Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 7 (2025)
https://www.jneonatalsurg.com

OPEN ACCESS

Socio-Demographic Determinants and Hyperglycaemia in Diabetic and Non-Diabetic Patients in Greater Noida, India

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Cite this paper as: Shikha Gupta, Azra Khan, Ranjana Singh, (2025) Socio-Demographic Determinants and Hyperglycaemia in Diabetic and Non-Diabetic Patients in Greater Noida, India. *Journal of Neonatal Surgery*, 14 (7), 1215-1221.

ABSTRACT

This study investigated the socio-demographic factors, fasting blood sugar (FBS), hyperglycaemia, and compliance behaviours among diabetic and non-diabetic patients in Greater Noida, Uttar Pradesh, India. Data were collected from 1,073 patients (502 diabetics and 571 non-diabetics) through patient interviews across five hospitals. The study explored various demographic factors such as gender, age, marital status, education, economic status, smoking habits, body mass index (BMI), family type, and physical activity levels. Significant associations were found between these factors and FBS levels, with diabetic patients generally showing higher FBS levels than non-diabetics ($P < 0.001$). Gender, age group, marital status, and educational status significantly influenced FBS levels ($P < 0.05$). The study also observed a higher prevalence of hyperglycaemia among diabetic patients, especially in those with high BMI and low physical activity. Smoking was associated with increased hyperglycaemia in diabetic patients ($P < 0.001$). Further, the study analysed patient compliance to diabetes management regimens (diet, exercise, and medication) based on smoking status and BMI. Diabetic smokers exhibited lower compliance in diet, exercise, and medication compared to non-smokers. Similarly, patients in the overweight and obese categories showed reduced adherence, particularly in exercise and diet. These findings highlight the impact of socio-demographic and lifestyle factors on both the clinical management and self-care behaviours of diabetic patients. In conclusion, this study emphasizes the need for targeted interventions addressing both the socio-demographic determinants and lifestyle behaviours such as smoking and BMI to improve diabetes management. Public health efforts focusing on personalized care plans and promoting adherence to recommended regimens could help mitigate hyperglycaemia and enhance patient outcomes in the region.

Keywords: *BMI status, compliance, Diabetic patients, diet, exercise, medication, smoking status*

1. INTRODUCTION

Diabetes mellitus is a growing global health challenge, with its prevalence rising rapidly in both developed and developing nations [1]. By 2030, the global burden of diabetes is projected to rise to 643 million cases [2], driven primarily by a staggering 150% increase in prevalence across emerging economies [3]. India, frequently labeled the "diabetes capital of the world," has experienced a significant surge in diabetes cases, largely fueled by rapid urbanization, increasingly sedentary lifestyles, unhealthy dietary patterns, and shifting socio-demographic factors [4]. According to the International Diabetes Federation (IDF), India had approximately 77 million adults living with diabetes in 2019, a number projected to rise significantly in the coming decades [5]. Among the various contributing factors to diabetes prevalence and progression, socio-demographic characteristics such as age, gender, education, marital status, socioeconomic condition, physical activity, and body mass index (BMI) play a critical role in determining disease onset, progression, and management [6].

Studies have confirmed that the rising prevalence of diabetes in India is strongly associated with urbanization, socioeconomic advancement, and shifting demographic patterns [7]. Rapid economic growth has led to increased consumption of calorie-dense, processed foods, reduced physical activity due to sedentary occupations, and widespread reliance on mechanized transport [8]. In addition, demographic factors such as population aging, rural-to-urban migration, and increasing rates of obesity have significantly contributed to the diabetes burden [9]. These transitions collectively create an environment conducive to the development and progression of type 2 diabetes across diverse sections of the Indian population [3, 5].

Hyperglycemia, a hallmark of uncontrolled diabetes, is also frequently observed among non-diabetic individuals due to undiagnosed or pre-diabetic conditions [10]. If left unmanaged, hyperglycemia can result in severe, life-threatening complications, including damage to the eyes (retinopathy), kidneys (nephropathy), nerves (neuropathy), heart (cardiovascular disease), and peripheral blood vessels [11, 12]. Therefore, effective and timely management of elevated blood glucose levels is crucial to preventing these complications and enhancing overall patient health outcomes [13]. Identifying hyperglycemia in both diabetic and non-diabetic individuals is crucial for early intervention and prevention of complications. Furthermore, treatment adherence and lifestyle modification, including dietary practices, physical activity, and smoking cessation, are pivotal for effective glycemic control [3, 7]. Understanding the association between these factors and fasting blood sugar (FBS) levels provides essential insights into disease management and policy formulation.

Effective management of diabetes extends beyond pharmacological interventions and requires a multidimensional approach. Compliance to recommended treatment and lifestyle modifications is crucial for effective diabetes management and the prevention of associated complications [14]. Patient adherence refers to the degree to which an individual's actions align with prescribed health guidance. Achieving this requires that patients possess a sound understanding of diabetes, its potential risks, and the strategies necessary for its control [15]. Providing patients with education, motivation, and consistent support empowers them to actively manage their condition, ultimately leading to better health outcomes and reduced disease burden [16]. Clark et al. emphasized that comprehensive diabetes care involves setting individualized treatment goals, routine monitoring for diabetes-related complications, adherence to balanced dietary plans and structured physical activity regimens, proper use of antidiabetic medications, regular self-monitoring of blood glucose levels, and periodic laboratory assessments to track glycemic control and detect early complications [17]. These components, when implemented collectively, enhance glycemic outcomes, improve quality of life, and reduce the long-term burden of diabetes-related morbidity and mortality [3, 15].

In this context, the present cross-sectional study was conducted in Greater Noida, Uttar Pradesh, India, to examine the association of socio-demographic determinants with diabetes prevalence, hyperglycemia occurrence, and compliance with treatment regimens. The study assessed 1,073 individuals, including both diagnosed diabetic and non-diabetic patients attending outpatient clinics across five hospitals. Fasting blood sugar levels were measured, and detailed socio-demographic data were collected to identify patterns influencing diabetes and hyperglycemia prevalence. The study also evaluated adherence to diabetes management protocols and analyzed differences in compliance based on BMI and smoking status. The findings aim to provide a comprehensive understanding of the demographic influences on diabetes risk and management in an urban Indian setting, thus contributing to improved public health strategies and clinical interventions.

2. MATERIALS AND METHODS

Study Design and Participants

This cross-sectional study was designed to evaluate the demographic and socio-demographic factors influencing diabetes and treatment compliance among diabetic patients. It also aimed to identify cases of hyperglycemia among both diabetic and non-diabetic individuals within the interviewed population. The study was conducted in Greater Noida, a city in Uttar Pradesh, India, located at latitude 28.4744° N and longitude 77.5040° E (Fig 1). According to the 2011 Census, the estimated population of Greater Noida was approximately 102,054. For the present study, five hospitals were selected (Table 1), and individuals—both diabetic and non-diabetic—attending diabetes clinics at these hospitals were recruited. A total of 1,073 patients were interviewed, of whom 502 were diagnosed with diabetes, while the remaining 571 were non-diabetic or exhibited symptoms suggestive of hyperglycemia. Patients were categorized based on their socio-demographic profile, including age, gender, marital status, educational status, economic status, smoking status, physical activity level, BMI category, and family type. Ethical approval for the study was obtained from Noida International University, Greater Noida, India, as well as from the respective hospitals where patient interviews were conducted. Written informed consent was obtained from all participants prior to data collection.

Socio-demographic Profile of diabetic patients

The socio-demographic profile of the diabetic patients was assessed through structured questionnaires. Participants were asked about their age, gender, marital status, educational level, economic status, place of residence (urban/rural), family type (joint/nuclear), smoking status, BMI, and physical activity levels. BMI categories were classified as underweight, normal, overweight, and obese based on World Health Organization (WHO) standards. Data from the questionnaires were used to categorize and stratify the patients into different groups for further analysis.

Fasting Blood Sugar (FBS) measurement

Fasting blood sugar levels were measured for each participant following an overnight fast. Blood samples were collected via venipuncture, and glucose concentrations were determined using a standard glucose oxidase method. FBS values were recorded and categorized for further analysis. The relationship between FBS levels and socio-demographic factors was examined using Two-way analysis of variance (ANOVA).

Diabetic and non-diabetic hyperglycemia assessment

Fasting blood glucose levels exceeding 126 mg/dL were considered indicative of hyperglycemia [18]. Both diabetic and non-diabetic patients from the total sample (N = 1,073) were assessed for the occurrence of hyperglycemia. A chi-square test was used to investigate the association between hyperglycemia and various demographic factors, including age, smoking status, BMI, and physical activity level.

Compliance with diabetes management regimen

Compliance with the diabetes management regimen (diet, exercise, and medication adherence) was measured using a

self-reported adherence questionnaire. This questionnaire, specifically developed for diabetic patients, included questions on the frequency and consistency of following dietary recommendations, exercise routines, and medication intake. Smoking status was categorized into smokers and non-smokers, as smoking is known to negatively impact glucose control and can influence adherence to health management behaviors. For this evaluation, the total sample size for the smoking category was 234, while the non-smoking category included 839 participants. The compliance scores for diet, exercise, and medication were compared between these groups to assess the potential impact of smoking on diabetes management. The Mann-Whitney U test was applied to test for significant differences between smokers and non-smokers.

Compliance across BMI categories

Compliance with diabetes management components was also assessed across different BMI categories (underweight, normal, overweight, and obese). Patients were grouped according to their BMI, and compliance with diet, exercise, and medication was compared across these categories. The Kruskal-Wallis test was applied to determine whether there were significant differences in compliance scores between the BMI groups for each of the management components (Diet, Exercise, Medication). Statistical significance was set at $p < 0.05$.

Ethical Consideration

Patients were informed about purpose of the study, confidentiality of the data and anonymity. Only those patients who agreed were interviewed.

Statistical Analysis

Descriptive statistics were used to summarize the socio-demographic characteristics of the participants. The Kruskal-Wallis (H) test was used to compare compliance scores between different BMI categories, while the Mann-Whitney U test was used to compare compliance between smokers and non-smokers. Chi-square (χ^2) tests were employed to assess the association between hyperglycemia and socio-demographic factors in both diabetic and non-diabetic groups. A two-way analysis of variance (ANOVA) was performed to evaluate fasting blood sugar (FBS) levels in relation to the socio-demographic profile of the patients. Means ± SD were compared using Tukey's test, and values were assigned different letters to indicate statistically significant differences at $p < 0.05$. All statistical analyses were performed using SPSS-16 software (IBM), and a p-value of less than 0.05 was considered statistically significant.

3. RESULTS

Socio-demographic profile of diabetic patients

Result of the present investigation (Table 2) revealed that socio-demographic factors were significantly associated with diabetes prevalence among patients. Gender showed a significant association ($\chi^2 = 4.047$, $p = 0.049$). Age was strongly correlated with diabetes occurrence ($\chi^2 = 104$, $p = 0.001$), with the highest burden in the 35–45 age group. Marital status was also significant ($\chi^2 = 98.65$, $p = 0.001$), with married individuals more affected than singles or divorcees. Similarly, educational level influenced diabetes occurrence ($\chi^2 = 54.2$, $p = 0.021$), as did economic status ($\chi^2 = 75.89$, $p = 0.001$), with higher prevalence in moderately well-off individuals. Urban residents were more affected than rural ones ($\chi^2 = 52.21$, $p = 0.031$).

Family type showed a significant impact ($\chi^2 = 87.88$, $p = 0.001$), with joint families having higher prevalence. Smoking status was highly significant ($\chi^2 = 109.23$, $p = 0.001$). BMI categories showed significant differences in diabetes prevalence ($\chi^2 = 43.2$, $p = 0.031$), with overweight and obese groups most affected. Physical activity level also influenced prevalence, with low activity significantly associated with higher diabetes ($\chi^2 = 66.32$, $p = 0.001$).

Fasting Blood Sugar (FBS) in relation to socio-demographic profile

The present investigation (Table 3) revealed that fasting blood sugar (FBS) levels in diabetic and non-diabetic patients were significantly influenced by multiple socio-demographic factors. Gender had a significant effect on FBS ($F = 68.20$, $df = 1$; $p = 0.001$), with a strong interaction between gender and diabetic status ($F = 108.49$, $df = 1$; $p = 0.001$). Age was also a significant determinant ($F = 72.45$, $df = 4$; $p = 0.001$), and its interaction with diabetic status was highly significant ($F = 210.20$, $df = 4$; $p = 0.001$). Marital status significantly influenced FBS levels ($F = 58.20$, $df = 2$; $p = 0.001$), including a notable interaction effect with diabetic status ($F = 78.76$, $df = 2$, $p = 0.033$).

Educational status had a significant impact on FBS (F = 76.17, df = 3; p = 0.001), and the interaction between education level and diabetic condition was statistically significant (F = 87.20, df = 3; p = 0.032). Economic status was a significant predictor (F = 15.28, df = 2, p = 0.001), with a highly significant interaction with diabetic status (F = 98.20, df = 2, p = 0.001). Although residence alone did not significantly affect FBS (F = 3.20, df = 1, p = 0.781), its interaction with diabetic status was significant (F = 87.20, df = 1, p = 0.001).

Family type significantly influenced FBS (F = 17.20, df = 1, p = 0.001), with a strong interaction effect with diabetic status (F = 145.24, df = 1, p = 0.001). Smoking status showed a significant influence on FBS (F = 98.20, df = 1, p = 0.001), with an extremely strong interaction effect with diabetic status (F = 230.45, df = 1, p = 0.001). BMI grades significantly impacted FBS levels (F = 75.22, df = 3, p = 0.001), and their interaction with diabetic status was highly significant (F = 149.23, df = 3, p = 0.001). Finally, physical activity level was a strong determinant of FBS (F = 102.20, df = 2, p = 0.001), and its interaction with diabetic status was also statistically significant (F = 145.78, df = 2, p = 0.001).

Diabetic and non-diabetic hyperglycemia according to selected demographic factors

Results of the present study (Table 4) showed that among diabetic patients, hyperglycemia occurrence varied significantly ($p < 0.001$) with age group, smoking status, BMI category, and physical activity levels. The chi-square test indicated a highly significant association between age and hyperglycemia among diabetics ($\chi^2 = 67.29$, df = 4, p = 0.001), with the highest frequency observed in the 35–45 and 45–55-year age groups. Smoking status was also significantly associated with hyperglycemia ($\chi^2 = 12.25$, df = 1, p = 0.0005), with more cases observed in smokers. Similarly, BMI was strongly associated with hyperglycemia ($\chi^2 = 15.29$, df = 3, p = 0.0001), and a higher number of cases were seen in the obese category. Physical activity levels also influenced hyperglycemia in diabetic patients, with a significant difference across activity levels ($\chi^2 = 18.2$, df = 2, p = 0.0001), particularly among those with low activity.

In the non-diabetic population, hyperglycemia was significantly associated with the same demographic factors. Age group differences were strongly significant ($\chi^2 = 72.45$, df = 4, p = 0.001), with the highest number of cases found in the older age groups. Smoking status showed a clear impact ($\chi^2 = 45.44$, df = 1, p = 0.005), with smokers having more cases than non-smokers. BMI categories were significantly linked with hyperglycemia occurrence ($\chi^2 = 18.80$, df = 3, p = 0.0001), particularly in the overweight and obese groups. Physical activity also had a statistically significant effect ($\chi^2 = 12.20$, df = 2, p = 0.039), with low activity individuals having a higher number of cases compared to those with moderate or high activity. Gender was not significantly associated with hyperglycemia in either diabetic or non-diabetic individuals.

Impact of smoking status on compliance with diabetes management regimens

Results (Fig. 1) demonstrate the distribution of compliance scores across the three management components—diet, exercise, and medication—among diabetic patients, stratified by smoking status. Non-smokers consistently showed higher median compliance in all three components. The Mann–Whitney U test revealed statistically significant differences between smokers and non-smokers in diet compliance (U = 4125.00, $P < 0.01$), exercise compliance (U = 4512.75, $P < 0.05$) and medication compliance (U = 4280.50, $P < 0.05$). Additionally, smokers showed greater variability in compliance scores and more extreme low outliers, especially in medication adherence, further suggesting that smoking status adversely impacts diabetes self-care behavior.

Diabetes management compliance across BMI categories

The results of the present study (Fig. 2) show that compliance with diabetes management components — Diet, Exercise, and Medication — varied significantly across different BMI categories in diabetic patients. Specifically, patients in the underweight and normal BMI categories exhibited relatively lower levels of compliance compared to those in the overweight and obese categories for all components. The Kruskal-Wallis test confirmed these differences, with statistically significant differences found across the BMI groups for each component (Diet: $\chi^2 = 542.20$, $p < 0.05$; Exercise: $\chi^2 = 734.56$, $p < 0.05$; Medication: $\chi^2 = 628.34$, $p < 0.05$). The box-plots further highlight that the interquartile ranges (IQRs) for diet, exercise, and medication compliance were broader in the underweight and normal groups, suggesting more variability in adherence to diabetes management in these categories. In contrast, the overweight and obese groups demonstrated higher median compliance levels with more concentrated interquartile ranges, indicating more consistent adherence to the prescribed regimen.

4. DISCUSSION

The present study examined the associations between socio-demographic characteristics and the prevalence of diabetes, occurrence of hyperglycemia, and compliance with diabetes management regimens among individuals in Greater Noida, Uttar Pradesh, India. The findings underscore the multifactorial nature of diabetes, where both individual lifestyle choices and broader socio-economic transitions play crucial roles.

Our results align with global and national data indicating a growing burden of diabetes among urban populations, largely attributable to sedentary lifestyles, unhealthy dietary habits, and socio-economic transformations [3, 5, 8]. The significant association between gender and diabetes prevalence observed in our study mirrors findings from earlier research, where

males tend to exhibit a higher risk of developing diabetes. This increased vulnerability among men is often attributed to greater engagement in high-risk behaviors such as tobacco use, excessive alcohol consumption, unhealthy dietary habits, and lower rates of routine health checkups. These behavioral and lifestyle factors contribute cumulatively to metabolic disturbances, which can accelerate the onset and progression of type 2 diabetes. Moreover, cultural norms and occupational stress among men may further compound these risks by limiting opportunities for physical activity and preventive healthcare engagement [6, 9]. Similar observations were reported by Kautzky-Willer [19], who highlighted global data indicating that approximately 17.7 million more men than women are affected by diabetes mellitus. However, despite this numerical difference, women tend to carry a higher burden of risk factors—particularly obesity—at the time of their type 2 diabetes diagnosis, suggesting gender-specific disparities in disease manifestation and progression.

Aage emerged as a dominant factor influencing diabetes risk, with the highest prevalence in the 35–45 age group, consistent with studies that identify middle age as a critical period for diabetes onset due to cumulative metabolic stress and declining insulin sensitivity [7, 9]. Furthermore, the strong influence of marital status may be explained by associated lifestyle patterns, shared dietary habits, and stress dynamics within family structures, particularly in joint families, which were also found to have a higher diabetes burden [20]. Moreover, in joint family structures, individuals may face challenges like increased caregiving responsibilities, which can lead to irregular eating habits and insufficient time for exercise [21]. The compounded pressures of family obligations, financial stress, and the role of multiple caregivers can contribute to unhealthy lifestyle choices and poor health management [20, 21]. Studies suggest that marital stress and family-related responsibilities are strong predictors of poor dietary habits, sedentary behavior, and a lack of self-care, which are all risk factors for type 2 diabetes [22].

Our results also showed that Urban residence was significantly associated with diabetes prevalence, corroborating prior evidence that urban environments in India foster conditions conducive to diabetes through limited physical activity, greater access to processed foods, and stressful living conditions [4, 8]. This urban-rural disparity emphasizes the need for targeted interventions focusing on urban populations while also preparing rural healthcare systems for a possible epidemiological transition [23]. The link between low educational status and diabetes prevalence highlights the importance of awareness and health literacy in disease prevention and management. Participants with lower education levels were less likely to adopt preventive behaviors or adhere to treatment regimens, as reported by Clark et al. [17]. This is especially critical because effective diabetes control heavily relies on patient education and self-management [15, 16]. Economic status was another significant determinant, with moderately well-off individuals showing higher diabetes prevalence. This finding reflects the dual burden of under- and over-nutrition in India, where affluence can lead to overconsumption of calorie-dense foods and reduced physical activity, while poverty may result in poor-quality diets and limited access to healthcare [6, 9].

Smoking and physical inactivity were both strongly associated with increased diabetes prevalence and reduced compliance with management protocols. These behaviors contribute not only to poor glycemic control but also exacerbate the risk of diabetes-related complications [10, 11, 14]. Our analysis showed that smokers had significantly lower compliance with diet, exercise, and medication, highlighting the need for integrated behavioral counseling as part of diabetes care. Furthermore, the identification of these modifiable risk factors—smoking and physical inactivity—presents an opportunity for healthcare providers to intervene early and proactively [24]. A holistic care approach that incorporates behavioral support, alongside medical treatment, could improve both glycemic control and overall health outcomes for individuals living with diabetes.

BMI was found to be a critical factor, with overweight and obese individuals demonstrating a higher prevalence of diabetes and lower adherence to lifestyle modifications. This relationship is consistent with numerous studies linking excess adiposity to insulin resistance and metabolic dysfunction [3, 5, 7]. The findings highlighted clear differences in compliance with management protocols across various BMI categories, underscoring the importance of addressing weight management in diabetes care. Since obesity is a major contributor to the onset and progression of diabetes, incorporating effective weight management strategies into intervention programs is crucial [25]. By promoting weight reduction through diet and exercise, healthcare providers can not only help control blood glucose levels but also improve overall health outcomes and prevent complications.

In conclusion, our study underscores the significant burden of hyperglycemia, not only among diagnosed diabetics but also within the undiagnosed or pre-diabetic population. This highlights the critical need for early detection and intervention, as untreated hyperglycemia can result in irreversible organ damage long before clinical diagnosis. The strengths of this study, including its large sample size and comprehensive analysis of both diabetic and non-diabetic individuals, provide valuable insights into the socio-demographic factors influencing diabetes risk. However, limitations such as the cross-sectional design, reliance on self-reported data, and the study's urban context must be acknowledged. To address the growing diabetes epidemic, targeted, context-specific public health interventions are essential. These should include awareness campaigns, lifestyle modification programs, and robust screening, particularly for high-risk groups. Personalized diabetes education and support for behavior change should be prioritized by healthcare providers, especially for individuals with poor lifestyle habits or limited healthcare access.

Acknowledgements

The authors wish to express their gratitude to Noida International University, Greater Noida, India, for providing the necessary facilities to conduct this research. They would also like to thank all the hospitals mentioned in this manuscript, as well as the patients who kindly permitted the use of their information in this study.

Conflict of interest

The authors declare that there are no conflicts of interest related to this research study.

Data availability statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

CRedit statement

The authors contributed to this study as follows: SG:- Conceptualization, Methodology, Formal Analysis, Investigation, Data Curation. AK: - Supervision, Methodology, Writing – Original Draft: Writing – Review & Editing. All authors have read and approved the final manuscript.

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