Student's Journal of Health Research Africa
Vol. 4 No. 12(2023): December 2023 Issue
https://doi.org/10.51168/sjhrafrica.v4i12.763
Original article

A NARRATIVE REVIEW ADDRESSING THE GAP IN DIABETES DIAGNOSIS: CHALLENGES AND PATHWAYS IN INDIA.

Anand Shankar[a*]
[a]*Diabetologist, Shankar Diabetes Care Centre, Patna, Bihar, India*

ABSTRACT.

Diabetes mellitus, an enduring pathological condition distinguished by heightened levels of blood glucose and changes in metabolic processes, continues to pose a substantial global predicament. The condition may result in significant impairment to essential bodily systems, encompassing the cardiovascular system, the arteries and veins, optical systems, renal function, and neural pathways. India faces a substantial burden due to diabetes, fuelled by unhealthy lifestyles and genetic factors unique to its population. Rapid urbanization and economic development of the nation have led to unhealthy lifestyle changes, contributing to a surge in obesity and metabolic disorders, particularly diabetes. In India, undiagnosed cases are prevalent, driven by limited healthcare access and awareness, resulting in delayed care. Despite an alarmingly high prevalence rate, over 50% of diabetes cases remain undiagnosed, straining the healthcare system. In addition to this, treatment and management of diabetes pose further challenges from inadequate infrastructure, workforce shortages, overcrowding, and financial constraints. Not only this, but among diabetic people, non-compliance of medications and variations in treatment strategies, further hinder its management. Thus, there is an imperative need for effective strategies to address these challenges which will overall reduce the burden on the healthcare system and importantly help the nation to tackle diabetes. The objective of the review paper is to highlight the substantial burden of diabetes mellitus in India, focusing on the challenges it presents to healthcare systems and the population. The paper aims to emphasize the need for effective strategies to address these challenges and reduce the burden of diabetes on the healthcare system and the nation as a whole. By taking comprehensive steps, India can offer accessible, efficient, and quality healthcare, ultimately alleviating the burden of preventable diseases and deaths.

Keywords: Diabetes, Prevalence, Diagnosis, Challenges, Management, Gaps in Diabetes Diagnosis
Submitted: 2023-10-21 Accepted: 2023-10-25

Corresponding author: Anand Shankar
Email: *shankardiab@gmail.com*
Diabetologist, Shankar Diabetes Care Centre, Patna, Bihar, India

INTRODUCTION.

Diabetes, a pathological state first identified by ancient Egyptian and Indian medical practitioners over three millennia ago[1], continues to present as an enduring and formidable clinical dilemma in contemporary times. The condition under consideration is classified as a chronic ailment, characterized by the presence of persistently elevated levels of glucose in the bloodstream and disturbances in the metabolism of carbohydrates, fats, and proteins. This condition, known as pancreatic insufficiency or insulin resistance, manifests when the pancreatic gland exhibits inadequate secretion of insulin or when the body demonstrates an impaired ability to effectively utilize the endogenous insulin it synthesizes. Insulin, an endocrine hormone vital for the regulation of blood glucose levels, assumes a pivotal role in the pathophysiology of this particular ailment.[2] Uncontrolled diabetes mellitus can lead to the manifestation of hyperglycemia, characterized by elevated blood glucose levels. Prolonged exposure to hyperglycemia can give rise to significant pathological consequences, exerting detrimental effects on multiple essential physiological systems within the human body. These systems include but are not limited to the cardiovascular system, vasculature, vision systems, renal system, and peripheral nerves. Diabetes mellitus presently stands as a prominent etiological factor contributing to the occurrence of lower limb amputations, myocardial infarctions, cerebrovascular accidents, end-stage renal disease, and visual impairment on a global scale.[2] Henceforth, diabetes mellitus manifests not solely as an autonomous pathological condition, but also assumes the role of a transitional phase, predisposing individuals to a myriad of consequential and grave medical ailments. Diabetes, a significant global health crisis, is positioned among the top ten primary contributors to mortality, alongside cardiovascular disease (CVD), respiratory disease, and cancer.[3] Indeed, it is noteworthy that India experiences the most substantial decrement in potentially productive life years as a consequence of mortality attributed to cardiovascular diseases (CVDs).4 In the year 2021, the International Diabetes Federation documented a total of 6.7 million deaths among the adult population attributed to diabetes, accounting for approximately 12.2% of the overall global mortality rate. [5]

According to projections, approximately 592 million people are expected to lose their lives due to diabetes by the year 2035.6 Type 2 diabetes mellitus (T2DM), which constitutes around ninety percent of all cases of diabetes,

has emerged as a significant global health issue, with particularly alarming prevalence rates observed in several developing economies, most notably in nations such as China and India.[5]

The widespread incidence of diabetes in India is a notable public health concern, with various factors contributing to its high prevalence (Table 1). There exists a discernible rise in the prevalence of diabetes among the Indian population, particularly among individuals of younger age and lower body weights, when compared to other ethnic groups.[7] The present study has identified notable variations in the prevalence of diabetes across different states, as well as among urban and rural populations. The prevalence of the condition varied across different regions, with a range of 2.02% observed in rural Madhya Pradesh to 40.3% in Tamil Nadu.8 According to the findings of the India State-Level Disease Burden Initiative Diabetes study collaborators, the incidence of diabetes exhibits the highest rates in Tamil Nadu, succeeded by Kerala, Delhi, Punjab, Goa, and Karnataka.[9] Furthermore, it is noteworthy to mention that the frequency of pre-diabetes exhibits considerable variation among the different Indian states, with rates ranging from a modest 2.4% in Meghalaya to a significantly higher 47.6% in Delhi.[8]

Table 1: The Incidence of Diabetes in the Indian Population[5]

Estimates	**Year-2021**
Diabetes*, in 1000s	74,194.70
Undiagnosed diabetes*, in 1000s	39,397.40
Impaired glucose tolerance*, in 1000s	40,143.80
Impaired fasting glucose*, in 1000s	75,123.90
Type 1 diabetes estimates in children and adolescents	
New cases#, in 1000s	24
Type 1 diabetes#, in 1000s	229.4
Prevalence of gestational diabetes mellitus %	29.3
Demographics	
Total adult population*, in 1,000s	893,910.00
Population of children and adolescents (0-19 y), in 1,000s	485,464.90

Age 20-79 years, #0-19 years. Adapted from IDF Diabetes Atlas, 10th edition 2021.

METHODS.

Using PubMed search criteria that included "diabetes and India," this narrative review makes use of the scant primary data currently available from a literature search. Additional data was obtained from Internet searches of credible and well-known organizations, such as the World Diabetes Foundation, the World Health Organization (WHO), the International Diabetes Federation (IDF), governmental organizations, and other institutions as cited. In cases where information and data are not accessible, the authors have pointed out the deficiency and offered well-informed perspectives and firsthand narratives from their ten years of experience implementing diabetes treatment in India. The utilization of the narrative technique has enabled a thorough evaluation of the obstacles and deficiencies impeding the advancement of diabetes treatment in India, while also pinpointing possible avenues for growth.

Types of Diabetes.

Table 2 provides a brief overview of each type of diabetes along with some key points and risk factors associated with each type.

Table 2: Overview of different types of diabetes and key points[5,10,11,12]

Type of Diabetes	Description	Key points	Risk Factors
Type 1 Diabetes	The body produces minimal or no insulin	Typically identified in individuals during childhood and adolescence	Family history, genetics, and environmental factors
	The immune system targets and damages pancreatic cells responsible for insulin production	Necessitates daily insulin injections to stay alive	
Type 2 Diabetes	Cells exhibit impaired insulin utilization	The most common type of diabetes	Overweight, obese, family history of diabetes, unhealthy diet sedentary lifestyle
	Pancreas may not produce enough insulin	Controlled with lifestyle changes, oral medications, or insulin	
Gestational Diabetes (GDM)	Develops during pregnancy	Often goes away after childbirth	Maternal obesity, Excessive weight gain during pregnancy, Family history of GDM, Polycystic ovary syndrome (PCOS), Habitual smoking
		Elevates the likelihood of developing type 2 diabetes in the future when encountered during pregnancy	
Prediabetes	Blood glucose levels exceed the normal range but do not reach the threshold for a type 2 diabetes diagnosis	Increased susceptibility to the onset of both type 2 diabetes and heart disease	Age, overweight, obesity
Maturity Onset Diabetes of the Young (MODY)	A unique type of diabetes arises from a genetic mutation in a single gene	Runs strongly in families	Family history
	Generally, develops before age 25	Inherited from the parent (50% chance if a parent has the gene mutation)	Stimulated C peptide cut points are useful for diagnosis
Latent Autoimmune Diabetes in Adults (LADA)	Exhibits features found in both type 1 and type 2 diabetes	Also known as type 1.5 diabetes or type 1 ½ diabetes	
Other Types of Diabetes	Monogenic diabetes: Arises due to a genetic alteration in a single gene.		
	Diabetes can develop as a consequence of pancreatic surgery or injury to the pancreas		Cystic fibrosis, pancreatitis
	Diabetes due to endocrine disorders	Excessive secretion of Insulin-antagonizing hormones	Cushing's syndrome
	Diabetes due to certain drugs, viral infections, and immunological disorders	Beta cell dysfunction or disruption in insulin secretion	

Type 1, type 2, and GDM are most common whereas other types of diabetes have a prevalence of about 2%.

Root Causes of the Rise in Diabetes in India

a) **Increased Prevalence:** One of the primary reasons for the high frequency of diabetes in India

is the rapid epidemiological change the nation has experienced in recent years. With economic development and urbanization, there has been a shift in lifestyle and dietary habits. Sedentary lifestyles, unhealthy diets, and increased stress levels have become more common, leading to a rise in obesity and metabolic disorders, including diabetes.[13] A significantly higher occurrence of diabetes has been observed in city areas than in rural areas.[8]

b) **Undiagnosed Disease**: A substantial portion of the diabetic population in India remains undiagnosed. This is partly due to limited access to healthcare facilities, especially in rural areas, and an absence of alertness about diabetes and its symptoms. As a result, many individuals with diabetes are unaware of their condition, leading to delayed diagnosis and treatment. Studies have shown that a substantial number of diabetes cases in India are undiagnosed, contributing to the growing burden of the disease.[14]

c) **Genetic Factors:** The current research suggests that individuals of Asian Indian descent exhibit a genetic predisposition toward the development of diabetes mellitus. Individuals within this particular demographic exhibit a propensity for diminished beta cell function, as determined by genetic factors, in contrast to other cohorts. The pancreatic beta cells play a crucial role in the synthesis and secretion of insulin, a hormone essential for maintaining glucose homeostasis. Dysfunction or impairment of these beta cells can result in a deficiency of insulin, ultimately leading to the development of diabetes mellitus.[15] Additionally, in the Indian population, *Pro12ala* polymorphisms in peroxisome proliferator-activated receptor gamma (PPARγ) genes do not offer protection against diabetes. Also, in obese Indian people, *Gly1057Asp* polymorphism of the insulin receptor substrate-2 (IRS-2) gene predisposes them to diabetes.[16] This genetic susceptibility, combined with the aforementioned lifestyle changes, significantly contributes to the high occurrence of diabetes in the population.[15]

d) **Obesity Prevalence:** Obesity is a chief risk variable for T2DM. In India, the prevalence of obesity has been steadily increasing over the years. According to a survey conducted between 2019 and 2021, the prevalence of obesity in Indian adults reached 23.4%.[17] Excessive body weight precipitates the development of insulin resistance, a condition characterized by suboptimal responsiveness of the body's cells to the actions of insulin, causing blood glucose levels to rise.[5,18] Consequently, the risk of developing diabetes increases substantially among obese individuals.[18] The high prevalence of diabetes in India is compounded by several challenges in its treatment and management. These challenges significantly impact the value of care provided to individuals with diabetes and hinder effective control of the disease.

e) **Epigenetic factors:** Epigenetic mechanisms have been proposed as a potential explanation for the association between factors influencing fetal development and the heightened susceptibility to the development of type 2 diabetes in subsequent stages of life. However, to date, there is insufficient compelling evidence to establish epigenetic changes as the primary and direct cause of diabetes.[1]

f) **Gaps in diabetes diagnosis in India:** The prevalence of complications of diabetes in emerging economies is significantly elevated such as in India may result from factors including delayed diabetes diagnosis and complications, the presence of coexisting illnesses, insufficient healthcare systems, and the elevated cost of medications, particularly insulin.[20]

g) **Rising prevalence and undiagnosed cases:** In the Indian population, diabetes has an alarming prevalence rate of 8.3% among individuals aged between 20 and 79 years.[5] A significant concern arises from the fact that a considerable proportion exceeding 50% of individuals remain oblivious to their diabetic condition, resulting in the untimely identification and management of the disease.[21] A Chennai Urban Rural Epidemiology Study (CURES) revealed that 25% were unaware and 22.2% knew diabetes is preventable; awareness was higher among well-educated individuals. Only 11.9% recognized obesity's role, 23% knew of potential foot problems, and 5.8% were aware of diabetes causing heart attacks.22 Another study noted that 41% of Indian adults knew diabetes risks, and 92.3% of diabetic patients consulted general practitioners over specialists, highlighting the need to improve awareness for better self-management and early diagnosis of diabetes.[23]

h) **Inadequate healthcare infrastructure and investment:** This lack of timely intervention contributes to severe health complications and an increased burden on the healthcare system.[24] Diagnosis frequently occurs when complications arise, such as vision problems, kidney issues, or heart problems, leading to delayed intervention.2 The healthcare sector in India faces a multitude of challenges that hinder its ability to provide effective services to the population and contribute to delayed diagnosis and management of diabetes. [25]

i) **Challenges for patients for diagnostic services:** Accessing diagnostic services is a challenging journey for patients and caretakers, involving cost, distance, social dynamics, and complex steps such as sample transportation and

managing diagnosis consequences. The quality of interactions with providers significantly impacts the testing process. When responsibilities became burdensome, patients exhibited various responses, including voluntary withdrawal, postponement of testing, alteration of healthcare providers, or reliance on self-administered testing and treatment.26 This contributes to the reduced diagnosis of diabetes.

j) **The impact of stigma on diabetes self-care and health:** Stigma and discrimination profoundly impact diabetes self-care, self-esteem, and overall health. They induce negative emotions like depression and anxiety, hampering effective diabetes management. Stigmatization discourages people with diabetes from performing important day-to-day diabetes self-care tasks like insulin injection, blood sugar monitoring, and treatment seeking.[27]

k) **Workforce shortage and facility overcrowding:** One of the significant issues that delay diabetes diagnosis is the acute shortage of skilled and qualified employees, including doctors, nurses, and other healthcare professionals. This scarcity not only strains the existing healthcare workforce but also compromises the quality of care delivered to patients.[25] Overcrowding in healthcare facilities due to insufficient primary and secondary care facilities is another problem that affects the system's functionality.[28]

l) **Affordability and Accessibility:** Diagnostic tests and healthcare services might be costly or inaccessible for a significant portion of the population. One of the reasons for this could be due to the government and private sector's low investment in healthcare infrastructure.[2,24,28] This inadequacy in funding leads to subpar facilities and limited access to essential medical services, especially for those belonging to economically disadvantaged groups.[24,28] Also, socioeconomic factors, including poverty and lack of health insurance, can prevent individuals from seeking medical care and early diagnosis of diabetes.[29]

m) **Pressure on healthcare staff and urgent reforms:** Overcrowding not only puts a burden on doctors but also compromises the time spent on each patient, potentially compromising the quality of care provided.[28] High treatment costs can deter patients from seeking regular healthcare, leading to poor disease management and increased risk of complications. Furthermore, the healthcare system's inefficiency in preventing deaths remains a critical concern. Preventable deaths due to inadequate healthcare infrastructure and lack of timely medical intervention highlight the urgent need for healthcare reform and improved emergency services.[2,25]

n) **Variations in care:** Variations in diabetes diagnosis, treatment, and control between different districts within a state further complicate efforts to standardize care and achieve optimal outcomes.[30]

o) **Challenges to diabetes management:** One of the primary obstacles in diabetes treatment is the low level of awareness among the general population. Many individuals lack information about diabetes, its risk variables, and the significance of timely identification and proper management. This lack of awareness delays diagnosis and timely intervention, leading to an increased burden of complications and healthcare costs.[14,31]

p) **A bridge between research and policy:** Despite the availability of research evidence, the unfortunate reality is that it is often not adequately utilized in policy-making, resulting in suboptimal decisions that may not fully address the healthcare system's needs and challenges.[32]

q) **Strategies to be implemented to improve the diabetes care system in India:** Indian Diabetes Risk Score (IDRS) is a valuable device for detecting undiagnosed diabetes in urban areas.[33] It is related to a five-fold danger for incident diabetes, along with 2-fold and 3-fold risks with obesity and hypertension, respectively.34 Higher IDRS is also associated with a rise in the risk of metabolic syndrome and CVD, even in non-diabetic individuals.[34]

r) **Enhance Diabetes Management Practices:** Promote evidence-based diabetes management practices that emphasize early diagnosis, regular monitoring, and comprehensive treatment plans. This includes encouraging lifestyle modifications, such as healthy eating and regular physical activity, as essential components of diabetes management.[35]

s) **Primary Care Role:** The primary focus lies in enhancing the capability of primary care facilities to effectively diagnose and treat diabetes.[2]

t) **Greater Role of Secondary Care Facilities**: Strengthen the role of secondary care facilities in diabetes management. These facilities can play a crucial role in providing specialized continuation research and identification for complications, ensuring timely interventions, and reducing the burden on primary care centers.[35]

u) **Holistic Diabetic Care Package:** Develop a comprehensive diabetic care package that addresses all aspects of diabetes management, from screening and diagnosis to long-term follow-up. Implementing a robust recording and cohort monitoring system can facilitate continuous evaluation of patient outcomes and help identify areas for improvement.[2,35]

v) **Scientific Guidelines and Norms:** The development of scientific guidelines for diabetes

for healthcare providers to deliver quality diabetes services.[2,36]

w) **Public Awareness Initiatives:** Public awareness campaigns must be launched to teach the population about diabetes, its risk variables, and the importance of early detection and timely management. Observing events like World Diabetes Day (14th November) can serve as a

By addressing these challenges and implementing comprehensive strategies, India can improve its diabetes care system and effectively manage the growing burden of diabetes, leading to better health outcomes for individuals with diabetes and reduced healthcare costs.

CONCLUSION.

Overall, the Indian healthcare sector is grappling with numerous obstacles, ranging from a shortage of skilled personnel and financial constraints to the high prevalence of diseases and overcrowding (Table 3). It is crucial to fill gaps in diabetes diagnosis in India (Figure 1). To create a sustainable and effective healthcare system, comprehensive reforms are required, encompassing increased investment, better utilization of research evidence, improved medical education, and enhanced healthcare infrastructure. Only by collectively addressing these challenges can India strive towards providing accessible, efficient, and high-quality healthcare services to all its citizens.
Efforts should be made to bolster preventive measures, raise public awareness, and implement timely interventions to reduce the incidence of preventable diseases and deaths.

LIMITATIONS.

The review relies on existing literature, which may have limitations in accuracy and completeness. It lacks systematic analysis or detailed statistical analysis for more precise insights. The challenges and healthcare issues discussed may change over time, and the review may not be up to date.

NEED FOR FUTURE RESEARCH.

Further research is required for comprehensive epidemiological studies and surveys to gather recent diabetes prevalence data in various Indian regions. Investigate the effectiveness of preventive measures, interventions, and healthcare policies in reducing diabetes incidence and complications. Assess the impact of healthcare reforms on diabetes management for valuable policymaker insights.

regulation and supervision along with established norms and standards for diagnosis and care, will provide a standardized framework
platform to raise awareness about the global epidemic of diabetes.[31,33,36]

x) **Surveillance and Risk Factor Assessment:** Regular surveillance of diabetes and its risk factors must be conducted to better understand the disease trends and prevalence. Monitoring risk factors can help identify vulnerable populations and design targeted interventions.[2,5,36]

RECOMMENDATION:

Policymakers should prioritize healthcare infrastructure, workforce training, and capacity building. Invest in diabetes prevention programs, public health campaigns, and early diagnosis. Promote collaboration among healthcare providers, researchers, and government agencies for evidence-based practice and policy development. Update medical education to include comprehensive diabetes training for healthcare professionals.

ACKNOWLEDGEMENT:

We would like to acknowledge the valuable contributions of healthcare professionals, researchers, and organizations working tirelessly to address the challenges posed by diabetes in India. Their dedication and efforts are instrumental in improving healthcare outcomes and reducing the burden of preventable diseases.

LIST OF ABBREVIATIONS.

CVD: Cardiovascular Disease

T2DM: Type 2 Diabetes Mellitus

WHO: World Health Organization

IDF: International Diabetes Federation

GDM: Gestational Diabetes

MODY: Maturity Onset Diabetes of The Young

LADA: Latent Autoimmune Diabetes in Adults

PCOS: Polycystic Ovary Syndrome

PPARγ: Peroxisome Proliferator-Activated Receptor Gamma

IRS-2: Insulin Receptor Substrate-2

CURES: Chennai Urban Rural Epidemiology Study

IDRS: Indian Diabetes Risk Score

CONFLICT OF INTEREST.

The authors report no conflicts of interest in this work.

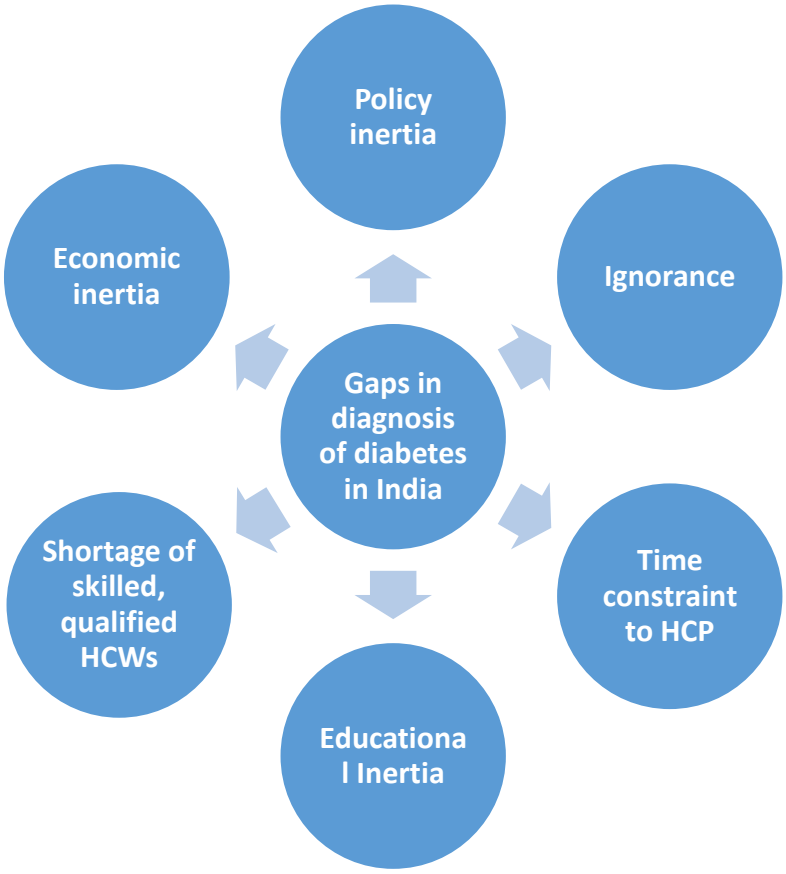
The study was not funded.

SOURCE OF FUNDING.

Table 3: Summary of reasons, complications, and gaps in diagnosis of diabetes in India.

Reasons for High Diabetes Cases in India	Complications Due to Diabetes	Gaps in Diabetes Diagnosis in India
• Increased prevalence • Obesity prevalence • Genetic predisposition • Lower genetically determined beta-cell function • Epigenetic factors • Undiagnosed disease • Sedentary lifestyle • Lack of awareness • Lack of effective public health policies • Non-compliance with medication	• Higher risk of cardiovascular disorders • Heart attacks • Stroke • Increased risk of microvascular complications • Damage to blood vessels • Blindness • Kidney failure • Nerve damage • Lower limb amputations	• High prevalence • Lack of awareness in more than 50% of people of their diabetic status • Shortage of skilled and qualified employees • Health expenditure/financial burden/low investment in healthcare • Necessary skilled education for medical students • No use of research evidence in policy-making • Overcrowding in primary and secondary care facilities • Inefficiency of the health care system in preventing deaths • Increased burden on the medical staff • Time spent on every patient in the healthcare unit

Figure 1. A comprehensive depiction of the gaps in the diagnosis of diabetes in India



REFERENCES.

1. Papaspyros NS. The history of diabetes. In: The history of diabetes mellitus, 2nd ed. *Stuttgart: G Thieme Verlag*; 1964:4.
2. Roglic G, Varghese C, Thamarangsi T. Diabetes in South-East Asia: burden, gaps, challenges and ways forward. *WHO South East Asia J Public Health*. 2016;5(1):1-4.
3. The top 10 causes of death; available at https://www.who.int/news-room/fact-sheets/detail/the-top-10-causes-of-death. Accessed on 24th July 2023.
4. Srinath Reddy K, Shah B, Varghese C, Ramadoss A. Responding to the threat of chronic diseases in India. *Lancet*. 2005;366(9498):1744-9.
5. IDF Diabetes Atlas. 10th ed. Brussels, Belgium: International Diabetes Federation; 2021. Available at https://diabetesatlas.org/atlas/tenth-edition/. Accessed on 24th July 2024.
6. Tao Z, Shi A, Zhao J. Epidemiological Perspectives of Diabetes. *Cell Biochem Biophys*. 2015 Sep;73(1):181-5.
7. Wells JC, Pomeroy E, Walimbe SR, Popkin BM, Yajnik CS. The Elevated Susceptibility to Diabetes in India: An Evolutionary Perspective. *Front Public Health*. 2016;4:145.
8. Swathy Govindaswamy S, Dhivya PS, Sivaprakasam SSK. Prevalence and complications of diabetes mellitus In India - A systematic review. *Ind. J. Pharm. Edu. Res*., 2023; 57(2s):s213-s225.
9. India State-Level Disease Burden Initiative Diabetes Collaborators. The increasing burden of diabetes and variations among the states of India: the Global Burden of Disease Study 1990-2016. *Lancet Glob Health*. 2018; 6(12):e1352-e1362. PMID: 30219315; PMCID: PMC6227383.

10. Types of diabetes. Available at https://www.diabetes.org.uk/diabetes-the-basics/types-of-diabetes. Accessed on 27th July 2023.
11. What is diabetes? Available at https://www.niddk.nih.gov/health-information/diabetes/overview/what-is-diabetes. Accessed on 27th July 2023.
12. Aarthy, R., Aston-Mourney, K., Amutha, A. *et al*. Identification of appropriate biochemical parameters and cut points to detect Maturity Onset Diabetes of Young (MODY) in Asian Indians in a clinical setting. *Sci Rep.*2023; 13, 11408.
13. Kaveeshwar SA, Cornwall J. The current state of diabetes mellitus in India. *AMJ* 2014, 7, 1, 45-48.
14. Unnikrishnan, R., Anjana, R. & Mohan, V. Diabetes mellitus and its complications in India. *Nat Rev Endocrinol*. 2016; 12, 357–370.
15. Siddiqui MK, Anjana RM, Dawed AY, Martoeau C, Srinivasan S, Saravanan J, Madanagopal SK, Taylor A, Bell S, Veluchamy A, Pradeepa R, Sattar N, Venkatesan R, Palmer CNA, Pearson ER, Mohan V. Young-onset diabetes in Asian Indians is associated with lower measured and genetically determined beta cell function. *Diabetologia*. 2022;65(6):973-983.
16. Joshi SR, Parikh RM. Family history and pedigree charting--a simple genetic tool for Indian diabetics. *J Assoc Physicians India.* 2006;54:437-9.
17. Obesity prevalence, Adults, 2019-2020; Available at https://data.worldobesity.org/country/india-95/#data_prevalence, Accessed on 24th July 2023.
18. Carr MC, Brunzell JD. Abdominal obesity and dyslipidemia in the metabolic syndrome: importance of type 2 diabetes and familial combined hyperlipidemia in coronary artery disease risk. *J Clin Endocrinol Metab*. 2004; 89:2601–7.
19. Vaag A, Brøns C, Gillberg L, Hansen NS, Hjort L, Arora GP, Thomas N, Broholm C, Ribel-Madsen R, Grunnet LG. Genetic, nongenetic and epigenetic risk determinants in developmental programming of type 2 diabetes. *Acta Obstet Gynecol Scand*. 2014; 93(11):1099-108.
20. Pradeepa R, Mohan V. Epidemiology of type 2 diabetes in India. Indian J Ophthalmol 2021;69:2932-8.
21. Mobile technology for preventing NCDs; Available at, https://www.who.int/india/health-topics/mobile-technology-for-preventing-ncds. Accessed on 24th July 2023.
22. Mohan D, Raj D, Shanthirani CS, Datta M, Unwin NC, Kapur A, Mohan V. Awareness and knowledge of diabetes in Chennai--the Chennai Urban Rural Epidemiology Study [CURES-9]. *J Assoc Physicians India.* 2005;53:283-7.
23. Murugesan N, Snehalatha C, Shobhana R, Roglic G, Ramachandran A. Awareness about diabetes and its complications in the general and diabetic population in a city in southern India. *Diabetes Res Clin Pract.* 2007;77(3):433-7.
24. Nagarathna R, Madhava M, Patil SS, Singh A, Perumal K, Ningombam G, Nagendra AHR. Cost of Management of Diabetes Mellitus: A Pan India Study. *Ann Neurosci.* 2020; 27(3-4):190-192.
25. Kasthuri A. Challenges to Healthcare in India - The Five A's. *Indian J Community Med*. 2018; 43(3):141-143.
26. Vijayashree Yellapa, Narayanan Devadasan, Anja Krumeich, Nitika Pant Pai, Caroline Vadnais, Madhukar Pai & Nora Engel. How patients navigate the diagnostic ecosystem in a fragmented health system: a qualitative study from India. *Global Health Action*, 2017;10(1):1350452.
27. Diabetes Stigma: Learn About It, Recognize It, Reduce It. Available at https://www.cdc.gov/diabetes/library/features/diabetes_stigma.html#print. Accessed on 23rd August 2023.
28. Mishra A, Doke P. Assessing the Gap in Policies of Human Resources, Quality and

Communication for Indian Teaching Hospitals. *MGMJMS*; 2015;2(1):7-12
29. Behera UC, Brar AS. Socioeconomic status and diabetic retinopathy in India. Indian J Ophthalmol. 2021;69(11):2939-2943.
30. Varghese J, Anjana R, Geldsetzer P, Sudharsanan N, Manne-Goehler J, Thirumurthy H, Bhattacharya S, Narayan V, Mohan V, Tandon N, Mohammed KA. Diabetes diagnosis, treatment, and control in India: results from a national survey of 1.65 million adults aged 18 years and older, 2019-2021. *medRxiv*. 2023.02.06.23285544.
31. Deepa M, Bhansali A, Anjana RM, Pradeepa R, Joshi SR, Joshi PP, Dhandhania VK, Rao PV, Subashini R, Unnikrishnan R, Shukla DK, Madhu SV, Das AK, Mohan V, Kaur T. Knowledge and awareness of diabetes in urban and rural India: The Indian Council of Medical Research India Diabetes Study (Phase I): Indian Council of Medical Research India Diabetes 4. *Indian J Endocrinol Metab*. 2014;18(3):379-85.
32. Kumar M, Ebrahim S, Taylor FC, Chokshi M, Gabbay J. Health technology assessment in India: the potential for improved healthcare decision-making. *Natl Med J India*. 2014;27(3):159-63.
33. Dudeja P, Singh G, Gadekar T, Mukherji S. Performance of Indian Diabetes Risk Score (IDRS) as a screening tool for diabetes in an urban slum. *Med J Armed Forces India.* 2017;73(2):123-128.
34. The Indian Diabetes Risk Score; Available at https://cadiresearch.org/topic/diabetes-indians/the-indian-diabetes-risk-score, accessed on 25th July 2023.
35. Tripathy JP, Sagili KD, Kathirvel S, Trivedi A, Nagaraja SB, Bera OP, Reddy KK, Satyanarayana S, Khanna A, Chadha SS. Diabetes care in public health facilities in India: a situational analysis using a mixed methods approach. *Diabetes Metab Syndr Obes*. 2019;12:1189-1199.
36. Diabetes; Available at https://www.who.int/news-room/fact-sheets/detail/diabetes. Accessed on 24th July 2023.

Publisher details.

Publishing Journal: Student's Journal of Health Research Africa.
Email: studentsjournal2020@gmail.com or admin@sjhresearchafrica.org

(ISSN: 2709-9997)

Publisher: SJC Publishers Company Limited
Category: Non-Government & Non-profit Organisation
Contact: +256775434261(WhatsApp)
Email: admin@sjpublisher.org
Website: https://sjpublisher.org
Location: Wisdom Centre Annex, P.O. BOX. 701432 Entebbe, Uganda, East Africa.