fraction method

The contribution of a risk factor to a disease or a death is quantified using the population attributable fraction.

Autoimmune reaction

A reaction that is characterised by a specific humoral or cell-mediated immune response against the constituents of the body's own tissues.

B

Beta cells

Cells found in the pancreas that produce, store and release insulin.

Body mass index (BMI)

A measure of weight (or body mass), which is approximately independent of height. It is calculated by dividing weight in kilograms by the square of height in metres. Also sometimes expressed as "body weight in kilograms divided by height in metres and then divided by height in metres again". The units are kilograms per square metre (kg/m^2).

Bootstrap analysis

A re-sampling technique used to estimate statistics for a population by sampling a dataset with replacement (i.e. by putting back any item sampled so that it stands a chance of being sampled again).

C

Calculus

Also known as tarter, in dentistry, this is a form of hardened dental plaque.

Cardiovascular diseases (CVD)

Diseases and injuries of the circulatory system: the heart, blood vessels of the heart and the system of blood vessels throughout the body and to (and in) the brain; generally, refers to conditions that involve narrowed or blocked blood vessels.

Caries

Decay and crumbling of a tooth or bone.

Cerebral oedema

The excess accumulation of fluid (sometimes spelt 'edema') in the intracellular or extracellular spaces of the brain.

Common soil hypothesis

Conditions having common genetic and environmental antecedents.

D

de-novo

A Latin expression (literally 'of new') used in English that means 'from the beginning.'

Diabetes complications

Acute and chronic conditions caused by diabetes.

Diabetic foot

A foot that exhibits any disease that results directly from diabetes or a complication of diabetes.

Diabetes in pregnancy (DIP)

Diabetes in pregnancy in women previously diagnosed with diabetes or having hyperglycaemia first diagnosed during pregnancy, and meets WHO criteria of diabetes in the non-pregnant state.

Diabetic ketoacidosis (DKA)

A complex metabolic disorder that occurs when the liver starts breaking down fat at an excessive rate. The by-product of this process, ketones, can cause the blood to become dangerously acidic.

Diabetes (mellitus)

A condition arising from the pancreas's inability to produce enough insulin, or when the body cannot effectively use the insulin that it produces. The three most common forms of diabetes are type 1, type 2 and gestational.

Diabetic neuropathy

A type of nerve damage that can occur if a person has diabetes; depending on the affected nerves, symptoms of diabetic neuropathy can range from pain and numbness in the legs and feet to problems with the digestive system, urinary tract, blood vessels, and heart.

Dialysis

A procedure to remove waste products and excess fluid from the blood when the kidneys stop working normally.

Direct costs

The costs of providing, for a given condition or disease, health services (preventive and curative), family planning activities, nutrition activities and emergency aid designated for health. It does not include provision of water and sanitation but it does include health expenditures from both public and private sources.

DPP-4 inhibitors

A class of oral hypoglycaemic drugs that blocks the enzyme dipeptidyl peptidase 4 (DPP-4), used to treat type 2 diabetes.

Dyslipidaemia

An abnormal amount of lipids (fats) in the blood.

E

Endothelial dysfunction

A condition in which the endothelial layer (the inner lining) of the small arteries fails to function normally.

Epidemiology

The study of the occurrence, distribution and patterns of disease in populations, including factors that influence disease and the application of this knowledge to improve public health.

Essential hormone

Hormones that are required for life including: insulin, parathyroid hormone, glucocorticosteroids (cortisol), mineral corticosteroids (aldosterone).

Estimates

Values that are usable for some purpose even if input data may be incomplete, uncertain, or unstable; the value is nonetheless usable because it is derived from the best information available.

Exocrine pancreas

The part of the pancreas that secretes enzymes playing a role in the food digestion process.

Extrapolate

Extending values or conclusions from a known situation to an unknown situation, assuming that similar conditions, methods or trends are applicable.

F

Fasting plasma glucose (FPG)

A common but flawed method of screening for diabetes. The FPG measures a person's blood glucose concentration after fasting – not eating anything for at least eight hours. Normal FPG is less or equal to 6.1 millimoles per litre (mmol/l) or less than or equal to 110 milligrams per decilitre (mg/dL). The disadvantages of using FPG for screening include: the possibility that the person has not fasted, its inability to detect diabetes diagnosed by a post-glucose load value alone and the fact that FPG alone cannot identify impaired glucose tolerance (see letter I). FPG alone fails to detect approximately 30% of undiagnosed diabetes.

G

G7

A governmental political forum that currently includes Canada, France, Germany, Italy, Japan, the United Kingdom, the United States of America, and the European Union.

G20

An international forum for the governments and central bank governors from 20 major economies: Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Mexico, Russia, Saudi Arabia, South Africa, South Korea, Turkey, the United Kingdom, the United States of America, and the European Union.

Genes

The basic physical and functional units of heredity found in the nuclei of all cells.

Gestational diabetes mellitus (GDM)

Women with elevated blood glucose concentrations during pregnancy are classified as having GDM.

Gingivitis

A common and mild form of gum disease that causes irritation, redness and swelling of the gum around the base of the teeth.

Glossodynia

Also known as burning mouth syndrome, it is a multifunctional disorder characterised by painful sensations in the mouth and throat and especially on the tongue.

Glucagon

A hormone produced in the pancreas. If blood glucose levels decrease, it triggers the body to release stored glucose into the bloodstream.

Glucagon-like peptide 1

Also known as GLP-1, a naturally occurring peptide hormone, released from the gut after eating.

Glucose

Also called dextrose or blood sugar. The main sugar the body absorbs, uses as a form of energy and stores for future use. Glucose is the major source of energy for living cells and is carried to each cell through the bloodstream. However, the cells cannot use glucose without the action of insulin.

Glycogen

A form of glucose used for storing energy in the liver and muscles. If blood glucose levels decrease, the hormone glucagon triggers the body to convert glycogen to glucose and release it into the bloodstream.

Gross national income

A measure of the size of a country's economy. It is the sum of the products produced by enterprises owned by a country's citizens, excluding products produced by foreign-owned enterprises.

H

Haemoglobin A1c (HbA1c)

Also called glycosylated haemoglobin, a haemoglobin to which glucose is bound. Glycosylated haemoglobin is tested to determine the average level of blood glucose over the past two to three months.

Heterogeneity

The quality or state of being diverse in character or content.

High-income country

A country defined by the World Bank to have a gross national income per capita of USD 12,235 or more (in 2017).

Hyperfiltration

Also called an increased glomerular filtration rate (GFR), it is a proposed mechanism for renal injury in several clinical conditions.

Hyperglycaemia

A raised concentration of glucose in the blood. It occurs when the body does not have enough insulin or cannot use the insulin it does have to turn glucose into energy. Signs of hyperglycaemia include great thirst, dry mouth, weight loss and the need to urinate often.

Hyperglycaemic hyperosmolar state (HHS)

A complication of diabetes mellitus in which high blood glucose results in high osmolarity (concentration) of the blood without significant ketoacidosis. Symptoms include signs of dehydration, weakness, legs cramps, vision problems, and an altered level of consciousness.

Hyperglycaemia in pregnancy (HIP)

Hyperglycaemia in pregnancy (HIP) can be classified as either gestational diabetes mellitus (GDM) or diabetes in pregnancy (DIP).

Hyperinsulinaemia

A condition describing an excess concentration of insulin circulating in the blood relative to the level of glucose. It is a characteristic of advanced type 2 diabetes and is often a feature of diabetes. It can result from a variety of metabolic diseases and conditions.

Hyperpotassaemia

Also known as hyperkalaemia, is the medical term that describes a potassium level in the blood that is higher than normal.

Hyperbilirubinaemia

A condition in which there is too much bilirubin in the blood. When red blood cells break down, a substance called bilirubin is formed.

Hypoglycaemia

A low concentration of glucose in the blood. This may occur when a person with diabetes has injected too much insulin, eaten too little food, or has exercised without extra food.

Hyposalivation

A clinical diagnosis that is made based on the history and measurement of salivary flow. Reduced salivary flow rates have been given objective definitions. Salivary gland hypofunction has been defined as any objectively demonstrable reduction in whole and/or individual gland flow rates.

I

IDF Region

The International Diabetes Federation (IDF) is divided into seven Regions: Africa, Europe, Middle East and North Africa, South-East Asia, North America and the Caribbean, South and Central America, Western Pacific. IDF Regions aim to strengthen the work of national diabetes associations and enhance collaboration between them.

Impaired fasting glucose (IFG)

Blood glucose that is higher than normal blood glucose, but below the diagnostic threshold for diabetes after fasting (typically after an overnight fast). Sometimes termed impaired fasting glycaemia.

Impaired glucose tolerance (IGT)

Blood glucose that is higher than normal, but below the diagnostic threshold for diabetes, after ingesting a standard amount of glucose during an oral glucose tolerance test. Fasting and two-hour glucose values are needed for its diagnosis.

Incidence

The number of new cases of a disease or condition among a defined group of people during a specified time period. For example, the number of new cases of type 1 diabetes in children and adolescents living in a given country in one year.

Indirect costs

The costs of loss of production resulting, for a given condition or disease, from labour-force drop out (from disability), pre-mature mortality, absenteeism and so called 'presenteeism' (see letter P).

Insulin

A hormone produced in the pancreas, as a response to glucose. Insulin triggers cells to take up glucose from the blood stream and to convert it to energy.

Insulin resistance

The inability of cells to adequately use circulating insulin, resulting in increased levels of blood glucose.

Intermediate hyperglycaemia

The condition of raised blood glucose levels above the normal range and below the diabetes diagnostic threshold. Alternative terms are 'prediabetes', 'non-diabetic hyperglycaemia', IFG and IGT.

International Dollar (ID)

A hypothetical unit of currency that has the same purchasing power in every country. Conversions from local currencies to international dollars are calculated using tables of purchasing power parities, taken from studies of prices for the same basket of goods and services in different countries. Internationals Dollars are used to compare expenditures between different countries or regions.

in utero

A Latin term literally meaning "in the womb" or "in the uterus", in biology, the phrase describes the state of an embryo or fetus.

K

Knockout model

Naturally occurring genetic variants providing 'experiment of nature' that can directly inform on the function of human genes

L

Legacy effect

The phenomenon of ongoing beneficial effects of active treatments in clinical trials that persist after the trial has stopped. For example, reduced incidence of diabetic complications after a period of improved glycaemic control induced by an effective intervention.

Lipids

A group of biomolecules that are insoluble in water and soluble in organic solvents such as ethanol. Lipids are an important component of living cells.

Liver

A vital organ located below the diaphragm. It has a wide range of functions, including storing glucose as glycogen when triggered by insulin, and releasing glucose into the blood when triggered by glucagon.

Loss of filtration surface

Decrease in the capacity of the kidney glomerulae, the filtration compartments of kidneys. This loss leads to a lower rate of filtering of waste products from the blood by the kidney.

Low-income country

A country defined by the World Bank with a gross national income per capita of USD 1,005 or less (in 2017).

M

Macrosomia

Birth weight more than 4.0 kg

Macrovascular angiopathy

The generic term for a disease of the large blood vessels (arteries and veins).

Macrovascular complications

Macrovascular complications of diabetes include coronary artery disease (CAD), peripheral arterial disease (PAD) and stroke.

Maturity-onset diabetes of the young (MODY)

A group of rare forms of diabetes caused by one of several single gene mutations, belonging to the monogenic types of diabetes.

Metabolic syndrome

A cluster of conditions that occur together, increasing one's risk of heart disease, stroke and type 2 diabetes. These conditions include overweight and obesity (particularly characterised by increased abdominal girth), hyperglycaemia, hyperlipidaemia and hypertension.

Metformin

A form of oral therapy for type 2 diabetes, and one of a group of drugs known as biguanides. These lower blood glucose levels in people with type 2 diabetes by increasing the sensitivity of muscle cells to insulin, and by reducing the amount of glucose in the liver.

Microbiome

The microorganisms in a particular environment (including the body or a part of the body).

Microvascular complications

Complications of diabetes that include diabetic nephropathy, neuropathy and retinopathy, which are caused by pathological changes in capillaries.

Middle-income country

A country defined by the World Bank that has a gross national income per capita of more than USD 1,006 and less than USD12,235 (in 2017).

Monogenic diabetes

Less common types of diabetes, resulting from single genetic mutations. Examples include MODY and Neonatal Diabetes Mellitus.

Myocardial ischaemia (MI)

Occurs when blood flow to the heart muscle is obstructed by a partial or complete blockage of a coronary artery, typically due to a build-up of plaques. MI can lead to heart attack, heart failure and death.

N

Neonatal diabetes mellitus

A rare form of diabetes that is diagnosed in children under six months of age. Caused by a mutation in a single gene. It is a type of monogenic diabetes.

Neonatal hyperbilirubinaemia

Also known as neonatal jaundice, a yellowish discoloration of the white part of the eyes and skin in a newborn baby due to high bilirubin levels.

Neonatal hypoglycaemia

Defined as a plasma glucose level of less than 30 mg/dL (1.65 mmol/L) in the first 24 hours of life and less than 45 mg/dL (2.5 mmol/L) thereafter. It is the most common metabolic problem in newborns.

Nephropathy

Exacerbated by prolonged hyperglycaemia, damage, disease or dysfunction of the kidney, which can cause the kidneys to be less efficient or to fail.

Neuropathy

Refers to any condition that affects the normal activity of the nerves in the peripheral nervous system or the sympathetic (autonomic) nervous system. The former (peripheral neuropathy) can cause pain, tingling, numbness, loss of sensation etc. The latter (sympathetic or autonomic neuropathy) can cause problems with digestion, cardiac function etc.

Non-communicable disease (NCD)

Chronic disease that is not caused by a transmissible pathogen.

Non-diabetic hyperglycaemia

Condition of raised blood glucose levels above the normal range but below the diabetes diagnostic threshold. Alternative terms are 'prediabetes', 'intermediate hyperglycaemia', IFG and IGT.

O

Obesity

A condition in which a person carries excess weight or body fat that might affect their health (BMI ≥30 Kg/m^2).

Oral glucose tolerance test (OGTT)

A medical test in which glucose is given after an overnight fast and blood samples taken after a certain time to determine how quickly it is cleared from the blood.

Oral medication

A medication administered by mouth.

Overweight

A condition of having more body fat than is optimally healthy, though not in the obese range (BMI of 25.0 Kg/m^2 to 29.9 Kg/m^2).

P

Pancreas

An organ situated behind the stomach, which produces several important hormones, including insulin and glucagon.

Pancreatitis

An inflammation of the pancreas.

Peri-implantitis

A site-specific infectious disease that causes an inflammatory process in soft tissues, and bone loss around an osseointegrated implant.

Periodontitis

An inflammatory disease that affects the tissues that surround and support the teeth, also known as gum disease.

Peripheral neuropathy

A condition that results when nerves that carry messages to and from the brain and spinal cord from and to the rest of the body are damaged or diseased. The peripheral nerves make up an intricate network that connects the brain and spinal cord to the muscles, skin and internal organs.

Peripheral vascular disease (PVD) or peripheral artery disease (PAD)

A progressive disorder that causes narrowing or blocking of the blood vessels outside the heart, including arteries, veins or lymphatic vessels.

Polyneuropathic bladder dysfunction

The condition where multiple peripheral sympathetic nerves that control the bladder become damaged.

Podocytes

Cells in the Bowman's capsule of the kidneys that wrap around capillaries of the glomerulus. The Bowman's capsule filters the blood, retaining large molecules such as proteins while smaller molecules such as water, salts and sugars are filtered as the first step in the formation of urine.

Prediabetes

Elevated blood glucose above the normal range but below the diabetes diagnostic threshold. Alternative terms are IFG, IGT, non-diabetic hyperglycaemia, and intermediate hyperglycaemia.

Presenteeism

A term used by economists to denote loss of productivity resulting from employees, as a result of a condition or disease, being not fully functioning in the work-place. Thus, although at work, these employees are not performing as effectively as they would in the absence of the condition or disease and are more likely to make mistakes.

Polydipsia

Excessive thirst.

Polyuria

Frequent urination.

Preterm birth

A birth that occurs before the 37th week of pregnancy.

Prevalence

The proportion or number of individuals in a population that has a disease or condition at a particular time (a point in time or over a period of time). For example, the proportion of adults aged 20–79 with diabetes in 2017. Prevalence is a proportion or number, and not a rate, even though the term 'prevalence rate' is often used.

Primary caesarean section

The percentage of caesarean deliveries out of all births to women who have not had a previous caesarean delivery.

Primary prevention

Disease prevention before a disease or condition occurs. Usually refers to the prevention of exposures to hazards that cause disease or injury, and altering unhealthy or unsafe behaviours.

Projections

Estimates of a future situation based on a study of past and present trends.

Q

QALY (quality-adjusted life year)

A measure of disease burden that takes into account both the quality of life and the quantity of life lived.

Quality of life

The standard of health, comfort and happiness experienced by an individual or group.

R

Ratio

The diabetes cost ratio, which is the ratio of health expenditures for people with diabetes compared to health expenditures for age- and sex-matched persons who do not have diabetes. The R=2 estimates assume that health care expenditures for people with diabetes are on average two-fold higher than people without diabetes, and the R=3 estimate assumes that health care expenditures for people with diabetes are on average three-fold higher than people without diabetes.

Raw diabetes prevalence

Also called country, national or regional prevalence, the number or percentage of each country's or region's population that has diabetes. It is useful for assessing the impact of diabetes for each country or region.

Relapsing urinary tract infections

Presenting as dysuria (pain, burning or other abnormal symptoms when passing urine), irritative voiding symptoms, are most commonly caused by re-infection with the original bacterial in (typically) young, otherwise healthy women with no anatomical or functional abnormalities of the urinary tract.

Relative risk

The ratio of the probability of an outcome in an exposed group to the probability of an outcome in an unexposed group.

Retinopathy

A disease of the retina of the eye, which may cause visual impairment or blindness.

S

Sampling frame

A list of the items, or people forming a population, from which a sample is taken.

Screening approach

A method used to make a diagnosis of a given disease or condition.

Secondary diabetes

Less common forms of diabetes, which arise as a consequence of other diseases or conditions (e.g. diseases of the pancreas such as cystic fibrosis).

Self-management

Management of or by oneself; the taking of responsibility for one's own behaviour and well-being.

Shoulder dystocia

A complication that occurs during delivery when an infant's shoulders become lodged in the mother's pelvis, often because the baby is proportionately too big for the birth canal (cephalopelvic disorder, known as CPD).

Stroke

A sudden loss of function in part of the brain resulting from the interruption of its blood supply by a blocked or burst artery.

Sulphonylureas

Oral medications used for the treatment of type 2 diabetes. They work mainly by stimulating the cells in the pancreas to release more insulin.

T

Task-shifting

A process of delegation whereby tasks are moved, where appropriate, to less specialized health workers.

Thrush

A fungal infection typically of the skin or mucous membranes (often of the mouth or genitals) caused by *Candida sp.*

Type 1 diabetes

People with type 1 diabetes, who cannot produce enough insulin. The disease can affect people of any age, but onset often occurs in children or young people.

Type 2 diabetes

People with type 2 diabetes are compromised in their ability to use insulin to allow glucose to enter cells. Type 2 diabetes mellitus is much more common than type 1 and occurs mainly in adults, although it is now also increasingly found in children and young people.

U

UN languages

The official languages of the United Nations are Arabic, Chinese, English, French, Russian and Spanish.

Universal health coverage (UHC)

Also called universal coverage or universal care, it is a health care system that ensures that all people obtain the health services they need without suffering financial hardship when paying for them.

W

WHO global health

The Every Woman Every Child Global Strategy indicator and monitoring framework that includes 60 indicators from health and other sectors.

Lists of figures, maps and tables

Figures

Maps

Tables

International Diabetes Federation

atlas@idf.org I www.diabetesatlas.org