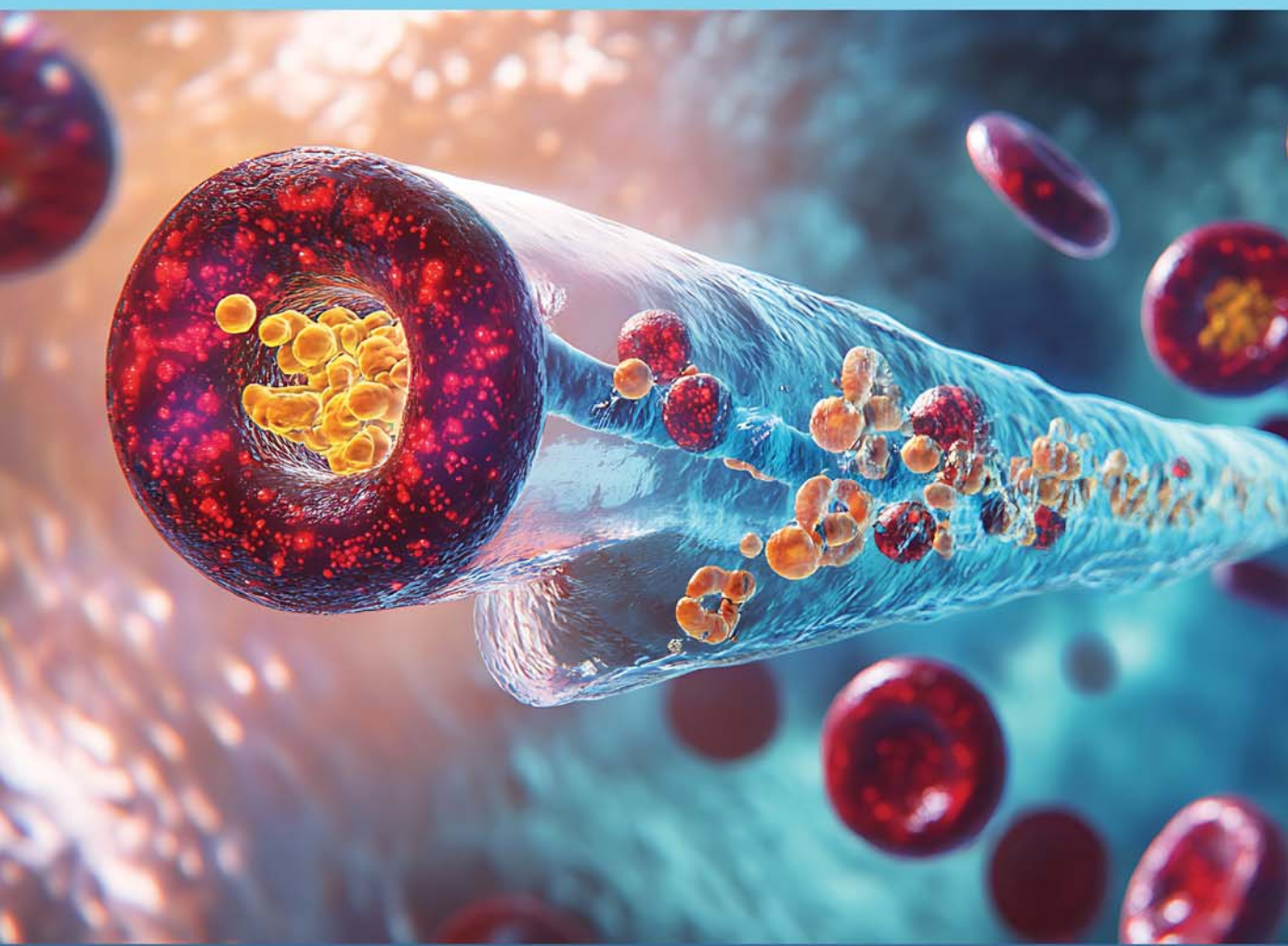
Progress in Diabetes



Editor-in-Chief
Anuj Maheshwari

Executive Editor
Shambo Samrat Samajdar

JAYPEE

CONTENTS

1. **The Global Diabetes Landscape in 2025: Epidemiology and Burden** 1
   Anuj Maheshwari, Shambo Samrat Samajdar

2. **Genetics and Epigenetics of Diabetes: Emerging Insights** 9
   Praveen Gangadhara, Shambo Samrat Samajdar

3. **Immunotherapy in Type 1 Diabetes: Toward Disease Modification** 15
   Banshi Saboo, Rutul Gokalani

4. **Emerging Biomarkers for Early Detection of Diabetes** 25
   Ajoy K Tewari, Veneeta Tewari, Jay Tewari

5. **Beta-cell Replacement and Regeneration: Progress Toward a Cure** 34
   Jayshree Swain, Shivangi Maheshwari, Sidharth Shankar Panigrahi

6. **Innovative Pharmacotherapy** 42
   Part A: Sodium-glucose Cotransporter-2 Inhibitors *42*
   Manoj Chawla, Purvi Chawla
   Part B: GLP-1 Receptor Mono-agonists and GLP-1/GIP Dual Agonist *47*
   Awadhesh Kumar Singh, Akriti Singh

7. **Precision Medicine in Diabetes Care: Tailoring Treatment to Individuals** 57
   Krishna G Seshadri

8. **Achieving Type 2 Diabetes Remission—Weight Loss and Metabolic Surgery** 64
   Shashank R Joshi, Shambo Samrat Samajdar

9. **Artificial Intelligence-driven Diabetes Care: Predictive Analytics and Personalized Interventions** 76
   Amit Kumar Dey, Avneesh Khare

10. **Continuous Glucose Monitoring and Wearable Tech for Diabetes** 86
    Purvi Chawla, Supratik Bhattacharya

11. Closed-loop Insulin Delivery Systems: Toward an Artificial Pancreas **93**
Bharat Saboo, Shubhashree Patil

12. Telemedicine and Digital Health in Diabetes Management **98**
Anil Kumar Virmani, Vinayak Hiremath

13. Public Health Strategies for Diabetes Prevention **104**
Ranjit Mohan Anjana, Akshay Subramanian A, Viswanathan Mohan

14. Global Initiatives and Policies in Diabetes Care **113**
Amit Gupta, Sanjay Agarwal, Soumyaranjan Mohanty

15. Addressing Diabetes Disparities: Toward Health Equity **126**
Anuj Maheshwari, Shambo Samrat Samajdar

16. Cardiovascular Complications: Reducing Heart Disease Risk in Diabetes **135**
Ayush Agarwal, Sujoy Ghosh

17. Diabetic Kidney Disease: Advances in Prevention and Treatment **148**
TEO Boon Wee Jimmy

18. Diabetic Retinopathy and Neuropathy: Protecting Vision and Nerve Health **155**
Vijay Viswanathan, Reshma Mirshad

19. Psychosocial Support and Mental Health in Diabetes Care **164**
NK Singh, M Shunmugavelu

20. Lifestyle Interventions: Nutrition and Exercise in Diabetes Care **172**
Vanisha S Nambiar, Shonima Venugopal, Sabat Imran Ansari

21. Landmark Randomized Controlled Trials in Diabetes: Evidence and Implications **180**
Hemant P Thacker, Shambo Samrat Samajdar, Anuj Maheshwari

22. Emerging Therapeutics: New Molecules and the Pipeline **193**
Aravinda J, Bijay Patni

23. Diabetes in Special Populations (Pediatric, Elderly, and Gestational) **204**
N Bhavatharini, Sunil S Gupta, VK Sanjeev, ARA Changanidi

24. Microbiome and Gut Health in Diabetes **214**
Dhruvi Hasnani, Vipul Chavda

25. Artificial Intelligence and Big Data in Diabetes Research **225**
Alok Modi, Shambo Samrat Samajdar

26. Diabetes and Cancer Risk **237**
Jayanta Kumar Panda, Narsingh Verma

27. Diabetes Remission: Strategies, Evidence, and Long-term Outcomes **248**
Krishnadev Jothydev, Mohamed Abdul Khader M, Jothydev Kesavadev

28. Diabetes Mellitus and Sports Medicine **268**
Kenjom Ngomdir, Abhinav Verma

29. Obesity Management in Diabetes Mellitus Care: Integrative Approaches **280**
Neeta Deshpande, Brij Mohan Makker

Index **291**

13

Public Health Strategies for Diabetes Prevention

Ranjit Mohan Anjana, Akshay Subramanian A, Viswanathan Mohan

ABSTRACT

The International Diabetes Federation (IDF) estimates that there are 589 million people living with diabetes worldwide as of 2024, and this number is expected to increase to 853 million by the year 2050. As diabetes is associated with considerable morbidity and mortality as well as costs to the individual and society, it is imperative to employ effective public health strategies at population level to counter the increasing prevalence of diabetes. Individuals at risk of diabetes progress from normoglycemia through stages of intermediate hyperglycemia (prediabetes) before they develop frank diabetes, providing a window of opportunity for primary prevention. It has now been unequivocally shown that lifestyle modification, with or without medication, can delay or prevent the progression from prediabetes to diabetes. However, translating these findings into real life is challenging and requires reorientation of health policy as well as intersectoral coordination between various stakeholders. Several such initiatives have been launched at the National and State level in India, holding out promise for diabetes prevention at the population level.

Keywords: Public, Strategies, Diabetes, Prevention.

INTRODUCTION

Diabetes is a silent chronic noncommunicable disease (NCD) that occurs either when the pancreas does not produce enough insulin or when the body cannot effectively use the insulin it produces. Uncontrolled diabetes is characterized by chronic hyperglycemia that can, over time, lead to serious damage to various organs and culminate in severe morbidity or even mortality.

MAGNITUDE OF THE PROBLEM

The International Diabetes Federation (IDF) estimates that there are 589 million people living with diabetes worldwide as of 2024, and this number is expected to increase to 853 million by the year 2050. The prevalence is particularly high and is increasing rapidly in low- and middle-income countries compared to high-income countries.[1]

In India, the large, nationally representative—Indian Council of Medical Research-India Diabetes (ICMR-INDIAB) study—showed that there were 101 million individuals with diabetes, much higher than the previously reported figures.[2]

NEED FOR PREVENTING DIABETES

Diabetes and its complications are a leading cause of morbidity and mortality worldwide. The IDF Diabetes Atlas[1] estimates 3.4 million

annual deaths from diabetes complications worldwide as of 2024. Individuals with diabetes have higher all-cause mortality and mortality due to cardiovascular disease (CVD), cancer, chronic lower respiratory diseases, cerebrovascular disease, and kidney disease.[3] Further morbidity occurs due to limb amputations and vision loss following proliferative diabetic retinopathy, diabetic cataract, or glaucoma.

Globally, the average annual medical expenditure for people with diabetes is around $19,736, with about $12,022 attributed to diabetes itself.[4] Costs increase with complications, with patients with greater number of complications incurring higher expenses. The costs for insulin and medications as well as inpatient care necessitated by the presence of serious complications, represents a serious financial drain on individuals in countries like India, where medical expenses need to be borne out of pocket.

NATURAL HISTORY OF DIABETES

The natural history of diabetes is characterized by gradual progression from normal glucose tolerance through a stage of intermediate hyperglycemia or prediabetes [defined as impaired glucose tolerance (IGT) or impaired fasting glucose (IFG)], then to clinical diabetes and finally to the stage of complications. Prediabetes is that stage in an individual where the blood glucose level is higher than the normal but not high enough to be diagnosed as diabetes.

Individuals with fasting glucose between 100 and 125 mg/dL are considered to have IFG while those with 2-hour post-load blood glucose (during an oral glucose tolerance test) between 140 and 199 mg/dL are considered to have IGT. IFG and IGT can occur in isolation, or together (combined IFG and IGT). With the increasing use of glycated hemoglobin (HbA1c) for diagnosis of diabetes, individuals with HbA1c between 5.7 and 6.4% are considered to be "at risk of diabetes", yet another phenotype of prediabetes.

The progression from prediabetes to type 2 diabetes (T2D) is not inevitable and does not occur at the same rate in all populations, occurring at high levels in populations such as Pima Indians and Asian Indians.[5] There is now sufficient evidence to show that pharmacological and nonpharmacological interventions can prevent or slow the progression of prediabetes to diabetes. Many of these interventions can also reduce cardiovascular risk in individuals with prediabetes. Therefore, there is an urgent need to identify individuals with prediabetes so that prompt preventive measures can be implemented in them. However, most people with prediabetes are asymptomatic and can only be identified by screening. The need for screening is particularly high in populations with high prevalence of T2D, such as Asian Indians. **Figure 1** depicts the stages of prevention of diabetes.

In general, there are four levels of prevention for any disease: Primordial prevention, primary prevention, secondary prevention, and tertiary prevention.

The prevention of emergence of the risk factors for a disease is called primordial prevention. When the risk factors are already present in an individual, the measures taken to prevent the individual from developing the disease are called primary prevention. Once the disease has developed in a person, early and prompt diagnosis with adequate treatment will help in preventing or delaying the complications. This is called secondary prevention. When the patient has ended up with complications of the disease, providing proper rehabilitation and disability limitation to ensure quality of life becomes a priority. This is tertiary prevention. Preventing individuals with prediabetes from developing T2D is an example of primary prevention. **Figure 2** shows the complexity of diabetogenic factors.

EVIDENCES FOR TYPE 2 DIABETES PREVENTION

Da Qing Study

The Da Qing study conducted in China[6] attempted to demonstrate feasibility of prevention of T2D.

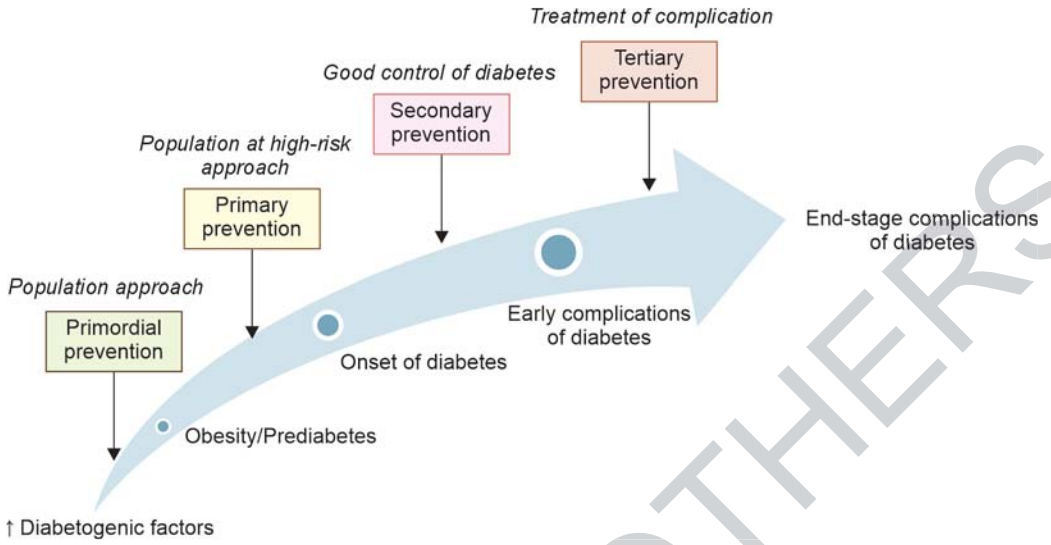


Fig. 1: Stages of diabetes prevention.

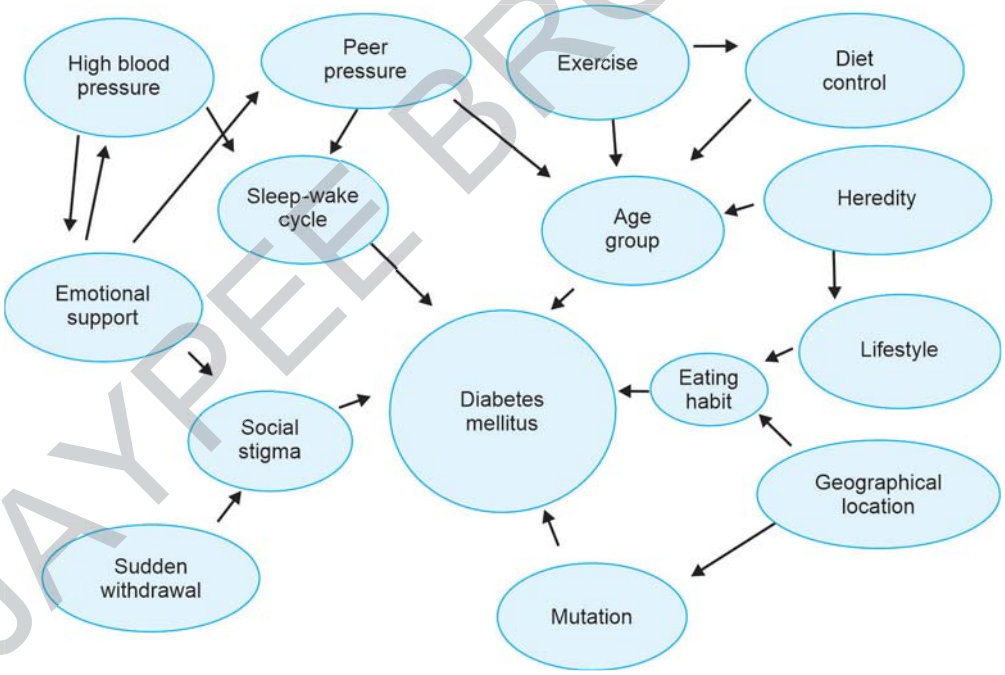


Fig. 2: Multifactorial causation of diabetes.

This was a cluster randomized trial in which 577 adults with IGT attending 33 clinics were randomly assigned to four groups: Control, diet, exercise, and diet plus exercise for 6 years. At the end of the study period, individuals randomized to diet, exercise and diet, and exercise had a

lower risk of developing diabetes by 31.5, 46, and 42% compared to those assigned to control. Subsequently, participants were followed to assess the long-term effects of intervention on the incidence of diabetes, CVD events, composite microvascular complications, CVD death, all-cause mortality, and life expectancy. At the end of the 30 years of follow-up, the combined intervention group had a median delay of about 3.96 years for T2D onset, fewer cardiovascular events and deaths, and lesser incidence of microvascular complications.

Finnish Diabetes Prevention Study

In the Finnish DPS,[7] 522 individuals with IGT were randomized to intervention group (individualized counseling aimed at reducing weight, total intake of fat, and intake of saturated fat and increasing intake of fiber and physical activity) or control group and followed up for a mean duration of 3.2 years. At the end of follow-up, individuals randomized to the intervention group had a 58% lower risk of diabetes compared to the control group. These benefits were maintained at the 7-year follow-up, with 43% risk reduction in progression to T2D compared to nonintervention.

Diabetes Prevention Program

The United States (US) Diabetes Prevention Program (DPP)[8] was a large randomized controlled trial evaluating the effects of lifestyle intervention or metformin on modifying the risk of T2D in individuals at high risk. The DPP enrolled 3,234 individuals with prediabetes and assigned them to one of three groups: Placebo, lifestyle intervention, and metformin. After a mean follow-up of 2.8 years, individuals randomized to lifestyle modification had a 58% lower, and those randomized to metformin, 31% lower risk of developing T2D as compared to those assigned to placebo. The long-term follow-up of the DPP, the DPP-Outcomes Study (DPP-OS) showed that the benefits of lifestyle intervention and metformin were maintained for up to 15 years, albeit attenuated (27% risk reduction in the lifestyle group and 18% in the metformin group).

Indian Diabetes Prevention Program

This prospective community-based study analyzed if progression to diabetes can be influenced by interventions among Asian Indians with IGT. Study participants (n = 531) were randomized into four different groups—(1) control, (2) lifestyle modification, (3) metformin, and (4) lifestyle modification plus metformin. The study concluded[9] that combination of lifestyle intervention along with metformin was associated with the greatest risk reduction for T2D (relative risk reduction of 28.2%).

Diabetes-community Lifestyle Intervention Program

This study[10] tested the effectiveness, cost-effectiveness, and acceptability of a stepwise model of diabetes prevention with lifestyle modifications as a continuous intervention in the targeted group, and metformin added only when needed (stepwise addition of 500 mg metformin twice a day to those who were at highest risk of conversion to T2D after 4 months or more of follow-up). Participants with prediabetes (IGT, IFG, or both IFG and IGT) (n = 578) were randomly assigned into intervention and control groups. While those in the control group received only the standard of care, the intervention was put to rigorous lifestyle modification with 16 weekly classes and an additional 8 weeks of maintenance classes. At the end of the 3-year follow-up period, only 25.7% of those among the intervention group progressed to T2D compared with 34.9% of those in the control group. This program also provided clues for the sustainability of these lifestyle modification programs, as it utilized the services of lay "diabetes ambassadors" who helped in training and motivating participants.

ARE WE TREATING EARLY OR PREVENTING?

Several randomized trials (including some of those listed above) have made use of medications to prevent the development of T2D, in addition to lifestyle modifications, with varying results. These medications include the antidiabetic drugs metformin, acarbose, rosiglitazone, and nateglinide and the renin–angiotensin–aldosterone system blockers, ramipril and valsartan. While some of the newer antidiabetic agents (such as the glucagon-like peptide 1 receptor agonists and glucagon-like peptide–glucose-dependent insulinotropic peptide dual receptor agonists) have been shown to reduce the incidence of diabetes, these findings have emerged predominantly from weight loss trials and not from formal diabetes prevention trials. The use of antidiabetic drugs to prevent diabetes raises an important question: In the name of preventing T2D, are we merely initiating pharmacotherapy for hyperglycemia earlier? Also, none of the drugs mentioned above are approved for prevention of diabetes, although some national diabetes associations do provide guidance supporting this indication. The case is often made that popping a daily pill is easier and more convenient for the individual than undertaking the significant lifestyle modifications that have been shown to be necessary to prevent diabetes. Such an argument fails to take into consideration, issues regarding the sustainability, cost-effectiveness, and long-term safety of pharmacotherapy, with particular reference to the newer agents. Lifestyle modification, on the other hand, has benefits not only in preventing diabetes but also other metabolic conditions such as hypertension, dyslipidemia, and obesity. As will be seen below, there is now evidence that less stringent lifestyle modifications than those trialled in randomized prevention programs might suffice to prevent diabetes at the population level. Therefore, for most individuals with prediabetes, lifestyle change should be the initial intervention of choice.

TRANSLATING RESULTS OF CLINICAL TRIALS INTO PRACTICE: WHAT IS THE EVIDENCE?

As discussed earlier, bringing into practice intensive lifestyle modification interventions (such as those described in the trials above) in large populations is largely impractical. It requires logistics, trained human resources and the need for societal adjustments coupled with health system strengthening. However, some population-based interventions in advanced countries provide hope that this can indeed be achieved.

United Kingdom National Health Service Diabetes Prevention Program

The United Kingdom National Health Service Diabetes Prevention Program (UK NHS DPP) aims to integrate diabetes prevention into routine health care. It offers individuals with prediabetes and others at high risk with 9–12 months of behavioral modification intervention sessions for adopting a healthier lifestyle, aiming at weight reduction and counseling to improve physical activity and to develop habits of healthier eating. Participants who signed up to the program had significant reductions in HbA1c, body mass index (BMI), body weight, triglycerides and increased high-density lipoprotein (HDL)-cholesterol with a nonsignificant reduction in systolic blood pressure.[11] These sessions are based on the NICE guidelines and participants are referred by general practitioners. This program has been shown to be cost-effective and represents a major advance toward diabetes prevention being employed at a population level.

National Diabetes Prevention Program

The National Diabetes Prevention Program (National DPP) has been implemented since 2012 by the Centers for Disease Control (CDC) in the US. It focuses on structured lifestyle interventions targeting weight loss and increased physical activity. It has demonstrated significant

success in reducing diabetes incidence among adults with prediabetes. In one study from the University of Michigan,[12] enrollees had lower odds of developing T2D (40% lower at 1 year and 20% lower at 2 years) compared to nonenrollees. Overall, the National DPP has demonstrated that a structured lifestyle intervention program can effectively lower T2D risk at the population level and can be cost-effective.

However, both these population-based programs have been conducted in developed countries. Whether similar programs can be successfully planned and implemented in resource-constrained settings is yet to be determined.

EVIDENCE FROM INDIA; SMALL CHANGES CAN LEAD TO BIG BENEFITS!

Dietary Changes

Hippocrates has rightly said "Let food be thy medicine and medicine be thy food". What he meant to emphasize was the profound correlation between what we eat and its impact on health. Diet is not just about calories (quantity of food) but also about the quality of the food. A good curated medical nutrition therapy will largely help in achieving and maintaining the required weight of the individual for age, thereby also helping in improving insulin sensitivity and reducing risk of T2D. A healthy diet is characterized by a balanced intake of both macronutrients and micronutrients. Various dietary approaches to treating and preventing diabetes employ drastic changes in the composition of the diet, such as total removal of carbohydrates or avoidance of all processed foods. Such diets, although effective, are not sustainable and their long-term safety has also been called into question.

Data from ICMR - INDIAB study suggest[13] that even minimal modification of dietary macronutrient intake can help to prevent diabetes in those with prediabetes, or even lead to remission of diabetes in those who have newly developed the disorder. For instance, it has been shown that reducing the carbohydrate content of the diet to 50–56% total daily energy intake and increasing protein intake to 18–20% can help individuals with prediabetes return to normal glucose tolerance. Similarly, a carbohydrate content of 54–57% and protein,16–20% was shown to prevent progression of prediabetes to T2D. These dietary intakes do not represent a major deviation from the typical Asian Indian diet and should therefore be easy for individuals to adopt and follow over the long term.

Physical Activity

Physical activity levels have declined worldwide on account of urbanization, automation of occupations, and availability of motorized transport. In developed countries, part of this decline has been compensated by increases in leisure-time physical activity (LTPA). However, in developing countries such as India, levels of LTPA are abysmally low[14] rendering the population at high risk of developing metabolic diseases such as obesity and T2D. Low levels of physical activity also make diabetes prevention challenging.

Many reasons have been given for the low levels of LTPA in India. In addition to lack of awareness, these include lack of time, lack of places to exercise, unfavorable weather, and safety concerns. These issues are particularly relevant among women and girls, in whom societal norms pose an additional barrier to exercising. In order to improve physical activity levels among women and girls and thereby reduce their risk of diabetes and other metabolic disorders, a novel high-intensity interval training (HIIT) dance routine called THANDAV has recently been introduced.[15] THANDAV is a 10-minute HIIT routine consisting of four loops including a 2 minutes high [80–90% of maximum heart rate (HR)] and a 30 seconds low (50–60% of maximum HR). The movements are choreographed in a simple and repetitive manner so that they can be done in a loop without much stress. THANDAV has been shown to favorably

impact parameters such as step count, skeletal muscle mass, fat mass, blood pressure, sleep, and stress levels in adolescent girls and may represent an easily scalable, culturally acceptable approach to diabetes prevention in this population.

ROLE OF PUBLIC HEALTH POLICY

The current global pandemic of T2D is a direct consequence of the obesogenic environment that exists today in most parts of the world. While the ultimate responsibility for health lies on the individual, the role of other stakeholders such as local and national governments cannot be forgotten.

Global Initiatives to Improve Metabolic Health

Taking cognizance of the burgeoning epidemic of NCDs, the World Health Organization (WHO) proposed a Global Action Plan on Physical Activity (GAPA)[16] in 2018. This plan aims at reducing physical inactivity by 15% by the year 2030. The strategies under this plan include creating active societies by mass awareness campaigns, developing active environments by providing safe parts and cycling paths, promoting active people by community-based programs and building active systems via policy support and workforce training.

The WHO's Global Strategy on Diet, Physical Activity and Health,[17] unveiled in 2004, urges governments to implement policies to promote healthy diets (low in sugar, salt, and fat and high in fiber), increase physical activity in daily routines and in schools, and support public education and food labeling reforms.

Initiatives in the Indian Context

There is much that health policy can do to slow down the spread of diabetes in developing countries like India. The explosive increase in T2D in India mainly occurred following the liberalization and globalization policies adopted by the government in the early 1990s. These policies, doubtless, contributed to the prosperity of the nation, but brought other problems in their wake. Higher levels of disposable income led to increased discretionary expenditure on items such as junk foods and high-calorie, low nutritional value foods that suddenly became available consequent to opening up of the economy. Parallelly, there was a shift away from labor-intensive occupations and nonmotorized transport, reducing levels of physical activity in the occupational and transport domains. All these have led to burgeoning obesity rates and rising prevalence of T2D.

While one cannot argue in favor of a return to the conditions of 1950s or 1960s, there needs to be a clearsighted policy on improving the metabolic health of the population so that India's gains in healthcare over the last 75 years are not compromised by a tsunami of NCDs. In recent years, the Government of India has prioritized NCD prevention and management in its national health policies. The National Multi-sectoral Action Plan (NMAP)[18] for NCDs was launched in 2017 to promote lifestyle modification as a core strategy for NCD prevention. This plan encourages intersectoral collaboration between health, education, urban planning, and agriculture to tackle the growing epidemic of NCDs in India.

- *Policy on diet:* Awareness needs to be created on healthy eating. In a country where, until recently, the main issue was not having enough to eat, the new paradigm of overnutrition demands out-of-the-box solutions. Enforcing food labeling (and training consumers to read them) and instituting sugar and fat taxes (as has already been done by several states) will motivate adoption of healthier diets. Of course, healthier foods need to be made more easily available, accessible, and affordable. In this context, Government needs to rethink the easy availability of refined cereals through the public distribution system and consider providing healthier options such as pulses, legumes and vegetables through the system, so that the

less well-off can also eat healthy. Awareness on healthy diets should be inculcated from childhood. In this context, the recent initiative by the Central Board of Secondary Education (CBSE) to promote healthy eating in schools, in particular by cutting down sugar intake, is timely and welcome. Healthier meals can also be provided through the "mid-day meal scheme" operational in many states of India. The "Eat Right India" movement,[19] led by the Food Safety and Standards Authority of India (FSSAI), focuses on reducing trans fat, sugar, and salt in the diet, promoting fortified foods, and nutrition labeling and public awareness.

- Encouraging physical activity from a young age is essential to prevent the development of prediabetes and T2D. With the enormous industrialization and overcrowding prevalent in a populous country like India, sometimes finding the right space for exercise becomes challenging. The government again needs to allocate more resources and infrastructure into finding large spaces for physical activity, such as public parks. Emphasis should be laid on improving the built environment[20] by promoting walkable and bicycle-friendly cities. Schools should be required to allocate sufficient time for physical activity. Initiatives such as THANDAV can be adopted to bring physical activity within the reach of individuals who would otherwise be excluded. The Fit India Movement[21] launched in 2019, is a national campaign to encourage citizens to adopt physically active lifestyles. This is being implemented in schools, workplaces, and communities.
- In spite of all the above efforts, some individuals in the population will develop prediabetes. The objective in these cases should be to identify them at the earliest possible stages such that they can adopt intensive lifestyle changes and delay or prevent T2D. As prediabetes is a silent condition, it can only be picked up by screening using a blood test. At the population level, it is impractical to screen all adults; it would be more cost-effective to identify individuals at high risk using validated tools such as the Indian Diabetes Risk Score (IDRS), and direct screening and prevention efforts to them. Screening for diabetes and prediabetes should be incorporated into primary care across India.

CONCLUSION

In conclusion, delaying/preventing the onset of T2D in India can be achieved by lifestyle intervention with or without medication in individuals found to have prediabetes. This can be integrated into primary healthcare across the country. However, arresting the diabetes epidemic in India ultimately demands correction of the obesogenic environment in the country. This can only be achieved by multisectoral coordination including the health, transport, food, and education sectors.

REFERENCES

1. International Diabetes Federation. (2025). IDF Diabetes Atlas 2025. [online] Available from https://diabetesatlas.org/resources/idf-diabetes-atlas-2025/ [Last accessed September, 2025].
2. Anjana RM, Unnikrishnan R, Deepa M, Pradeepa R, Tandon N, Das AK, et al. Metabolic non-communicable disease health report of India: the ICMR-INDIAB national cross-sectional study (ICMR-INDIAB-17). Lancet Diabetes Endocrinol. 2023;11(7):474-89.
3. Li S, Wang J, Zhang B, Li X, Liu Y. Diabetes Mellitus and Cause–Specific Mortality: A Population–Based Study. Diabetes & Metabolism Journal 2019;43(3):319.
4. Bommer C, Sagalova V, Heesemann E, Manne-Goehler J, Atun R, Bärnighausen T, et al. Global Economic Burden of Diabetes in Adults: Projections From 2015 to 2030. Diabetes Care. 2018;41(5):963-70.
5. Anjana RM, Shanthi Rani CS, Deepa M, Pradeepa R, Sudha V, Divya Nair H, et al. Incidence of Diabetes and Prediabetes and Predictors of Progression Among Asian Indians: 10-Year Follow-up of the Chennai Urban Rural Epidemiology Study (CURES). Diabetes Care. 2015;38(8):1441-8.
6. 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;20(4):537-44.
7. 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;344(18):1343-50.
8. Crandall JP, Dabelea D, Knowler WC, Nathan DM, Temprosa M; DPP Research Group. The Diabetes Prevention Program and Its Outcomes Study: NIDDK's Journey Into the Prevention of Type 2 Diabetes and Its Public Health Impact. Diabetes Care. 2025;48(7):1101-11.
9. Ramachandran A, Snehalatha C, Mary S, Mukesh B, Bhaskar AD, Vijay V. 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;49(2):289-97.
10. 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.
11. Ravindrarajah R, Sutton M, Reeves D, Cotterill S, Mcmanus E, Meacock R, et al. Referral to the NHS Diabetes Prevention Programme and conversion from nondiabetic hyperglycaemia to type 2 diabetes mellitus in England: A matched cohort analysis. PLoS Med. 2023;20(2):e1004177.
12. Herman WH, Villatoro C, Joiner KL, McEwen LN. Retention and outcomes of National Diabetes Prevention Program enrollees and non-enrollees with prediabetes: The University of Michigan experience. J Diabetes Complications. 2023;37(8):108527.
13. Anjana RM, Srinivasan S, Sudha V, Joshi SR, Saboo B, Tandon N, et al. Macronutrient Recommendations for Remission and Prevention of Diabetes in Asian Indians Based on a Data-Driven Optimization Model: The ICMR-INDIAB National Study. Diabetes Care. 2022:dc220627.
14. Strain T, Flaxman S, Guthold R, Semenova E, Cowan M, Riley LM, et al. National, regional, and global trends in insufficient physical activity among adults from 2000 to 2022: a pooled analysis of 507 population-based surveys with 5·7 million participants. Lancet Glob Health. 2024;12(8):e1232-e1243. Erratum in: Lancet Glob Health. 2025;13(2):e202.
15. Anjana RM, Nitika S, Jagannathan N, Vinothini D, Yuvarani K, Mohan V, et al. A Novel High-Intensity Short Interval Dance Intervention (THANDAV) for Non-Communicable Disease Prevention Tailored to Asian Indian Adolescent Girls. J Diabetes Sci Technol. 2025;19(4):1035-50.
16. WHO. (2018). Let's be active, the global action plan on physical activity 2018-2030. [online] Available from www.who.int. or https://www.who.int/initiatives/gappa [Last accessed September, 2025].
17. WHO. (2004). Global Strategy on Diet, Physical Activity and Health. [online] Available from www.who.int. or https://www.who.int/publications/i/item/9241592222 [Last accessed September, 2025].
18. Ministry of Health & Family Welfare, Government of India. (2023). Operational Guidelines: National Programme for Prevention and Control of Non-Communicable Diseases (2023-2030). [online] Available from Mohfw.gov.in or https://www.mohfw.gov.in/sites/default/files/NP-NCD%20Operational%20Guidelines_0.pdf [Last accessed September, 2025].
19. Food Safety and Standards Authority of India (FSSAI). Eat Right India. [online] Available from https://eatrightindia.gov.in/ [Last accessed September, 2025].
20. Aarthi GR, Begum TSM, Moosawi SA, Kusuma D, Ranjani H, Pradeepa R, et al. Associations of the built environment with type 2 diabetes in Asia: a systematic review. BMJ Open. 2023;13(4):e065431.
21. FIT India Movement: Ministry of Education (MoE) Activities [Internet]. Education.gov.in. 2024. Available from https://dsel.education.gov.in/en/fit-india. [Last accessed September, 2025].

Progress in Diabetes

Salient Features

- *Global and genetic outlook:* Future trends in diabetes burden, global epidemiology and risk factors, genetics and epigenetics evolution, type 1 diabetes immunotherapy, emerging early detection biomarkers
- *Therapeutic innovations:* Beta-cell regeneration advancements, new drug classes: SGLT2-I, GLP-1, dual agonists, precision medicine in diabetes care, pharmacotherapy tailoring and trials, surgery and weight-loss for remission
- *Technology-driven care:* AI in prediction and treatment planning, wearables and continuous glucose monitoring, closed-loop insulin delivery systems, telemedicine for remote management, big data powering diabetes research
- *Holistic management approach:* Addressing mental health and support, cardiovascular and kidney complication care, retinopathy and neuropathy prevention, lifestyle modification via diet and exercise, diabetes in special populations addressed
- *Policy, equity, and research frontiers:* Public health and prevention strategies, global policies for improved care access, tackling disparities in diabetes outcomes, landmark RCTs and their implications, exploring cancer, microbiome, and sports links
- Future-focused global and genetic insights
- Innovative therapies and drug advancements
- AI-powered, tech-integrated diabetes care
- Holistic, complication-aware management
- Policy, prevention, and equity-driven strategies

Anuj Maheshwari MD FICP FIACM FIMSA FRSSDI FACP(USA) FACE(USA) FRCP(London, Edinburgh) is a senior physician, academician, and global thought leader in diabetes and hypertension. He is the President of RSSDI (2025–2026), President of the Asian Pacific Society of Hypertension and Vice President of Asian Heart Society. With over 110 scientific publications and 112 conference presentations, he has been recognized with prestigious orations and awards, including by the World Hypertension League and American College of Physicians. He is a Professor of Medicine at Hind Institute of Medical Sciences, Lucknow, Uttar Pradesh, India and Adjunct Professor at KMC, Manipal. A dedicated educator for 20+ years, he continues to inspire future generations through clinical excellence and research innovation.

Shambo Samrat Samajdar MD DM(Clinical Pharmacology) PG Diploma in Endocrinology and Diabetes(RCP) Diploma in Allergy Asthma and Immunology Fellowship in Respiratory and Critical Care(WBUHS) Fellow Diabetes India is a consultant physician and clinical pharmacologist with a focus on diabetes, allergy, and respiratory medicine. A prolific academic, he has authored over 148 indexed publications and contributed more than 80 book chapters. He is the author/editor of several landmark texts, including Artificial Intelligence for Physicians and Diabetes in Practice. He serves as faculty at JMN Medical College and Hospital, Nadia, West Bengal, and holds leadership roles in IPS, Association of Clinical Pharmacologists (ACP), API (WB), FERCI, and PRF-WB. Honored with multiple national and international awards, Dr Samajdar represents the next generation of clinician-researchers with a deep commitment to translational medicine.

Shelving Recommendations
DIABETES & ENDOCRINOLOGY

ISBN 978-93-7202-499-9