Review Article

Epidemiology of type 2 diabetes in India

Rajendra Pradeepa, Viswanathan Mohan

The burden of diabetes is high and increasing globally, and in developing economies like India, mainly fueled by the increasing prevalence of overweight/obesity and unhealthy lifestyles. The estimates in 2019 showed that 77 million individuals had diabetes in India, which is expected to rise to over 134 million by 2045. Approximately 57% of these individuals remain undiagnosed. Type 2 diabetes, which accounts for majority of the cases, can lead to multiorgan complications, broadly divided into microvascular and macrovascular complications. These complications are a significant cause for increased premature morbidity and mortality among individuals with diabetes, leading to reduced life expectancy and financial and other costs of diabetes leading to profound economic burden on the Indian health care system. The risk for diabetes is largely influence by ethnicity, age, obesity and physical inactivity, unhealthy diet, and behavioral habits in addition to genetics and family history. Good control of blood sugar blood pressure and blood lipid levels can prevent and/or delay the onset of diabetes complications. The prevention and management of diabetes and associated complications is a huge challenge in India due to several issues and barriers, including lack of multisectoral approach, surveillance data, awareness regarding diabetes, its risk factors and complications, access to health care settings, access to affordable medicines, etc. Thus, effective health promotion and primary prevention, at both, individual and population levels are the need of the hour to curb the diabetes epidemic and reduce diabetes-related complications in India.

Access this article online

Website: www.ijo.in

DOI: 10.4103/ijo.IJO_1627_21

Quick Response Code:

Key words: Burden, complications, type 2 diabetes

Diabetes is one of the largest global health emergencies of this century, ranking among the 10 leading causes of mortality together with cardiovascular disease (CVD), respiratory disease, and cancer.[1,2] According to the World Health Organization (WHO), noncommunicable diseases (NCDs) accounted for 74% of deaths globally in 2019, of which, diabetes resulted in 1.6 million deaths, thus becoming the ninth leading cause of death globally.[2] By the year 2035, nearly 592 million people are predicted to die of diabetes.[3] Type 2 diabetes, which constitutes 90% of all cases of diabetes, earlier considered to be a disease of the affluent "Western" countries, has now spread globally, and has become a major cause of disability and death affecting even younger age group.[1] Diabetes has reached epidemic proportions in many developing economies, such as China and India.[1] According to WHO, the prevalence of diabetes is growing most rapidly in low- and middle-income countries.[4] The rapid socioeconomic change in conjunction with urbanization and industrialization are the major factors for the global increase in the diabetes epidemic, with other associated risk factors such as population growth, unhealthy eating habits, and a sedentary lifestyle also playing an important role.[5]

Madras Diabetes Research Foundation and Dr. Mohan's Diabetes Specialities Centre, IDF Centre of Excellence in Diabetes Care and ICMR Centre for Advanced Research on Diabetes, Chennai, Tamil Nadu, India

Correspondence to: Dr. Viswanathan Mohan, President and Chief of Diabetes Research, Madras Diabetes Research Foundation, ICMR Centre for Advanced Research on Diabetes and, Chairman and Chief of Diabetology, Dr. Mohan's Diabetes Specialities Centre, IDF Centre of Excellence in Diabetes Care, No 4, Conran Smith Road, Gopalapuram, Chennai - 600 086, Tamil Nadu, India. E-mail: drmohans@diabetes.ind.in

Received: 12-Jun-2021 Revision: 21-Jun-2021
Accepted: 22-Jun-2021 Published: 29-Oct-2021

Diabetes is a progressive disorder that leads to serious complications, which are associated with increased costs to the family, community, and healthcare system. Uncontrolled diabetes leads to increased risk of vascular disease and much of the burden of type 2 diabetes is caused by macrovascular (cardiovascular (CV), cerebrovascular, and peripheral artery disease) and microvascular (diabetic retinopathy, nephropathy, and neuropathy) complications.[5,6]

Global Burden of Diabetes

Type 2 diabetes susceptibility varies to a great extent around the globe, with Pacific Islanders, Asian Indians, and Native Americans having a significantly higher risk of developing the disorder. The number of people with type 2 diabetes began to rise globally in the 1990s, and since 2000, the world has seen a dramatic increase in the number of people with diabetes.[7] According to the International Diabetes Federation (IDF), 8.8% of the adult population have diabetes, with men having slightly higher rates (9.6%) than women (9.0%).[1] Current global statistics shows that 463 million and 374 million individuals have diabetes and impaired glucose tolerance (IGT), a prediabetic condition. These numbers are estimated to increase to 700 million people with diabetes and 548 million people with IGT by 2045, which represents a 51% increase compared to 2019.[1]

Cite this article as: Pradeepa R, Mohan V. Epidemiology of type 2 diabetes in India. Indian J Ophthalmol 2021;69:2932-8.

Among the IDF regions, the Western Pacific has the highest number of people with diabetes (163 million), followed by the South-East Asian region (88 million), Europe (59 million), Middle East and North Africa (55 million), and North America and Caribbean (47.6 million). Currently, the lowest numbers are found in South and Central America (36.1 million) and Africa (19.4 million).[1] Thus, it is apparent that the affluent regions of Europe and North America are not the only ones dealing with the diabetes epidemic.

According to the IDF in 2019, the top three countries with the highest number of individuals with diabetes are China (116.4 million), India (77.0 million), and the United States of America (31.0 million). This trend is expected to continue in 2030 and 2045, with China (140.5 and 147.2 million) and India (101.0 and 134.2 million) continuing to have the highest burden of diabetes.[1] This is supported by the Global Burden of Disease Study, which reported that population growth and ageing in the world's largest countries, such as China and India, are driving the absolute increase in the number of people with diabetes.[8]

According to prevalence estimates by IDF, the diabetes burden is growing faster in low- and middle-income countries (367.8 million) than in high-income countries (95.2 million).[1] The Global Burden of Disease study conducted in 195 countries and territories provided a detailed overview of the numbers, rates, and rising trends in the diabetes burden between 1990 and 2025.[9] This study also reported that the low- and middle-income regions had higher burden of diabetes, while the high-income regions had lower burden of diabetes. This study reported that the number of people with incident diabetes increased from 11.3 to 22.9 million between 1990 and 2017 (an increase by 102.9%) and the number of prevalent diabetes increased from 211.2 to 476.0 million (an increase by 129.7%), respectively. Furthermore, modifiable metabolic, environmental, and behavioral factors were found to be the major risk factors for diabetes burden.

Another cause for concern is the high percentage of individuals with undiagnosed diabetes, which is currently more than 50%. This is observed mainly in developing economies due to less developed health care systems. It is estimated that approximately 231.9 million (one in two) of adults with diabetes are undiagnosed worldwide.[1] Fig. 1 depicts the proportion and number of individuals with undiagnosed diabetes in various IDF regions.[1] According to reports, nearly 59.7% of people with diabetes in Africa are unaware of their disease (the highest such proportion among all regions), while only 37.8% of people with diabetes in North America and the Caribbean are unaware of their disease (the lowest proportion among all the regions). When compared to other IDF regions, Africa and South and Central America have a lower number of individuals with undiagnosed diabetes (11.6 and 13.3 million, respectively).[1] According to these estimates, there is an urgent need for improved diabetes screening. They also highlight the importance of identifying undiagnosed diabetes and providing appropriate and timely care as undiagnosed diabetes can have negative consequences such as an increased risk of diabetes related complications, increased healthcare use, and associated costs.[10]

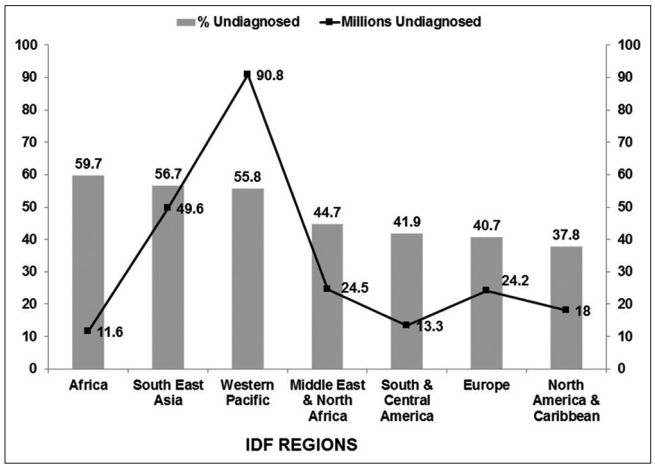

Figure 1: Proportion and number of individuals with undiagnosed diabetes – International Diabetes Federation (IDF) [Ref No: 1]

Burden of Diabetes in India

Diabetes has steadily increased in India and around the world over the last three decades, with India accounting for a sizable portion of the global burden. India's disease patterns have shown a switch due to an epidemiological transition: thus mortality from communicable, maternal, neonatal, and nutritional diseases (CMNNDs) has decreased significantly, while NCDs and injuries have markedly increased their contribution to overall disease burden and mortality.[11] In India in 1990, the total disability adjusted life years (DALYs) from CMNNDs were 61%, 30% from NCDs, and 9% from injuries. However, due to major epidemiological transitions in India over the years, total DALYs from CMNNDs have decreased to 33%, while those from NCDs and injuries have increased to 55 and 12%, respectively, in 2016 [Fig. 2]. Across India, the disease burden or DALY rate in 2016 was 4-fold for diabetes, and when looked at the leading individual causes of DALYs in India, most NCDs have risen in rank since 1990, with diabetes showing a dramatic increase, from 35th place in 1990 to 13th place in 2016.[11]

Prevalence of diabetes and trends over time

In India, the burden of diabetes has been increasing steadily since 1990 and leaps and at a faster pace from the year 2000. Fig. 3 shows the increasing trend in diabetes prevalence in India

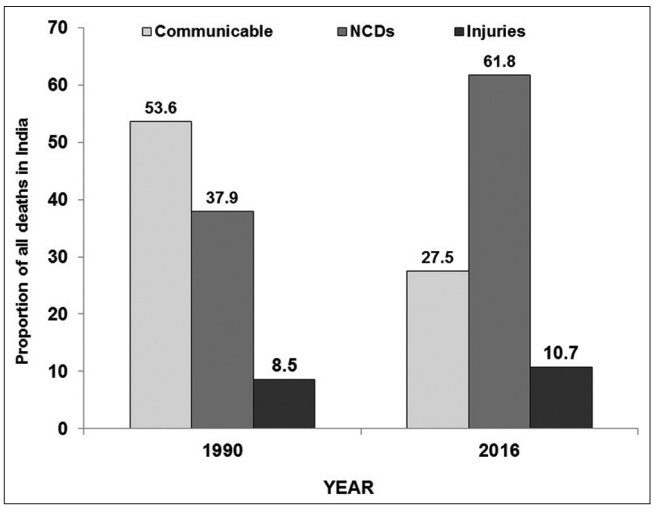

Figure 2: Causes of total deaths in India, 1990 and 2016 (Communicable vs noncommunicable vs injuries) [Ref No: 11]

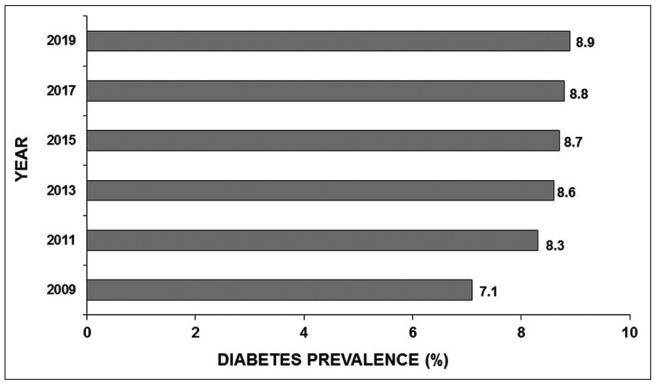

Figure 3: Trends in diabetes prevalence during the past decade in India [Source: Ref 1, 12–16]

during the past decade in India as per IDF.[1,12-16] The prevalence of diabetes in India has risen from 7.1% in 2009 to 8.9% in 2019. Table 1 provides the burden of diabetes in India at a glance. Currently, 25.2 million adults are estimated to have IGT, which is estimated to increase to 35.7 million in the year 2045. India ranks second after China in the global diabetes epidemic with 77 million people with diabetes. Of these, 12.1 million are aged >65 years, which is estimated to increase to 27.5 million in the year 2045. It is also estimated that nearly 57% of adults with diabetes are undiagnosed in India, which is approximately 43.9 million. The mean healthcare expenditure on diabetes per person is 92 US dollars, and total deaths attributable directly to diabetes account for 1 million.

The report on the state-level disease burden in India stated that the percent change in diabetes prevalence among all ages in India from 1990 to 2016 was 64.3%, while the age-standardized prevalence was 29.3%.[11] The India State-Level Disease Burden Initiative Diabetes study collaborators[17] reported that the prevalence and number of people with diabetes in India increased from 5.5% and 26.0 million in 1990 to 7.7% and 65.0 million in the year 2016. According to this report, Tamil Nadu had the highest prevalence in 2016, followed by Kerala, Delhi, Punjab, Goa, and Karnataka.

Diabetes is becoming more prevalent in India, based on the data obtained from cross-sectional surveys conducted in various parts of the country.[18] The first study was conducted in Mumbai in 1963 among 18,243 individuals, and the prevalence of diabetes was found to be 1.5% based on urine analysis.[19] There have been a few national studies on the prevalence of diabetes. The national prevalence of diabetes was reported to be 2.1% in the multicenter ICMR survey conducted between 1972 and 1975 in Ahmedabad, Calcutta, Cuttack, Delhi, Poona, and Trivandrum, as well as neighboring rural areas.[20] In 2001, the National Urban Diabetes Survey conducted in India's six major cities reported an age-standardized prevalence of 12.1%,[21] while the Prevalence of Diabetes in India Study, conducted in 40 urban and 37 small towns and rural areas across India in 2004, found that the prevalence of diabetes to be 5.9 and 2.7%, respectively.[22] The WHO-ICMR NCD Risk Factor Surveillance Study, conducted between 2003 and 2005 in urban and rural areas of six different states, reported a 4.5% prevalence of self-reported diabetes.[23]

In the Indian Council of Medical Research–India DIABetes study, the largest nationally representative epidemiological survey conducted in India on diabetes and prediabetes, the data from 15 states/UT of the country [Table 2] showed that the prevalence of diabetes ranged from 3.5 to 8.7% in rural to 5.8 to 15.5% in urban areas and the prevalence varied from 4.3% in Bihar to 13.6% in Chandigarh.[24,25] The prevalence of diabetes was higher in urban areas (11.2%) compared to rural areas (5.2%). The prevalence of prediabetes ranged from 5.8 to 14.7% in rural to 7.2 to 16.2% in urban areas. The prevalence of prediabetes exceeded that of diabetes in most states. This indicates the presence of a large number of individuals who may develop type 2 diabetes in the near future. There is also evidence that Asian Indians progress more rapidly through the prediabetes stage as compared to people of other ethnic groups.[25,26] The prevalence of diabetes was higher among states with higher per capita GDP and among individuals belonging to the higher SES. This study demonstrates that there is clear evidence of an epidemiological transition, with a higher prevalence of diabetes in low socioeconomic status of urban areas in more economically developed states.[25]

Table 1: Burden of diabetes/prediabetes in India (Ref No. 1)

	YEAR	
	2019	2045
Impaired glucose tolerance (estimates) [20-79 years]		
Number of people (million)	25.2	35.7
Rank	4	3
Diabetes (estimates) [20-79 years]		
Prevalence (%)	8.9	-
Age adjusted prevalence (%)	10.4	-
Number of people (million)	77.0	134.2
Rank	2	2
Diabetes (estimates) [>65 years]		
Number of people (million)	12.1	27.5
Rank	3	2
Undiagnosed diabetes (estimates)		
Prevalence (%)	57.0	-
Number of people (million)	43.9	-
Rank	2	
Healthcare expenditure on diabetes		
Mean expenditure per person with diabetes (USD)	92.0	-
Deaths related to diabetes		
Total deaths (million)	1.0	-

*USD - US dollars; Source IDF Diabetes Atlas 2019 (Ref No: 1)

The National Family Health Survey, four survey[27] conducted in 15 Indian states/union territories during the year 2014–2015, reported that Andaman and Nicobar Islands had the highest prevalence of diabetes (26 and 14.5% among men and women, respectively), while Haryana had the lowest prevalence of diabetes (8.2%) for men and Bihar (6.1%) for women. The prevalence was higher in urban than in rural areas. The recent Secular Trends in Diabetes in India study which assessed the change in diabetes prevalence between 2006 and 2016 in urban and rural areas of Tamil Nadu reported that the prevalence of diabetes increased from 18.6% in 2006 to 21.9 in 2016 in the city, while in the smaller towns, it increased from 16.4 to 20.3, and in the periurban villages, from 9.2 to 13.4, respectively.[28]

Table 2: Weighted prevalence of diabetes and prediabetes in 15 states/Union territory of India - the ICMR INDIAB Study [Ref Nos: 24,25]

States/UT	Prevalence of diabetes (%)			Prevalence of prediabetes (%)		
	Urban	Rural	Overall	Urban	Rural	Overall
Andhra Pradesh	12.6	6.3	8.4	11.1	9.6	10.1
Arunachal Pradesh	5.8	4.9	5.10	14.2	12.3	12.8
Assam	12.4	4.4	5.5	13.6	11.6	11.9
Bihar	10.5	3.5	4.3	15.5	9.3	10.0
Chandigarh	14.2	8.3	13.6	14.5	14.7	14.6
Gujarat	9.5	5.1	7.1	8.4	11.5	10.2
Jharkhand	13.5	3.0	5.3	10.7	7.4	8.1
Karnataka	11.1	5.6	7.7	14.1	10.2	11.7
Maharashtra	10.9	6.5	8.4	15.2	11.1	12.8
Manipur	7.1	4.4	5.1	7.2	7.5	7.5
Meghalaya	8.9	3.5	4.5	7.4	10.6	10.0
Mizoram	7.9	3.6	5.8	6.2	5.8	6.0
Punjab	12.0	8.7	10.0	8.6	7.9	8.2
Tamil Nadu	13.7	7.8	10.4	9.8	7.1	8.3
Tripura	15.5	7.2	9.4	16.2	14.2	14.7

Data from the population-based representative Center for Cardio-metabolic Risk Reduction in South Asia (CARRS) Study reports that 6 out of 10 adults in South Asian cities have either diabetes or prediabetes.[29] In Chennai, 22.8%, and in Delhi, 25.2% of the population was estimated to have diabetes. This study also reported a diabetes prevalence of 16.3% in Karachi, Pakistan, which is lower than the two cities in India. In the CARRS cohort, the lifetime diabetes risk for 20-year-old men was 55.5% compared to 64.6% for women and was high among obese women (86.0%) and men (86.9%). With increasing age (at age 60 years), the lifetime risk of diabetes decreased to 37.7% for women and 27.5% for men.[30] Recent studies contradict previous findings that migrant Indians had higher prevalence rates of type 2 diabetes than their counterparts in India. The prevalence of type 2 diabetes was reported to be higher in Asian Indians living in Chennai (38%) compared to those residing in San Francisco and Chicago, US (24%).[31] These findings highlight the fact that India's current rapid economic and nutritional transitions increase the risk of type 2 diabetes, and that the "diabetogenic" environment in India is now as bad, if not worse, as in the United States.

Incidence of diabetes

Apart to from the rising prevalence of diabetes in India, the incidence of diabetes are also rising steadily, with a fast transition from euglycemia to prediabetes and diabetes. In India, very few longitudinal studies have been conducted to assess the incidence of diabetes and prediabetes. In the Chennai Urban Population Study cohort, diabetes and prediabetes incidence rates were reported to be 20.2 and 13.1 per 1000 person-years, respectively,[32] while the follow-up study conducted in the Chennai Urban Rural Epidemiology Study (CURES) cohort reported the incidence rates of diabetes, prediabetes, and any dysglycemia to be 22.2, 29.5, and 51.7 per 1000 person-years, respectively.[33] The conversion rate to diabetes was reported to be 19.4% among those with normal glucose tolerance and 58.9% among those with prediabetes. Diabetes incidence was reported to be 78.9 per 1000 person-years among those with prediabetes.[33]

In Kerala, participants of the Study of Life Style Diseases in Central Kerala were followed up over a 10-year period from two semiurban wards of Venmony Panchayat of Alappuzha district. The incidence rate of type 2 diabetes and impaired fasting glucose (IFG) were 24.5 per 1000 person-years and 45.01 per 1000 person-years, respectively. During the follow-up period, nearly 60% of participants with baseline IFG converted to type 2 diabetes.[34]

In another follow-up study conducted in rural areas of Puducherry, the incidence rate of diabetes was reported to be 21.5 per 1,000 person-years. The incidence rate doubled among males (28.7 per 1000 person-years) compared with females (14.6 per 1000 person-years).[35]

Morbidity and mortality

Diabetes is well known for its systemic impact on a wide range of diabetes-related complications, including macrovascular and microvascular complications and death among the most feared outcomes. In addition, recently diabetes is also being linked to nontraditional complications such as mental health, cancer, disability, and liver disease.[36] Diabetic retinopathy is recognized as the most specific complication of diabetes and has been used to guide diabetes diagnostic thresholds. The prevalence of diabetic retinopathy has been estimated to be 17.6% among adults with diabetes in urban South India.[37] Spectrum of eye disorders in diabetes in India report, pan-India facility-based study, concluded that diabetic retinopathy was prevalent in one-third and sight-threatening diabetic retinopathy in one-fifth of people with type 2 diabetes presenting at 14 eye-care facilities.[38] The CURES study conducted in urban Southern India reported lower prevalences of retinopathy, nephropathy, neuropathy, and peripheral vascular disease and higher prevalence of coronary artery disease (CAD) compared to those reported for Western populations.[37,39-42] Data from rural areas indicate that the burden of complications is comparable, if not higher, in rural areas of South India than in urban areas.[43] The relatively high

prevalence of diabetic complications in developing economies like India could be due to delay in diagnosis of diabetes as well as complications, coexisting illness, inadequate health care systems, and high drug cost, particularly insulin leading to poor control of diabetes.

Diabetes, along with its complications, is a leading cause of mortality. The South East Asian region has the second highest number of deaths attributable to diabetes in adults among the IDF Regions, with 1.2 million deaths in 2019, with India contributing the lion's share with more than 1 million estimated deaths accountable to diabetes and related complications.[1] The Prospective Urban Rural Epidemiology study which compared CV events, all-cause mortality, and CV mortality rates among 143,567 adults with and without diabetes in 21 countries including India with different income levels reported that CVD rates, all-cause mortality, and CV mortality were markedly higher among those with diabetes in low-income countries compared with middle- and high-income countries.[44] The India State-Level Disease Burden Initiative Diabetes study reported that diabetes contributed to 3.1% of all deaths in India, with an increase in death rates due to diabetes from 1990 to 2016 by 131%.[17]

There are as yet no large-scale Indian studies on mortality in patients with type 2 diabetes, and most available studies are from clinical settings and therefore have shown different results. In a retrospective study from Srinagar[45] of 234,776 inpatient admissions, 16,690 died, of whom 4.4% had diabetes. Of the top five causes of death, infections were reported by 41%, chronic renal failure by 33.6%, CAD by 16.9%, cerebrovascular disease by 13.2%, and chronic obstructive pulmonary disease by 6.9%. A follow-up of the CURES cohort reported overall mortality rate to be nearly 4-fold higher in people with diabetes compared to those without diabetes (27.9 per 1000 person-years vs. 8.0 per 1000 person-years). The study also illustrated that ischemic heart disease and diabetes had the highest population-attributable risk for all-cause mortality in the entire study cohort.[46]

Risk Factors

The etiology of diabetes is believed to be multifactorial. Many individual-level nonmodifiable risk factors like genetic, age, ethnicity, and family history have been prospectively associated with type 2 diabetes, but the increases in prevalence in most populations have probably been driven by a modifiable risk factors including sedentary lifestyle and/or lack of exercise, increasing prevalence of overweight/obesity, unhealthy diets (increased intake of refined grains, fat, sugar, and sweetened beverages and decreased intake of fruits and vegetables) and habits (smoking and alcohol abuse), exposure to environmental pollutants, altered intrauterine environment and mental health (stress/depression), short sleep duration, and the built environment [Fig. 4].

According to the India state-level disease burden report,[47] in 1990, a tenth of the total disease burden in India was caused by a cluster of risk factors that included unhealthy diet, being overweight/obese, high blood pressure, blood sugar, and cholesterol, all of which contributed to ischemic heart disease, stroke, and diabetes, which increased to a quarter of the total disease burden in India in 2016. Tobacco use, which was accountable for 6% of the total disease burden in India in 2016, is another significant contributor to CVD and diabetes, as well as cancer and some other diseases.[47] The Global Burden of Disease Study 2016, reported obesity, low-dietary intake of fruits, nuts and seeds, and whole grains, and tobacco use to be the most important risk factors for DALYs and deaths due to diabetes.[48]

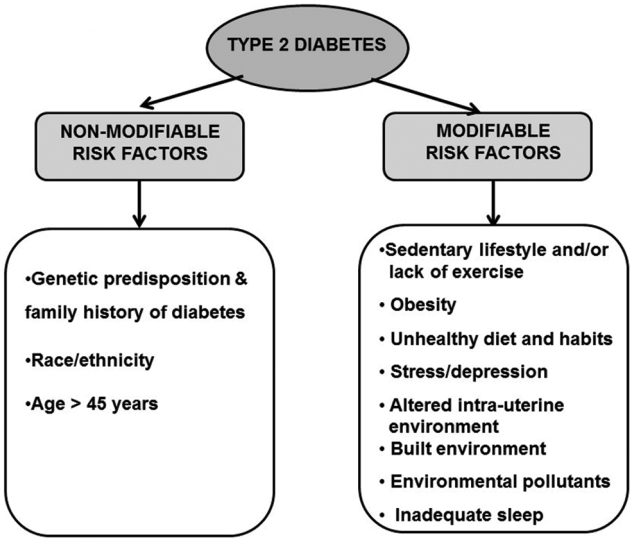

Figure 4: Risk factors for type 2 diabetes

Strategies to Tackle the Epidemic of Diabetes in India

The rising rates of prediabetes, diabetes, and associated complications in urban as well as in rural areas and among the young in India are of great concern. Addressing health issues related to diabetes in India, which is the second-most populous country and has a large and diverse population, poses many challenges. The specific challenges in diabetes prevention/management are (i) lack of strong national partnerships for multisectoral actions, (ii) lack of availability of robust surveillance and research data on diabetes, (iii) abysmally low disease awareness among the public, (iv) lack of access to basic prevention/management of diabetes in the primary health care setting, which includes access to affordable medicines leading to premature deaths, (v) disproportionate fund allocation for diabetes programs, (vi) difficulties in engaging the industry and private sector, (vii) limited human resources, and (viii) inadequate community mobilization and weak coordination among civil societies and between the civil societies and government agencies for diabetes.

Tackling diabetes calls for a fundamental change, from addressing each risk factor separately to collectively addressing a cluster of risk factors in an integrated manner, and from using a biomedical approach to a public health approach. Thus, when planning prevention/control programs, a multifaceted approach is essential for success. Diabetes prevention/control strategies include (i) reduction in exposure to lifestyle risk factors through health promotion and primary prevention, (ii) early detection and timely treatment, and (iii) surveillance to monitor trends in diabetes and associated risk factors. High levels of commitment and multisectoral actions are needed to reduce the growing burden of diabetes in India. Some of the

policies that may help to slow down the epidemic of diabetes in India include (i) national food policies targeting availability and accessibility of healthy and nutritious foods, ensuring that the food industry strictly complies with norms of food safety and standards and supporting production and distribution of healthy foods (whole grains, fruit, vegetables, legumes, and nuts), (ii) health policies to reduce harmful behaviors such as smoking, alcohol misuse, use of trans fat, and consumption of junk foods and increase physical activity by the creation of amenities such as public spaces (e.g., parks) for walking, cycling, etc., (iii) prevention policies such as health information and communication to improve population awareness, and (iv) policies to reduce the cost of essential drugs and ensuring reasonable access to care. All these efforts need a healthy collaboration between health, information, education, and agriculture ministries to create awareness and to facilitate a healthy lifestyle among the Indian population.

Conclusion

Diabetes has already become a leading threat to public health globally and the picture becomes grimmer for the low- and middle-income countries like India, where the burden has risen significantly in recent decades and will continue to rise in the coming decades. This could have a great influence on morbidity and mortality associated with diabetes and, thus, on the overall healthcare expenditure in India. To curb the epidemic of diabetes and its associated complications, there is a need for a multipronged strategy involving early diagnosis of diabetes, screening for its complications, and offering optimal therapy at all levels of care for those who already have diabetes and primary prevention of diabetes in those with prediabetes.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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