"Prevalence of Type 2 Diabetes Mellitus in Urban Indian Population: A Cross-Sectional Study"

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ABSTRACT

Background: Type 2 Diabetes Mellitus (T2DM) has emerged as a significant public health challenge in India, with a rapidly increasing prevalence, particularly in urban areas. This surge is largely attributed to urbanization, sedentary lifestyles, dietary changes, and genetic predisposition. Understanding the current prevalence and associated risk factors is crucial for developing effective prevention and management strategies. The escalating burden of T2DM poses a substantial strain on the healthcare system and necessitates urgent public health interventions.

Objective: This study aimed to estimate the prevalence of T2DM among adults residing in urban areas of India and to identify the key risk factors associated with its development. The objective was to provide a comprehensive assessment of the current epidemiological landscape of T2DM in urban India, which can inform targeted public health initiatives.

INTRODUCTION

Type 2 Diabetes Mellitus (T2DM) is a chronic metabolic disorder characterized by hyperglycemia resulting from insulin resistance and impaired insulin secretion. Globally, T2DM represents a major public health challenge, with an increasing prevalence that poses a significant burden on healthcare systems and economies. The International Diabetes Federation (IDF) estimates that approximately 537 million adults worldwide were living with diabetes in 2021, and this number is projected to rise to 783 million by 2045 (IDF Diabetes Atlas, 10th edition, 2021). The increasing prevalence is largely attributed to factors such as aging populations, urbanization, sedentary lifestyles, and dietary changes.

In India, the prevalence of T2DM has been rising at an alarming rate, particularly in urban areas. The country is often referred to as the "diabetes capital of the world," with a substantial proportion of the global diabetes burden. According to the IDF, India had an estimated 77 million people living with diabetes in 2019, and this number is expected to increase significantly in the coming decades. This rapid increase in prevalence is driven by a complex interplay of genetic predisposition, environmental factors, and lifestyle changes associated with urbanization.

Urbanization in India has led to significant shifts in dietary habits, with increased consumption of processed foods, refined carbohydrates, and saturated fats. Concurrently, there has been a decline in physical activity levels due to increased reliance on motorized transport and sedentary occupations. These lifestyle changes, coupled with genetic susceptibility, have contributed to the rising prevalence of obesity, insulin resistance, and ultimately, T2DM. Furthermore, the aging of the Indian population has also contributed to the increasing burden of T2DM, as the risk of developing the disease increases with age.

Several studies have investigated the prevalence and risk factors for T2DM in India. A systematic review and meta-analysis by Anjana et al. (2011) reported a pooled prevalence of diabetes of 7.3% in urban India and 3.9% in rural India, highlighting the significant urban-rural disparity. Another study by Ramachandran et al. (2014) found that the prevalence of diabetes in urban Chennai was 18.6%, indicating a substantial burden in specific metropolitan areas. These studies have consistently identified risk factors such as age, obesity, family history, sedentary lifestyle, and unhealthy dietary habits as major contributors to the development of T2DM.

Despite the existing body of evidence, there are still gaps in our understanding of the epidemiology of T2DM in urban India. Many studies have focused on specific cities or

regions, and there is a need for more comprehensive data that captures the heterogeneity of urban populations across the country. Furthermore, there is a need for more detailed analysis of the interplay between genetic and environmental factors in the development of T2DM. Understanding these complex interactions is crucial for developing effective prevention and management strategies.

The present study aims to address these gaps by estimating the prevalence of T2DM in a large, representative sample of adults residing in four major metropolitan cities in India: Delhi, Mumbai, Kolkata, and Chennai. The study also aims to identify the key risk factors associated with T2DM in this population, providing a comprehensive assessment of the current epidemiological landscape of the disease in urban India. The findings of this study will inform the development of targeted public health interventions aimed at preventing and managing T2DM in this high-risk population.

The objectives of this study are:

1. To estimate the prevalence of T2DM among adults aged 25-65 years residing in urban areas of Delhi, Mumbai, Kolkata, and Chennai.

2. To identify the key risk factors associated with T2DM in this population, including demographic, anthropometric, and lifestyle factors.

3. To provide a comprehensive assessment of the current epidemiological landscape of T2DM in urban India, which can inform targeted public health initiatives.

METHODS

Study Design and Setting

This study was a community-based cross-sectional study conducted across four major metropolitan cities in India: Delhi, Mumbai, Kolkata, and Chennai. The study was conducted between January 2022 and December 2022. These cities were selected to represent the diverse socio-economic and cultural characteristics of urban India. The study followed the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines for reporting cross-sectional studies.

Sample Size Calculation and Statistical Power

The sample size was calculated based on the estimated prevalence of T2DM in urban India, which was assumed to be 10% based on previous studies. To achieve a precision of ±2% with a 95% confidence interval and a power of 80%, a sample size of 2,250 participants was required. To account for potential non-response and incomplete data, the sample size was increased by 10%, resulting in a final target sample size of 2,500 participants. The sample size was proportionally allocated to each city based on its population size.

Participant Inclusion and Exclusion Criteria

The inclusion criteria for the study were:

1. Adults aged 25 to 65 years.

2. Residents of Delhi, Mumbai, Kolkata, or Chennai for at least one year prior to the study.

3. Willingness to provide informed consent and participate in the study.

The exclusion criteria were:

1. Pregnant women.

2. Individuals with type 1 diabetes mellitus.

3. Individuals with known secondary causes of diabetes (e.g., Cushing's syndrome, drug-induced diabetes).

4. Individuals with severe cognitive impairment or psychiatric disorders that would preclude their ability to provide informed consent or participate in the study.

Data Collection Tools

Data were collected using structured interviews, physical examinations, and laboratory tests. The following data collection tools were used:

1. Structured Interview Questionnaire: A pre-tested structured questionnaire was used to collect data on demographic characteristics (age, gender, education, socioeconomic status), lifestyle factors (diet, physical activity, smoking, alcohol consumption), medical history (including family history of diabetes, hypertension, and dyslipidemia), and current medication use. The questionnaire was administered by trained interviewers.

2. Anthropometric Measurements: Height, weight, waist circumference, and blood pressure were measured using standardized protocols. Height was measured to the nearest 0.1 cm using a stadiometer. Weight was measured to the nearest 0.1 kg using a calibrated electronic scale. Body mass index (BMI) was calculated as weight (kg) divided by height (m) squared. Waist circumference was measured at the midpoint between the lowest rib and the iliac crest. Blood pressure was measured using a digital sphygmomanometer after the participant had been resting for at least 5 minutes.

3. Laboratory Tests: Fasting blood samples were collected from all participants after an overnight fast of at least 8 hours. Fasting plasma glucose (FPG) and glycated hemoglobin (HbA1c) levels were measured using standard laboratory methods

. FPG was measured using the glucose oxidase method, and HbA1c was measured using high-performance liquid chromatography (HPLC).

Interventions, Exposures, or Treatment Regimens

This was an observational study, and no interventions, exposures, or treatment regimens were administered. The study focused on assessing the prevalence of T2DM and identifying associated risk factors in the study population.

Primary and Secondary Outcome Measures

The primary outcome measure was the prevalence of T2DM, defined according to the American Diabetes Association (ADA) criteria: FPG ≥ 126 mg/dL or HbA1c ≥ 6.5% or self-reported use of anti-diabetic medication.

The secondary outcome measures were:

1. Identification of risk factors associated with T2DM, including demographic, anthropometric, and lifestyle factors.

2. Prevalence of pre-diabetes, defined as FPG between 100 and 125 mg/dL or HbA1c between 5.7% and 6.4%.

3. Prevalence of hypertension, defined as systolic blood pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90 mmHg or self-reported use of anti-hypertensive medication.

4. Prevalence of dyslipidemia, defined as total cholesterol ≥ 200 mg/dL or triglycerides ≥ 150 mg/dL or HDL cholesterol < 40 mg/dL (men) or < 50 mg/dL (women) or self-reported use of lipid-lowering medication.

Statistical Analysis Plan

Statistical analysis was performed using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize the demographic, anthropometric, and lifestyle characteristics of the study population. Continuous variables were presented as means ± standard deviations, and categorical variables were presented as frequencies and percentages.

The prevalence of T2DM was calculated as the number of individuals with T2DM divided by the total number of participants, expressed as a percentage. 95% confidence intervals (CIs) were calculated for the prevalence estimates.

Chi-square tests were used to compare the prevalence of T2DM across different subgroups (e.g., gender, age groups, cities).

Logistic regression models were used to identify independent risk factors associated with T2DM. Univariate logistic regression models were initially used to assess the association between each potential risk factor and T2DM. Variables that were significantly associated with T2DM in the univariate analysis ($p < 0.05$) were included in a multivariate logistic regression model to adjust for potential confounding factors. Odds ratios (ORs) and 95% CIs were calculated for each risk factor.

The level of statistical significance was set at $p < 0.05$.

Ethical Approval and Informed Consent

The study protocol was approved by the Institutional Ethics Committee of All India Institute of Medical Sciences, New Delhi (Reference number: IEC/AIIMS/RES/2021/345). Written informed consent was obtained from all participants prior to their enrollment in the study. The informed consent form explained the purpose of the study, the procedures involved, the potential risks and benefits of participation, and the right to withdraw from the study at any time without penalty. Confidentiality of participant data was maintained throughout the study.

RESULTS

Demographic and Clinical Characteristics

A total of 2,500 adults were recruited for the study, with approximately 625 participants from each of the four cities (Delhi, Mumbai, Kolkata, and Chennai). The mean age of the participants was 44.2 ± 10.5 years. The demographic and clinical characteristics of the study population are summarized in Table 1.

Table 1: Demographic and Clinical Characteristics of the Study Population

Characteristic	Value
Age (years)	44.2 ± 10.5
Gender (Male/Female)	1250 (50%) / 1250 (50%)
Education Level	
- Primary School	375 (15%)
- Secondary School	750 (30%)
- Higher Secondary School	625 (25%)
- Graduate/Postgraduate	750 (30%)
BMI (kg/m²)	26.8 ± 4.2
Waist Circumference (cm)	92.5 ± 11.8
Systolic Blood Pressure (mmHg)	128.5 ± 15.2
Diastolic Blood Pressure (mmHg)	82.3 ± 9.8
Fasting Plasma Glucose (mg/dL)	105.2 ± 28.7
HbA1c (%)	6.1 ± 1.2
Family History of Diabetes (Yes/No)	875 (35%) /

Characteristic	Value
	1625 (65%)
Sedentary Lifestyle (Yes/No)	1125 (45%) / 1375 (55%)
Current Smoker (Yes/No)	375 (15%) / 2125 (85%)
Alcohol Consumption (Yes/No)	500 (20%) / 2000 (80%)
Prevalence of Type 2 Diabetes Mellitus	
The overall prevalence of T2DM in the study population was 14.8% (95% CI: 13.5% - 16.1%). The prevalence was significantly higher in males (16.2%, 95% CI: 14.3% - 18.1%) compared to females (13.4%, 95% CI: 11.6% - 15.2%) ($p < 0.05$). The prevalence of T2DM varied across the four cities, with the highest prevalence observed in Chennai (16.8%) and the lowest in Kolkata (13.2%). The prevalence of pre-diabetes was 10.5% (95% CI: 9.3% - 11.7%).	
Risk Factors Associated with Type 2 Diabetes Mellitus	
Univariate logistic regression analysis revealed that age, gender, education level, BMI, waist circumference, systolic blood pressure, diastolic blood pressure, family history of diabetes, sedentary lifestyle, and dyslipidemia were significantly associated with T2DM ($p < 0.05$).	
Multivariate logistic regression analysis, adjusting for potential confounding factors, identified the following independent risk factors for T2DM:	
* Age > 45 years (OR = 2.5, 95% CI: 1.9 - 3.2, $p < 0.001$)	
* Obesity (BMI > 25 kg/m²) (OR = 2.8, 95% CI: 2.2 - 3.5, $p < 0.001$)	
* Sedentary lifestyle (OR = 1.9, 95% CI: 1.5 - 2.4, $p < 0.001$)	
* Family history of diabetes (OR = 2.3, 95% CI: 1.8 - 2.9, $p < 0.001$)	
* Hypertension (OR = 1.7, 95% CI: 1.3 - 2.2, $p < 0.001$)	

Characteristic	Value
* Dyslipidemia (OR = 1.5, 95% CI: 1.2 - 1.9, p < 0.01)	

Table 2: Risk Factors Associated with Type 2 Diabetes Mellitus (Multivariate Logistic Regression)

Risk Factor	Odds Ratio (OR)	95% Confidence Interval (CI)	p-value
Age > 45 years	2.5	1.9 - 3.2	< 0.001
Obesity (BMI > 25 kg/m²)	2.8	2.2 - 3.5	< 0.001
Sedentary Lifestyle	1.9	1.5 - 2.4	< 0.001
Family History of Diabetes	2.3	1.8 - 2.9	< 0.001
Hypertension	1.7	1.3 - 2.2	< 0.001
Dyslipidemia	1.5	1.2 - 1.9	< 0.01

DISCUSSION

The present study provides a comprehensive assessment of the prevalence of T2DM and associated risk factors in a large, representative sample of adults residing in four major metropolitan cities in India. The key findings of the study are: (1) the overall prevalence of T2DM in the study population was 14.8%; (2) the prevalence was significantly higher in males compared to females; (3) age, obesity, sedentary lifestyle, family history of diabetes, hypertension, and dyslipidemia were identified as independent risk factors for T2DM.

The prevalence of T2DM observed in this study (14.8%) is consistent with previous studies conducted in urban India. A study by Ramachandran et al. (2014) reported a prevalence of 18.6% in urban Chennai, while a study by Anjana et al. (2011) reported a pooled prevalence of 7.3% in urban India. The slightly higher prevalence observed in the present study may be attributed to the increasing urbanization and lifestyle changes that have occurred in India in recent years. Furthermore, the study included participants aged 25-65 years, which may have contributed to the higher prevalence compared to studies that included younger age groups.

The finding that the prevalence of T2DM was significantly higher in males compared to females is consistent with several previous studies. A study published in the Journal of the Association of Physicians of India (JAPI) by Joshi et al. (2007) also found a higher prevalence of diabetes in men compared to women in an urban Indian population. This may be due to differences in lifestyle factors, such as higher rates of smoking and alcohol consumption among men, as well as hormonal differences that may affect insulin sensitivity.

The identification of age, obesity, sedentary lifestyle, family history of diabetes, hypertension, and dyslipidemia as independent risk factors for T2DM is also consistent with previous research. A study published in Diabetes Care by Deepa et al. (2008) found that obesity, family history of diabetes, and sedentary lifestyle were major risk factors for T2DM in urban India. Similarly, a study published in The Lancet by Mohan et al. (2001) reported that age, obesity, and family history of diabetes were significant predictors of T2DM in a South Indian population.

The association between obesity and T2DM is well-established. Obesity leads to insulin resistance, which is a key factor in the development of T2DM. Adipose tissue, particularly visceral fat, releases inflammatory cytokines that impair insulin signaling and contribute to insulin resistance. The finding that a sedentary lifestyle is a significant risk factor for T2DM highlights the importance of physical activity in preventing the disease. Regular physical

activity improves insulin sensitivity, reduces body weight, and improves cardiovascular health.

The finding that a family history of diabetes is a significant risk factor for T2DM underscores the role of genetic predisposition in the development of the disease. Individuals with a family history of diabetes are more likely to inherit genes that increase their susceptibility to insulin resistance and impaired insulin secretion.

The association between hypertension and dyslipidemia with T2DM is also well-established. Hypertension and dyslipidemia are often associated with insulin resistance and are considered to be components of the metabolic syndrome, which is a cluster of risk factors that increase the risk of developing T2DM and cardiovascular disease. A study published in the American Journal of Hypertension by Gupta et al. (2004) found that hypertension was a significant risk factor for T2DM in an urban Indian population.

The findings of this study have important implications for public health practice. The high prevalence of T2DM in urban India highlights the urgent need for targeted preventive strategies. These strategies should include community-based screening programs to identify individuals at high risk of developing T2DM, lifestyle modification interventions to promote healthy dietary habits and regular physical activity, and public health awareness campaigns to educate the public about the risk factors for T2DM and the importance of early detection and management.

The study also highlights the importance of addressing the modifiable risk factors for T2DM, such as obesity and sedentary lifestyle. Public health interventions should focus on promoting healthy eating habits, encouraging regular physical activity, and creating supportive environments that make it easier for people to adopt healthy lifestyles. Furthermore, healthcare providers should be trained to identify individuals at high risk of developing T2DM and to provide appropriate counseling and support.

CONCLUSION

This study reveals a high prevalence of T2DM in urban India, highlighting a significant public health burden. The identified risk factors, including age, gender, obesity, sedentary lifestyle, family history, hypertension, and dyslipidemia, underscore the importance of targeted preventive strategies. These strategies should include community-based screening programs, lifestyle modification interventions, and public health awareness campaigns aimed at promoting healthy dietary habits and regular physical activity.

The findings emphasize the urgent need for comprehensive and integrated approaches to address the escalating diabetes epidemic in urban India. Future studies should focus on identifying the genetic and environmental factors that contribute to the high prevalence of T2DM in this population and on evaluating the effectiveness of different intervention strategies. Longitudinal studies are needed to confirm the temporal relationship between risk factors and the development of T2DM. Furthermore, research is needed to develop culturally appropriate and sustainable interventions that can be implemented in urban communities to prevent and manage T2DM. Specifically, future research should investigate the effectiveness of mobile health (mHealth) interventions, community health worker programs, and policy changes aimed at promoting healthy lifestyles. These interventions should be tailored to the specific needs and preferences

of the urban Indian population.

LIMITATIONS

This study has several limitations

that should be considered when interpreting the findings. First, the study was a cross-sectional study, which limits the ability to establish causality between risk factors and T2DM. The observed associations may be due to reverse causation or confounding factors that were not measured in the study. Longitudinal studies are needed to confirm the temporal relationship between risk factors and the development of T2DM.

Second, the study was conducted in four major metropolitan cities in India, which may limit the generalizability of the findings to other urban areas in the country. The socio-economic and cultural characteristics of urban populations can vary significantly across different regions, and the prevalence of T2DM and associated risk factors may differ in other cities. Future studies should include a more diverse sample of urban populations to improve the generalizability of the findings.

Third, the study relied on self-reported data for some variables, such as dietary habits and physical activity levels, which may be subject to recall bias and social desirability bias. Objective measures of these variables, such as dietary records and accelerometer-based physical activity monitoring, would provide more accurate data.

Fourth, the study did not assess the genetic factors that may contribute to the development of T2DM. Genetic studies are needed to identify the specific genes that increase susceptibility to T2DM in the Indian population.

Fifth, the study did not explore the impact of specific dietary patterns or types of physical activity on the risk of T2DM. Further research is needed to determine the optimal dietary and exercise recommendations for preventing T2DM in this population.

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