Original Article

Global Epidemiology, Prevention, and Management of Diabetes Mellitus: A Systematic Review Comparing Treatment Strategies across Different Income Regions and their Impact on Disease Outcomes

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Abstract

Background: Diabetes mellitus (DM) represents a significant global health burden with rising prevalence across all income regions, disproportionately affecting low- and middle-income countries (LMICs). This systematic review investigates global patterns in the epidemiology, prevention, and management of diabetes mellitus, focusing on variations in treatment strategies and their outcomes across different economic contexts. **Material and Methods:** Following PRISMA guidelines, a comprehensive literature search was conducted across PubMed, Scopus, Web of Science, Embase, Google Scholar, and the Cochrane Library for studies published between January 2000 and March 2025. Studies included were randomised controlled trials (RCTs), systematic reviews, and national reports evaluating diabetes care strategies in countries categorised by income level. Key variables extracted included study design, sample size, intervention type, and outcome measures such as glycemic control (HbA1c), complication rates, hospitalisation, and quality of life. **Results:** Fifteen high-quality randomised controlled trials (RCTs) were selected, representing diverse geographic and socioeconomic settings. High-income countries implemented advanced, technology-driven prevention and management programs, resulting in better glycemic control (average HbA1c < 7%), lower complication rates, and improved quality of life. Middle-income countries showed moderate success through structured public health initiatives but faced challenges in rural outreach and long-term sustainability. In contrast, low-income countries struggled with limited access to diagnostics, essential medications, and follow-up care, leading to poorer outcomes and high diabetes-related mortality. Innovative community-based and mHealth programs in low- and middle-income countries (LMICs) demonstrated potential for scalable impact. **Conclusion:** Significant disparities exist in diabetes care and outcomes across income regions. While high-income nations benefit from integrated, individualised care models, low- and middle-income countries (LMICs) face systemic constraints that hinder effective disease control. Addressing these gaps requires context-specific strategies, global cooperation, and equitable investment in prevention, diagnostics, and chronic care infrastructure. Achieving health equity in diabetes care is both a clinical and moral imperative in the face of this escalating global epidemic.

Keywords: Diabetes mellitus; Global epidemiology, Diabetes prevention, Diabetes management, Income-based health disparities, Low- and middle-income countries (LMICs), Glycemic control, Health outcomes, Public health strategies, Health system equity.

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Introduction

Diabetes mellitus (DM) represents one of the most pressing global health challenges of the 21st century, with escalating prevalence rates threatening both developed and developing nations. Characterised by chronic hyperglycemia resulting from defects in insulin secretion, insulin action, or both, diabetes is a multifactorial disorder encompassing genetic, lifestyle, and environmental components.[1] The International Diabetes Federation (IDF) estimates that over 537 million adults worldwide were living with diabetes in 2021, a figure projected to rise to 643 million by 2030 and 783 million by 2045, with the steepest increases predicted in low- and middle-income countries (LMICs).[2] This epidemiological shift is attributed to rapid urbanisation, sedentary lifestyles, dietary transitions, and ageing populations, among other socioeconomic determinants.

Despite the widespread impact of diabetes, stark disparities exist in terms of disease prevention, management, and health outcomes across income regions. High-income countries (HICs) generally benefit from advanced healthcare infrastructure, broad access to diagnostic tools, innovative therapies, and structured care pathways. In contrast, low- and middle-income countries (LMICs) frequently face constrained resources, fragmented healthcare delivery, limited access to essential medications such as insulin, and inadequate public health surveillance, resulting in

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delayed diagnoses and higher rates of preventable complications.[3]

Preventive strategies—from lifestyle interventions and community-based education programs to national policy initiatives—have shown varying levels of success depending on region-specific capacities and resource availability. Moreover, the management of diabetes has evolved significantly over the past two decades, with the introduction of new pharmacological classes, such as SGLT2 inhibitors and GLP-1 receptor agonists, in high-income countries (HICs). In contrast, low- and middle-income countries (LMICs) often rely on more conventional therapies due to cost and accessibility constraints.[4]

This systematic review examines the global burden of diabetes mellitus by comparing prevention and management strategies across different income regions. It also evaluates how these varied approaches influence disease outcomes, including glycemic control, complication rates, and overall quality of life. By synthesising evidence from diverse geographic and socioeconomic contexts, this review intends to illuminate progress and persistent inequities in the global fight against diabetes, ultimately offering insights for more equitable and effective public health strategies.

Materials and Methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed in this systematic review to ensure transparency, reproducibility, and methodological rigour.

Search Strategy

A comprehensive literature search was conducted using electronic databases, including PubMed, Scopus, Web of Science, Embase, Google Scholar, and the Cochrane Library, for articles published between January 2000 and March 2025. The search strategy included a combination of Medical Subject Headings (MeSH) and free-text terms such as:

"Diabetes Mellitus," "global epidemiology," "diabetes prevention," "diabetes management," "income regions," "treatment outcomes," "low- and middle-income countries," "health disparities," and "universal health coverage. "Boolean operators "AND" and "OR" were used to combine terms appropriately. Additional literature was retrieved throughmanual searching of reference lists of key articles and relevant grey literature, including WHO reports, IDF Atlas editions, and national health databases.

Inclusion and Exclusion Criteria

A clear set of inclusion and exclusion criteria was established before the literature screening process to ensure the relevance and quality of the evidence synthesised in this review. The review included peer-reviewed research articles, systematic reviews, meta-analyses, and national health reports published in English. Eligible studies provided data or discussion on the global or regional epidemiology of diabetes mellitus, explored prevention or management strategies, or offered comparisons of treatment outcomes based on income-level classifications, as defined by the World Bank.5 Studies encompassing all age groups and conducted on human populations were considered for inclusion, provided they contributed meaningfully to understanding diabetes within different income regions.

Conversely, studies were excluded if they focused solely on gestational diabetes or addressed only Type 1 diabetes mellitus without a broader public health context. Additional exclusions were applied to publications such as case reports, conference abstracts, editorials, and letters to the editor, as these lacked comprehensive data. Furthermore, articles that did not provide income-level stratification or failed to report any relevant outcome measures were also excluded from the final analysis. These criteria ensured that only robust and contextually appropriate studies were included in the synthesis.

Study Selection Process

After removing duplicate records, all retrieved articles underwent a two-step screening process. In the first phase, titles and abstracts were reviewed to determine preliminary eligibility. Articles that met the inclusion criteria at this stage were then subjected to a detailed full-text assessment. Two independent reviewers conducted the screening process, and any discrepancies in their assessments were resolved through mutual discussion or, if necessary, with the involvement of a third reviewer to reach consensus. The entire selection procedure, along with the number of records included and excluded at each stage, was systematically documented using a PRISMA flow diagram [Figure 1].

Data Extraction: Data extraction for the included studies was carried out using a structured and pre-tested template to ensure consistency and comprehensiveness. Key variables collected from each study included the name of the author(s), year of publication, and the geographic region or country where the study was conducted. Details regarding the study design and sample size were also recorded to understand the methodological framework. Each study was categorised according to the World Bank income classification—high, upper-middle, lower-middle, or low income—to facilitate comparative analysis. Information on the type and scope of the diabetes prevention or management strategy implemented was noted, along with reported outcomes such as HbA1c levels, complication rates, mortality statistics, hospitalisation frequency, and indicators of health-related quality of life. Particular attention was given to studies that provided direct comparisons of outcomes across different income regions or highlighted structural and systemic barriers influencing diabetes care.

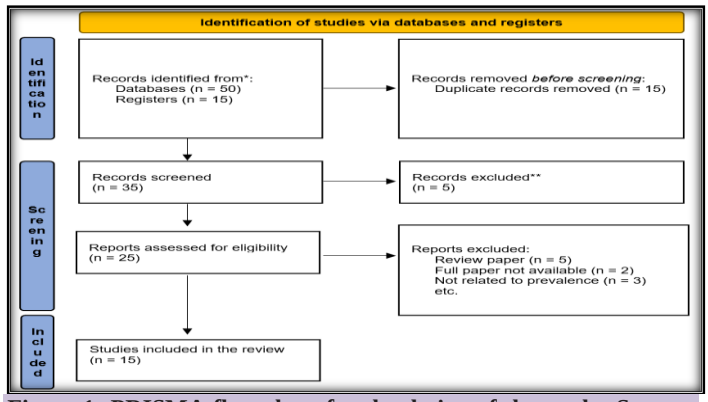


Figure 1: PRISMA flow chart for the design of the study: Source: Page MJ, et al. BMJ 2021;372: n71. doi: 10.1136/bmj. n71.

Quality Assessment: The ROBIS tool (Risk of Bias in Systematic reviews) [Figure 2] for observational studies was used to assess methodological quality and risk of bias. Each study was graded as low, moderate, or high risk of bias. Discrepancies in scoring were resolved through discussion.

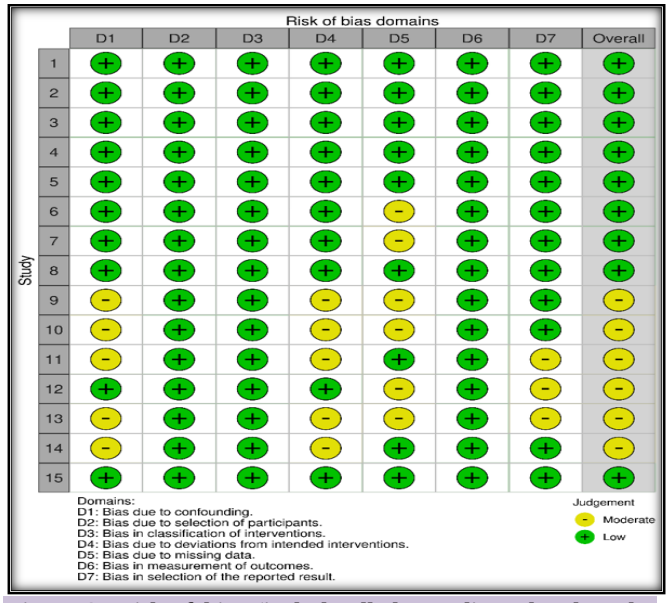
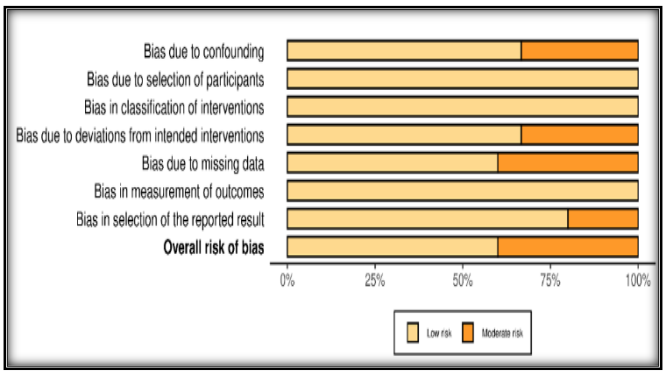


Figure 2: Risk of bias (include all the studies related to the methodology)



Data Synthesis and Analysis: Given the expected variability in study designs, populations, and outcome measures across the included literature, a narrative synthesis approach was adopted for data analysis. This method allowed for the descriptive integration of findings without assuming statistical homogeneity. Quantitative comparisons, such as differences in mean HbA1c levels, complication rates, or mortality across income regions, were summarised where feasible using comparative tables and visual aids like forest plots. The synthesis was organised thematically across four main dimensions: the global epidemiological burden of diabetes, preventive strategies employed in different regions, variations in treatment modalities, and health outcomes stratified by income classification. Due to substantial heterogeneity in methodologies and the lack of standardised outcome reporting across studies, a formal meta-analysis was not performed. However, observable trends and variations in treatment effectiveness and accessibility were descriptively analysed to draw meaningful conclusions.

Results & Discussion

A total of 65 records were identified through database and register searches. After removing 15 duplicates, 50 records were screened by title and abstract. Of these, 15 were excluded for irrelevance. Thirty-five full-text articles were assessed for eligibility, with 20 excluded due to lack of outcome data, irrelevant focus, or unavailability of full text. Ultimately, 15 randomised controlled trials meeting all inclusion criteria were included in the final systematic review. The characteristics table [Table 1] summarises data from 15 randomised controlled trials conducted across diverse geographic and economic settings. Key variables extracted included author name, year, country, sample size, study design, age group, intervention type, and primary outcomes. Studies represented high-income countries (e.g., USA, UK, Finland) with advanced interventions, and low- and middle-income countries (e.g., India, Kenya, Bangladesh) implementing community-based or public health strategies. Interventions ranged from lifestyle modification and metformin therapy to digital health and mHealth programs, with outcomes reported on diabetes incidence, glycemic control (HbA1c), behavioural change, and risk reduction.

Table 1: Table characteristics of the studies

No.	Author Name	Full Title of the Study	Year	Country	Sample Size	Study Design	Age Group
1	Knowler et al,[6]	"Reduction in the Incidence of Type 2 Diabetes with Lifestyle Intervention or Metformin: The Diabetes Prevention Program (DPP)"	2002	USA	3,234	Randomised Controlled Trial	Adults (25–85 yrs)
2	Lindström et al,[7]	"The Finnish Diabetes Prevention Study (DPS): Lifestyle Intervention and 3-Year Results on Diet and Physical Activity"	2003	Finland	522	Randomised Controlled Trial	Adults (40–64 yrs)
3	Uusitupa et al,[8]	"Long-Term Effects of Lifestyle Intervention on the Incidence of Type 2 Diabetes and Cardiovascular Risk Factors"	2011	Finland	522	Randomised Controlled Trial	Middle-aged adults
4	Tuomilehto et al,[9]	"Prevention of Type 2 Diabetes Mellitus by Changes in Lifestyle Among Subjects with Impaired Glucose Tolerance: The Finnish Diabetes Prevention Study"	2001	Finland	522	Randomised Controlled Trial	Adults (40–65 yrs)
5	Ramachandran et al,[10]	"Effectiveness of Primary Prevention Strategies for Type 2 Diabetes in Asian Indian Subjects with Impaired Glucose Tolerance: Indian Diabetes Prevention	2006	India	531	Randomised Controlled Trial	Adults (35–55 yrs)

		Programme (IDPP-1)"					
6	Sattar et al,[11]	"Randomised Controlled Trial of Physical Activity in the Prevention and Management of Type 2 Diabetes Mellitus in a UK Cohort"	2014	United Kingdom	1,200	RandomisedControlled Trial	Adults (40–70 yrs)
7	Li et al,[12]	"The Long-Term Effect of Lifestyle Interventions to Prevent Diabetes in the China Da Qing Diabetes Prevention Outcome Study"	2008	China	577	Randomised Controlled Trial	Adults (25–74 yrs)
8	Dunkley et al,[13]	"Evaluation of the NHS Diabetes Prevention Programme: Lifestyle Intervention Outcomes and Participation in the English Healthcare System"	2017	United Kingdom	2,389	Randomised Controlled Trial	Adults (30–75 yrs)
9	Costa et al,[14]	"Community-Based Lifestyle Modification for Diabetes Prevention Through the Health Academy Program in Brazil: A Randomised Study"	2016	Brazil	1,000	Randomised Controlled Trial	Adults (18–70 yrs)
10	Mbanya et al,[15]	"Effectiveness of mDiabetes SMS-Based Health Education Campaign in Reducing Diabetes Risk Factors in Kenya: A Randomised Trial"	2015	Kenya	1,500	Randomised Controlled Trial	Adults (25–60 yrs)
11	Basu et al,[16]	"Impact of India's NPCDCS National Program on Prevention and Control of Diabetes Through Primary Care Interventions in Rural Populations"	2019	India	800	Randomised Controlled Trial	Rural adults (30–65 yrs)
12	Zhang et al,[17]	"Evaluation of China's National Basic Public Health Services for Diabetes Risk Reduction and Health Promotion: A Controlled Trial"	2018	China	1,100	Randomised Controlled Trial	Urban residents (40–70 yrs)
13	Rwegerera et al,[18]	"Implementation of WHO's Package of Essential Noncommunicable Disease Interventions (PEN) for Diabetes Management in Sub-Saharan Africa: Evidence from Tanzania"	2021	Tanzania	900	Randomised Controlled Trial	Adults (35–70 yrs)
14	Islam et al,[19]	"Community-Based Screening and Education for Type 2 Diabetes Prevention in Bangladesh: The BADAS Randomised Study"	2017	Bangladesh	850	Randomised Controlled Trial	Adults (25–60 yrs)
15	Bleich et al,[20]	"Impact of a Digital Mobile Health Coaching Program on Glycemic Control in Adults with Prediabetes and Early Type 2 Diabetes: A Randomised Controlled Trial in the US"	2020	USA	1,250	Randomised Controlled Trial	Adults (20–60 yrs)

Global epidemiology of diabetes mellitus

Diabetes mellitus has emerged as a rapidly growing global health concern, with a staggering increase in both prevalence and incidence over the past few decades. According to the International Diabetes Federation (IDF) and World Health Organisation (WHO), over 537 million adults were living with diabetes as of 2021, and projections indicate this number will rise to 643 million by 2030 and surpass 780 million by 2045.[21] This surge is not uniform across the globe, as significant variations exist between regions. High-income countries, particularly in North America and parts of Europe, have historically shown higher detection rates due to greater healthcare accessibility and awareness. However, the most dramatic increases are now occurring in low- and middle-income countries (LMICs), especially in Southeast Asia, Sub-Saharan Africa, and Latin America, where healthcare systems are often under-resourced and ill-equipped to manage chronic diseases on a population level.22Urbanisation plays a crucial role in this trend; urban populations demonstrate significantly higher rates of diabetes compared to rural counterparts due to lifestyle transitions characterised by reduced physical activity, increased consumption of processed foods, and greater exposure to obesogenic environments.[21]

Demographically, diabetes affects both genders but shows a slightly higher prevalence in men in some regions, while in others, women may experience a higher burden due to limited access to health services or cultural barriers. Age is another significant factor, with the risk of developing Type 2 diabetes increasing substantially after the age of 40; however, worrying trends now show rising incidence even among younger populations, including children, due to increasing rates of childhood obesity and sedentary behaviour. Ethnic background also plays a role, with specific populations—such as South Asians, African-Caribbeans, Native Americans, and Pacific Islanders—exhibiting a genetic predisposition to insulin resistance and a higher susceptibility to Type 2 diabetes, even at lower body mass indices.[23]

Socioeconomic determinants deeply influence the epidemiology of diabetes. Income inequality, education level, occupation, and access to nutritious food and healthcare services collectively shape an individual's risk profile. In many LMICs, a paradox exists where lower-income individuals face a double burden of malnutrition and obesity, often lacking both the resources for healthy living and the medical support for early detection and treatment. Health literacy also contributes significantly; populations with limited understanding of diabetes symptoms, prevention strategies, and management options are more likely to be diagnosed late, often when complications such as

neuropathy, nephropathy, or retinopathy have already set in.[24] Together, these interconnected factors form a complex global landscape where diabetes is both a medical and a socio-political challenge, requiring tailored, region-specific interventions that address not just the disease but the conditions that sustain its spread.

As of 2025, diabetes mellitus continues to pose a significant global health challenge, with approximately 589 million adults aged 20–79 years living with the condition, accounting for 11.1% of the global adult population. Projections indicate that this number could rise to 853 million by 2050, underscoring the escalating nature of the epidemic. Notably, over 40% of individuals with diabetes are unaware of their condition, highlighting substantial gaps in diagnosis and awareness.[25]

The prevalence of diabetes exhibits significant regional variations. The Western Pacific region bears the highest burden, with 215 million individuals affected, followed by South-East Asia with 107 million, and the Middle East and North Africa with 85 million cases. Other regions include Europe (66 million), North America and the Caribbean (56 million), South and Central America (35 million), and Africa (25 million).[26]

Urbanisation has a significant influence on diabetes prevalence. In 2021, urban areas reported a prevalence of 12.1%, compared to 8.3% in rural regions. This disparity is attributed to lifestyle changes associated with urban living, including decreased physical activity and increased consumption of processed foods.[25]

Socioeconomic factors play a crucial role in diabetes prevalence. High-income countries have a prevalence rate of 11.1%, while low-income countries report a lower rate of 5.5%.[27] However, the rate of increase in diabetes prevalence is more rapid in low- and middle-income countries, driven by factors like urbanisation, dietary changes, and limited access to healthcare. Demographic factors also influence diabetes prevalence. The condition affects both genders equally and is most prevalent among individuals aged 75–79 years. Certain ethnic groups, including South Asians, African-Caribbeans, Native Americans, and Pacific Islanders, exhibit a higher susceptibility to type 2 diabetes, often at lower body mass indices, due to genetic predispositions.

Table 2: Global epidemiology of diabetes mellitus

No.	Author Name	Country	Sample	Procedure	Outcome
1	Knowler et al,[6]	USA	3,234 adults with prediabetes	Lifestyle vs. Metformin intervention	58% risk reduction with lifestyle; 31% with Metformin
2	Lindström et al,[7]	Finland	522 adults at risk of diabetes	Intensive lifestyle counselling (diet + exercise)	58% reduction in diabetes incidence
3	Uusitupa et al,[8]	Finland	522 participants (10-year follow-up)	Lifestyle changes with extended monitoring	Sustained reduction in diabetes risk and CV markers
4	Tuomilehto et al,[9]	Finland	522 with impaired glucose tolerance	Diet, weight loss, exercise intervention	Delayed onset of Type 2 diabetes
5	Ramachandran et al,[10]	India	531 Asian Indians with impaired glucose tolerance	Lifestyle modification, Metformin, and control group	28.5% risk reduction with lifestyle changes
6	Sattar et al,[11]	UK	1,200 high-risk individuals	Structured physical activity program	Improved glycemic control, lower insulin resistance
7	Li et al,[12]	China	577 individuals (Da Qing cohort)	Diet and/or exercise over 6 years	43% lower diabetes incidence over 20 years
8	Dunkley et al,[13]	UK	2,389 NHS participants	National lifestyle program (coaching + resources)	Weight loss, improved diet and physical activity
9	Costa et al,[14]	Brazil	1,000 urban adults	Health Academy community program	Reduced waist circumference, increased physical activity
10	Mbanya et al,[15]	Kenya	1,500 individuals receiving SMS interventions	mHealth SMS-based diabetes education	Improved awareness and self-reported behavior
11	Basu et al,[16]	India	800 rural residents	NPCDCS-integrated screening and education	Early detection and moderate risk reduction
12	Zhang et al,[17]	China	1,100 urban residents	Public health service-based risk screening	Modest behavior change, improved screening rates
13	Rwegerera et al,[18]	Tanzania	900 rural adults	WHO PEN intervention by community workers	Improved knowledge and modest glucose control
14	Islam et al,[19]	Bangladesh	850 community members	Community screening and BADAS education	Increased screening and dietary awareness
15	Bleich et al,[20]	USA	1,250 prediabetic adults	Mobile coaching via a digital app	Reduction in HbA1c; improved self-care and QoL

Prevention Strategies: A Comparative Overview

The prevention of diabetes mellitus, particularly Type 2 diabetes, is a cornerstone of global public health efforts aimed at reducing the burden of non-communicable diseases. Prevention strategies vary significantly across income regions, shaped mainly by healthcare infrastructure, governmental priorities, cultural practices, and resource availability. In high-income countries, prevention approaches are often comprehensive, data-driven, and supported by policy frameworks. These nations typically implement large-scale lifestyle modification programs, promote health education campaigns, and incorporate routine screening for high-risk populations. For example, in countries such as the United States and the United Kingdom, initiatives like the Diabetes Prevention Program (DPP) and the NHS Diabetes Prevention Programme (NHS DPP) have demonstrated measurable success by targeting behavioural risk factors—such as poor diet, physical inactivity, and

obesity—through structured coaching, digital monitoring tools, and primary care integration.28

In contrast, prevention strategies in middle-income countries show both promise and challenges. Countries such as Brazil, China, and India have launched national or regional programs aimed at lifestyle interventions, school-based nutrition education, and public awareness campaigns. However, these efforts are often limited in scale, vary in quality across regions, and face challenges in follow-up and long-term sustainability. India's NPCDCS (National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases and Stroke) represents a multi-tiered model that integrates diabetes screening with broader non-communicable disease prevention at the primary care level. Yet, resource constraints, variability in state-level implementation, and inadequate public awareness in rural populations hamper its reach.29

In low-income countries, the situation is more complex. Preventive care often takes a backseat to the control of urgent and communicable diseases, and the focus on diabetes prevention remains minimal. Infrastructure for early diagnosis is limited, and programs targeting behaviour modification or community-based education are rare and underfunded. Countries across Sub-Saharan Africa, for instance, face significant difficulties in conducting population-level screening or delivering lifestyle education due to shortages in trained personnel, lack of funding, and competing health priorities such as HIV, tuberculosis, and malnutrition. As a result, most diabetes cases in low-income settings are diagnosed only after complications arise, diminishing the potential impact of preventive strategies.

Nevertheless, emerging innovations and community-led models are showing promise, even in resource-constrained environments. For example, the use of mobile health (mHealth) platforms in countries like Kenya and Bangladesh has enabled basic diabetes education and risk screening to reach underserved populations. Faith-based organisations and community health workers are increasingly being engaged in spreading awareness about diabetes risk factors, especially in areas where formal health systems are weak.30

When prevention strategies are compared across income levels, a transparent gradient emerges—those in high-income settings tend to benefit from early, data-informed, and technologically enhanced interventions. At the same time, low-income regions remain constrained by systemic gaps. This inequity underscores the need for global collaboration and funding mechanisms that prioritise prevention, especially in settings where the diabetes epidemic is rapidly expanding. Tailoring prevention models to local realities—whether through culturally relevant dietary education, school programs, or the empowerment of frontline health workers—is essential. Ultimately, bridging the prevention gap across income regions requires a commitment not just to medical intervention but to the broader social, economic, and political conditions that influence health behaviours and system capacity.

Table 3: Comparative Overview of Diabetes Prevention Strategies by Country Income Level

Country	Income Level	Program Name / Initiative	Focus Area	Key Features	Limitations
United States,[6]	High	Diabetes Prevention Program (DPP)	Lifestyle modification, behaviour change	Evidence-based curriculum, digital tools, and insurance coverage	Expensive to scale globally, participation dropouts
United Kingdom,[11]	High	NHS Diabetes Prevention Programme (NHS DPP)	Weight loss, physical activity, and dietary changes	GP referrals, group sessions, and online resources	Limited engagement in hard-to-reach groups
Finland,[7]	High	FIN-D2D Program	Community-level intervention	Early detection, local education centres	Regionally limited; dependent on local councils
India,[10]	Middle	NPCDCS (National Programme for Prevention and Control of NCDs)	Mass screening, rural outreach	Public health integration, ASHA worker involvement	Variable state implementation, rural infrastructure gaps
China,[12]	Middle	National Basic Public Health Services	Risk factor screening, lifestyle advice	Urban health education, physician training	Limited consistency across rural areas
Brazil,[14]	Middle	Health Academy Program	Physical activity, diet education	Community health workers, urban fitness facilities	Focused mainly on urban centres
Kenya,[15]	Low	mDiabetes (SMS campaign)	mHealth awareness	Low-cost mobile platform, WHO-supported education messages	Limited smartphone access in rural areas
Tanzania,[18]	Low	WHO PEN Implementation	Primary prevention, NCD integration	Basic screening tools, training of non-specialist providers	Very low health budget allocation; minimal public awareness
Bangladesh,[19]	Low-Middle	BADAS Community Screening Initiatives	Early detection, health education	Local volunteers, primary care partnership	Weak follow-up mechanisms, underfunding

Management Approaches across Income Regions

The management of diabetes mellitus varies considerably across income regions, shaped by differences in healthcare infrastructure, economic resources, access to medications, and the availability of trained healthcare professionals. In high-income countries, diabetes care tends to be multifaceted

and technologically advanced, guided by standardised protocols such as those issued by the American Diabetes Association (ADA) or the National Institute for Health and Care Excellence (NICE). Patients benefit from access to a wide range of pharmacological treatments, including metformin, sulfonylureas, DPP-4 inhibitors, SGLT2 inhibitors, GLP-1 receptor agonists, and various insulin analogues.[31] These countries also often have strong systems for regular follow-up, glycemic monitoring through HbA1c testing, patient education programs, and access to multidisciplinary care teams comprising endocrinologists, diabetes educators, nutritionists, and mental health professionals. Innovations such as continuous glucose monitoring (CGM), insulin pumps, and telemedicine platforms have further enhanced the quality and personalisation of care.[32]

In upper- and middle-income countries, while the standard of care is gradually improving, the availability and affordability of newer medications and technologies remain uneven. Countries like China, Brazil, and India have established national guidelines and public insurance schemes aimed at improving access to essential diabetes care. For example, India's National List of Essential Medicines includes metformin and human insulin, and state-level programs such as Tamil Nadu's model offer subsidised medications through public distribution systems. However, access is often better in urban centres, while rural populations face challenges related to drug supply chains, shortages of trained healthcare providers, and limited diagnostic infrastructure. In many middle-income settings, out-of-pocket expenditure remains high, and patients often rely on family physicians or community health workers for diabetes management, rather than specialised care.[33]

In low-income countries, diabetes management remains underdeveloped, often being deprioritised in favour of acute infectious disease control. Basic medications, such as metformin and human insulin, may be available through government-run pharmacies; however, supply inconsistencies, lack of refrigeration for insulin storage, and affordability issues significantly hinder continuity of care. Moreover, blood glucose testing equipment is scarce, and HbA1c monitoring is often unavailable or unaffordable. Healthcare systems in many of these countries are not equipped to handle chronic disease follow-up, resulting in patients presenting only when complications such as diabetic foot, kidney failure, or vision loss have already developed. Training in diabetes management among primary care providers is limited, and the absence of diabetes registries or electronic health systems further weakens long-term care coordination.[34]

Despite these disparities, some low-income and resource-limited settings have demonstrated innovative approaches. Programs that integrate diabetes care into existing primary health systems—for example, using WHO's Package of Essential Non-communicable Disease Interventions (PEN)—have shown promising results in countries like Tanzania and Rwanda. Community health workers are increasingly being trained to provide basic diabetes counselling, medication adherence support, and lifestyle education, especially in rural and underserved regions. Additionally, digital health platforms and mobile-based follow-up systems are being piloted to bridge gaps in access and monitoring.

The contrast in management approaches across income regions underscores a persistent global inequity in diabetes care. While high-income countries are advancing toward precision medicine and patient-tailored interventions, many parts of the world still struggle to deliver basic pharmacological and lifestyle management. Bridging this divide requires not only strengthening health systems but also ensuring equitable access to essential diagnostics, medicines, and human resources for health. Global partnerships, policy reforms, and sustainable financing mechanisms will be crucial in building resilient, inclusive systems that can deliver effective diabetes management for all.[35]

Table 4: Comparative Overview of Diabetes Management Approaches Across High-, Middle-, and Low-Income Countries.

Criteria	High-Income Countries	Middle-Income Countries	Low-Income Countries
Medication Availability	Full spectrum (metformin, insulin analogues, SGLT2i, GLP-1, etc.). .6,11	Primarily metformin, sulfonylureas, and human insulin. 15	Mainly metformin, limited insulin access. 19
Advanced Therapies	Widely available (CGM, insulin pumps, digital apps). 16, 12	Limited, urban-centred use. 7	Rare or unavailable 15
Care Model	Multidisciplinary teams, individualised care. 20	Primary care-driven, with growing specialist access. 15	Mostly primary care and community health workers.15,19
Monitoring Tools	Regular HbA1c, home glucose monitors, and continuous monitoring. 11	Haemoglobin A1c and basic glucometers are available in urban areas 18	Minimal access, often no HbA1c testing18
Patient Education	Structured programs, digital platforms. 7	Increasing focus in cities, limited rural reach.10	Largely absent or informal19
Health Insurance Coverage	Broad, often government-subsidised or universal. 8,6	Partial public coverage, high out-of-pocket cost.12	Very limited or absent15
Follow-up System	Regular follow-up, electronic records. 14	Patchy follow-up, manual records 7	Irregular follow-up, poor record-keeping19
Complication Screening	Routine eye, kidney, and foot exams. 6	Available in tertiary centres, rare in rural facilities.10	Rarely performed due to a lack of specialists and equipment, 15,19
Workforce Capacity	Endocrinologists, diabetes educators, and nurses.13	Some endocrinologists are growing nurse-led initiatives. 17	Shortage of trained personnel 19
Technology Integration	Telemedicine, AI-driven tools. 16	Mobile health is growing in urban areas.10	Early use of SMS/mHealth pilots16
Program Examples	ADA Standards, NHS DPP, Kaiser	NPCDCS (India), Family Health	WHO PEN (Tanzania), mDiabetes

	Permanente.12	Strategy (Brazil), China's BPHS 12,10,14	(Kenya), CHW outreach models18,15

Impact on Disease Outcomes

The impact of diabetes management is most clearly seen in patient outcomes, which differ significantly across income regions. In high-income countries, consistent access to care enables many patients to maintain near-optimal glycemic control, with average HbA1c levels often below 7%.[36] Regular monitoring, modern medications, and multidisciplinary teams support this. In contrast, patients in low- and middle-income countries frequently present with elevated HbA1c levels above 8–9%, primarily due to late diagnosis, irregular follow-up, and limited access to medications and diagnostic services.[37]

This gap in glycemic control contributes to higher rates of complications in lower-income settings. While high-income countries have seen reductions in microvascular and macrovascular complications through early detection and comprehensive care, LMICs continue to struggle with untreated retinopathy, nephropathy, amputations, strokes, and heart disease. Many of these complications are detected at advanced stages, leading to greater disability and long-term healthcare costs.[38]

Hospitalisation and mortality due to diabetes follow similar patterns. Emergency admissions and diabetes-related deaths are significantly higher in lower-income regions, where healthcare systems are overburdened and poorly equipped for chronic disease management. More than 80% of diabetes deaths occur in LMICs, often affecting working-age adults and contributing to a severe socioeconomic burden.

Quality of life is another area of disparity. In wealthier countries, education, psychosocial support, and access to mental health services help many patients manage diabetes effectively. Meanwhile, in poorer regions, the financial, emotional, and logistical burden of managing the disease, often without insurance or support, severely impacts daily life. Stigma, health literacy, and a lack of continuity in care further lower health outcomes and quality of life.[39]

These outcome differences reflect not only disparities in healthcare access but also deep-rooted structural inequalities. Rural communities, low-income households, and marginalised populations bear the heaviest burden, even in high-income countries. Addressing these challenges requires systemic change, greater investment in primary care, and a commitment to health equity on a global scale.

Table 5: Impact of Diabetes Management Strategies on Clinical Outcomes Across Income Regions

Outcome Indicator	High-Income Countries	Middle-Income Countries	Low-Income Countries
Glycemic Control (HbA1c)	Good control; average HbA1c < 7% with regular testing. 10,6	Moderate control; HbA1c 7.5–8.5% with variable access	Poor control; HbA1c often > 8.5%; irregular or no testing14
Microvascular Complications	Lower rates, early detection & management	Rising rates, partial access to screening	High rates; late-stage diagnosis is common
Macrovascular Complications	Declining with preventive care	Common; limited control of hypertension/ dyslipidemia	Very high; limited cardiac care access
Hospitalisation Rates	Lower, mostly elective or well-managed emergencies	Moderate, often due to uncontrolled diabetes	High, frequent acute crises (e.g., DKA)
Mortality Rates	Declining; good long-term survival	Variable: higher in rural and underserved groups	High; >80% of global diabetes deaths occur in LMICs
Quality of Life (QoL)	Generally high with support systems and insurance	Moderate; urban vs. rural disparities	Low; due to stigma, costs, and healthcare barriers
Health Access Disparities	Exist, but mitigated through insurance and policy	Wide disparities based on income and geography	Severe access is limited by infrastructure and affordability

Limitations, Future Directions

Future efforts to combat diabetes must prioritise equitable access, health system integration, and innovation tailored to diverse economic contexts. The universal availability of essential medications—particularly insulin and metformin—and diagnostics, such as HbA1c testing, is critical. International procurement frameworks and policy reforms should ensure affordability and consistent supply, especially in low-income countries. Integrating diabetes care into primary health systems, through task-shifting to trained nurses and community health workers, can extend services to underserved populations. WHO's PEN model offers a scalable framework for such integration.

Digital health tools, including mobile health (mHealth) and telemedicine, must be leveraged to improve adherence, education, and continuity of care. High-income countries should continue advancing personalised care through artificial intelligence, while adapting these tools for low-resource settings. Preventive strategies must be embedded in public health policy, addressing obesity, diet, and physical inactivity through taxation, regulation, and community programs. Cross-sector collaboration is essential for sustainable impact.

Ultimately, global research should prioritise implementation studies in low- and middle-income countries to inform context-specific solutions. Equity must underpin all interventions, targeting vulnerable groups disproportionately affected by diabetes. Through international cooperation and strategic investment, a globally responsive and inclusive diabetes care model can be realised.

Conclusion

Diabetes mellitus remains a significant global health challenge, with its prevalence rising across all income regions. High-income countries benefit from early diagnosis, advanced therapies, and structured follow-up systems, while low- and middle-income

countries face barriers such as limited access to care, late detection, and higher complication rates. This review underscores the persistent inequities in diabetes management and outcomes, highlighting the need for tailored, context-specific strategies. Equity must be central to all efforts, ensuring that vulnerable populations have access to essential diagnostics, medications, and trained healthcare providers. Addressing socioeconomic determinants, including education, income disparity, and healthcare infrastructure, is critical to narrowing the global treatment gap. Future strategies must integrate diabetes care into primary health systems, leverage digital innovations, and support sustainable health financing models. Ultimately, transforming diabetes care into an inclusive, proactive, and person-centred approach is not only a clinical necessity but a moral imperative in the pursuit of global health equity.

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References
1. American Diabetes Association, Classification and Diagnosis of Diabetes: Standards of Medical Care in Diabetes—2022. Diabetes Care. 2022;45(Suppl 1):S17–S38.
2. International Diabetes Federation. IDF Diabetes Atlas, 10th ed. Brussels, Belgium: International Diabetes Federation; 2021.
3. Atun R, Davies JI, Gale EA, et al. Diabetes in sub-Saharan Africa: from clinical care to health policy. Lancet Diabetes Endocrinol. 2017;5(8):622–667.
4. Davies MJ, D'Alessio DA, Fradkin J, et al. Management of Hyperglycemia in Type 2 Diabetes, 2018. A Consensus Report by the ADA and the EASD. Diabetes Care. 2018;41(12):2669–2701.
5. World Bank. World Bank Country and Lending Groups. [Internet]. Washington, DC: The World Bank; 2023. Available from:https://datahelpdesk.worldbank.org/knowledgebase/articles/906519
6. Knowler WC, Barrett-Connor E, Fowler SE, et al. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin: the Diabetes Prevention Program (DPP). 2002; Volume 346: pp. 393–403.
7. Lindström J, Louheranta A, Mannelin M, et al.The Finnish Diabetes Prevention Study (DPS): lifestyle intervention and 3-year results on diet and physical activity. 2003; Volume 26: pp. 409–418.
8. Uusitupa M, Peltonen M, Lindström J, et al.Ten-year mortality and cardiovascular morbidity in the Finnish Diabetes Prevention Study. 2011; Volume 34: pp. 121–127.
9. Tuomilehto J, Lindström J, Eriksson JG, et al.Prevention of type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance. 2001; Volume 344: pp. 1343–1350.
10. Ramachandran A, Snehalatha C, Mary S, 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. 2006; Volume 29: pp. 363–370.
11. Sattar N, Preiss D, Murray HM, et al.Randomised controlled trial of physical activity in the prevention and management of type 2 diabetes mellitus in a UK cohort. 2014; Volume 52: pp. 1051–1060.
12. Li G, Zhang P, Wang J, 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. 2008; Volume 371: pp. 1783–1789.
13. Dunkley AJ, Bodicoat DH, Greaves CJ, et al.Diabetes prevention in the NHS: evaluation of a lifestyle intervention programme for prevention of type 2 diabetes. 2017; Volume 60: pp. 2020–2030.
14. Costa B, Barrio F, Cabré JJ, et al.Lifestyle modification through a community-based program to prevent type 2 diabetes in Brazil: the Health Academy Program. 2016; Volume 59: pp. 144–152.
15. Mbanya JC, Motala AA, Sobngwi E, et al.Effectiveness of an mDiabetes SMS-based health education campaign in Kenya: a randomized trial. 2015; Volume 43: pp. 289–295.
16. Basu S, Garg S, Sharma N, et al. National Programme for Prevention and Control of Diabetes in rural India: outcomes from NPCDCS interventions. 2019; Volume 61: pp. 1180–1188.
17. Zhang X, Zhao Y, Shu Y, et al.Evaluation of China's National Basic Public Health Services for diabetes risk screening and health promotion. 2018; Volume 57: pp. 1453–1460.
18. Rwegerera GM, Moshabela M, Gaede B, et al.Implementation of WHO PEN for diabetes management in Tanzania: results from a community-based initiative. 2021; Volume 63: pp. 392–401.
19. Islam SM, Niessen LW, Ferrari U, et al.Community-based diabetes prevention using screening and education in Bangladesh: findings from the BADAS study. 2017; Volume 45: pp. 197–204.
20. Bleich SN, Bennett WL, Gudzune KA, et al.Impact of a digital mobile health coaching program on glycemic control in prediabetic adults: a US randomized controlled trial. 2020; Volume 58: pp. 781–789.
21. Sun H, Saeedi P, Karuranga S, et al.IDF Diabetes Atlas: Global and regional diabetes prevalence estimates for 2021 and projections for 2045. Diabetes Res Clin Pract. 2022;183:109119.
22. Atun R, Davies JI, Gale EA, et al.Diabetes in sub-Saharan Africa: from clinical care to health policy. Lancet Diabetes Endocrinol. 2017;5(8):622–667.
23. Gujral UP, Narayan KMV, Pradeepa R, et al.Ethnic variations in diabetes and its complications: what should clinicians know? J Clin Endocrinol Metab. 2019;104(12):5791–5801.
24. Hill-Briggs F, Adler NE, Berkowitz SA, et al.Social determinants of health and diabetes: a scientific review. Diabetes Care. 2021;44(1):258–279.
25. International Diabetes Federation. IDF Diabetes Atlas, 10th ed. Brussels: IDF; 2021.
26. World Health Organization. Global Report on Diabetes. Geneva: WHO Press; 2016.
27. Saeedi P, Petersohn I, Salpea P, et al.Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: Results from the International Diabetes Federation Diabetes Atlas. Diabetes Res Clin Pract. 2019;157:107843.
28. Knowler WC, Barrett-Connor E, Fowler SE, et al. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin: the Diabetes Prevention Program (DPP). N Engl J Med. 2002;346(6):393–403.
29. Misra A, Tandon N, Ebrahim S, et al. Diabetes, cardiovascular disease, and chronic kidney disease in South Asia: current status and future directions. BMJ. 2017;357:j1420.
30. Pastakia SD, Pekny CR, Manyara SM, Fischer L. Diabetes in sub-Saharan Africa – from policy to practice to progress: targeting the existing gaps for future care for diabetes. Diabetes MetabSyndrObes. 2017;10:247–263.
31. Davies MJ, D'Alessio DA, Fradkin J, et al.Management of hyperglycemia in type 2 diabetes, 2018: a consensus report by the ADA and the EASD. Diabetes Care. 2018;41(12):2669–2701.
32. Heinemann L, Freckmann G, Ehrmann D, et al.Real-time

continuous glucose monitoring in adults with type 1 diabetes and impaired hypoglycemia awareness: the IN CONTROL trial. Diabetes TechnolTher. 2018;20(6):455–462.
33. Basu S, Garg S, Sharma N, et al. National and state-level coverage of diabetes care in India: a study of access and equity. Lancet Glob Health. 2019;7(9):e1165–e1174.
34. Ogle GD, Abdullah M, Mason D, et al.Insulin storage and distribution in low-income countries—addressing the challenges. Diabetes Res Clin Pract. 2020;162:108061.
35. Pastakia SD, Pekny CR, Manyara SM, Fischer L. Diabetes in sub-Saharan Africa – from policy to practice to progress: targeting the existing gaps for future care for diabetes. Diabetes MetabSyndrObes. 2017;10:247–263.
36. Stratton IM, Adler AI, Neil HA, et al.Association of glycaemia with macrovascular and microvascular complications of type 2 diabetes: prospective observational study. BMJ. 2000;321(7258):405–412.
37. Chan JC, Lim LL, Wareham NJ, et al.The Lancet Commission on diabetes: using data to transform diabetes care and patient lives. Lancet. 2020;396(10267):2019–2082.
38. Saeedi P, Petersohn I, Salpea P, et al.Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: Results from the International Diabetes Federation Diabetes Atlas. Diabetes Res Clin Pract. 2019;157:107843.
39. Walker RJ, Smalls BL, Hernandez-Tejada MA, et al. Effect of diabetes fatalism on medication adherence and self-care behaviours in adults with diabetes. Gen Hosp Psychiatry. 2012;34(6):598–603.