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Diabetes prevalence and associated risk factors in a Northern Kerala community: A Multistage Sampling Approach

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ABSTRACT

Introduction

Diabetes is a significant metabolic disorder characterized by high blood glucose levels, leading to various complications if not properly managed. Understanding these factors is crucial for early identification, effective prevention, and management of diabetes within this community. Our study focused on the prevalence and risk factors of diabetes in Puzhakkatiri, a village in Malappuram district, Kerala, aiming to provide insights into local epidemiological patterns and targeted public health interventions.

Methodology

The community-based cross-sectional study included 582 participants (≥18 years) selected via multistage sampling from Puzhakkattiri Panchayath, Northern Kerala, India. Selected participants were invited to a camp that was held at the Government school in collaboration with the panchayath office, where participants had their BMI, waist-to-hip ratio, fasting blood sugar (FBS), and postprandial blood sugar (PPBS) levels measured. Sociodemographic data were collected through interviews, and the data were analyzed using SPSS software, with a p-value of 0.05 or lower indicating statistical significance.

Results

The study, with participants having a mean age of 39.13 ± 12.56 years, found a diabetes prevalence of 30% and an impaired glucose tolerance prevalence of 47.4%. Higher diabetes rates were observed among individuals over 40 years (37.2%), those divorced/widowed/separated (46.5%), those with lower education levels (40%), those in unskilled occupations (34.4%), and those with overweight BMI (33%) or high waist-to-hip ratios (34.5%). Significant associations (p-value<0.05) were found between diabetes prevalence and age (p=0.0001) , marital status (p=0.001), education level (p=0.001), occupation (p=0.0001), family type (p=0.0003), BMI (p=0.029), and waist-to-hip ratio (p=0.043).

Conclusion

Our study revealed a high prevalence of diabetes and IGT among participants, highlighting a significant burden of impaired glucose regulation within the population. Key risk factors identified include age over 40, certain marital statuses, lower education levels, unskilled occupations, specific family living arrangements, being overweight, and having a high waist-to-hip ratio.

Key Words: diabetes, Kerala, diabetes prevalence, diabetes complication, prediabetes, waist-hip ratio, body mass index, family adoption program, Malappuram

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INTRODUCTION

Diabetes encompasses various metabolic disorders marked by high blood glucose levels due to issues with insulin secretion, insulin action, or both. This persistent hyperglycemia is linked to long-term damage and failure in organs such as the eyes, kidneys, nerves, heart, and blood vessels. Common symptoms include excessive urination, thirst, weight loss, increased hunger, and blurred vision. Chronic hyperglycemia can also impair growth and increase infection risk. Severe uncontrolled diabetes can lead to life-threatening conditions like ketoacidosis or hyperosmolar syndrome. [1] Over time, diabetes can cause serious complications like vision loss from retinopathy, kidney failure from nephropathy, foot ulcers and amputations from peripheral neuropathy, and gastrointestinal, genitourinary, cardiovascular issues, and sexual dysfunction from autonomic neuropathy. Additionally, diabetic patients are more prone to atherosclerotic cardiovascular diseases, peripheral arterial disease, and cerebrovascular disease, often accompanied by hypertension and lipid metabolism disorders. [1,2]In India, an estimated 77 million adults over 18 years old suffer from type 2 diabetes, and nearly 25 million are prediabetic, indicating a high risk of developing diabetes soon. India has the second highest number of type 2 diabetes mellitus (T2DM) cases worldwide, following China, and this number is expected to nearly double by 2030. Over 50% of individuals are unaware of their diabetic status, leading to health complications if undiagnosed and untreated. The prevalence of diabetes in India among those aged 15-49 is 4.90% (4.80-5.00%), with 24.82% (24.07-25.59%) of cases undiagnosed, higher among males (28.82%) than females (24.22%). According to the ICMR-INDIAB study, Kerala has a diabetes prevalence of 23.6%, ranking third after Goa (26.4%) and Puducherry (26.3%). The pre-diabetes rate in Kerala is 18.1%, and with a weighted diabetes to pre-diabetes prevalence ratio of 1:1, the state faces significant challenges. The mean HbA1c value in Kerala is 8.3 mg/dl, indicating poor glycemic control. [3,4] Researchers attribute the poor achievement of glycemic targets, despite widespread use of NCD drugs, to inadequate treatment escalation, often due to insufficient monitoring and follow-up care. Diabetes mellitus is rapidly emerging as a global epidemic. As a metabolic disorder, improper management of diabetes can result in severe, life-threatening complications and premature death. Additionally, the financial burden of managing this disease and its associated complications is substantial. [3-5]

Diabetes mellitus is influenced by various modifiable and non-modifiable risk factors. Non-modifiable factors include race, family history, genetic predisposition, general immune status, and gender. Modifiable risk factors, which can be mitigated, include education level, occupation, BMI, and waist-to-hip ratio. Additional predictors of diabetes encompass family type, marital status, and age group. Comorbid conditions like hypertension and hyperlipidemia often coexist with diabetes. According to the NFHS-5, middle-aged individuals (45-49), those with a higher BMI, individuals in lower wealth index groups, and residents of southern India are at greater risk of having undiagnosed diabetes. [6-8] Untreated diabetes can lead to numerous complications. Acute issues include diabetic ketoacidosis (DKA) and non-ketotic hyperosmolar coma. Long-term complications can be severe, such as heart disease, stroke, kidney failure, foot ulcers, and eye damage. Insulin's crucial role as an anabolic hormone means that metabolic abnormalities in carbohydrates, lipids, and proteins arise when insulin levels are insufficient or when target tissues primarily skeletal muscles, adipose tissue, and to a lesser degree, the liver exhibit insulin resistance. This resistance can occur at the level of insulin receptors, the signal transduction system, or effector enzymes and genes. [9-11]

Early identification of risk factors for diabetes mellitus is crucial for effective prevention and management of the disease. Recognizing these factors such as genetic predisposition, obesity, sedentary lifestyle, poor diet, and comorbid conditions like hypertension and hyperlipidemia allows for timely intervention, which can delay or prevent the onset of diabetes. [10-12] Early detection enables healthcare providers to implement lifestyle modifications, medical treatments, and monitoring strategies to manage blood glucose levels and reduce the risk of severe complications. This proactive approach not only improves the quality of life for individuals but also reduces the economic burden on healthcare systems by preventing the progression of diabetes and its associated complications. [11-13]

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Kerala is experiencing a significant epidemiologic transition, greatly impacting the state's morbidity and mortality rates. Rapid urbanization and modernization have permeated all levels of society, regardless of religion or economic status, altering lifestyles and creating a conducive environment for non-communicable diseases (NCDs) to thrive. The prevalent NCDs in Kerala include hypertension, diabetes mellitus, stroke, coronary artery disease, and cancer, with diabetes being the most common. Studying the prevalence and risk factors of diabetes in Malappuram district, Kerala, is crucial for developing targeted public health interventions to manage and prevent the disease in this specific region. Understanding local epidemiological data helps in identifying high-risk populations and tailoring prevention strategies to address specific lifestyle and genetic factors prevalent in Malappuram. Additionally, such studies contribute to the broader knowledge base necessary for formulating effective state-wide and national diabetes control programs. [12-14] Under the new curriculum by CBME, as proposed by NMC, the Family Adoption Programme has been initiated for medical students since 2021. This initiative mandates each MBBS student to adopt five families within their field practice area. In line with this, our medical college has undertaken the adoption of Puzhakkatiri, a village located in the Malappuram district in northern Kerala. Gathering data on the prevalence and risk factors of diabetes within this village will provide valuable insights for predicting similar patterns in neighboring villages across northern Kerala.Therefore, the main goal of our study is to determine the prevalence of diabetes among common people in a village in Kerala, India, as well as the determinants that are related to it.

2. METHODOLOGY

2.1. Study Design, Setting,

The current community-based cross-sectional study was carried out in a Family adoption field practice area of a tertiary healthcare facility in Northern Kerala, India.

2.2. Study population and Sample size

The study enrolled participants aged 18 and above residing in the Puzhakkattiri Panchayath.Based on a study conducted in Kerala by Anjana et al., the sample size was estimated using the formula 4pq/d2, where p is prevalence and d is precision, the target confidence level was 95% and the relative precision was 5%. [5] In the suggested study, diabetes was 23.6% prevalent. The formula yielded a minimal sample size of 288.

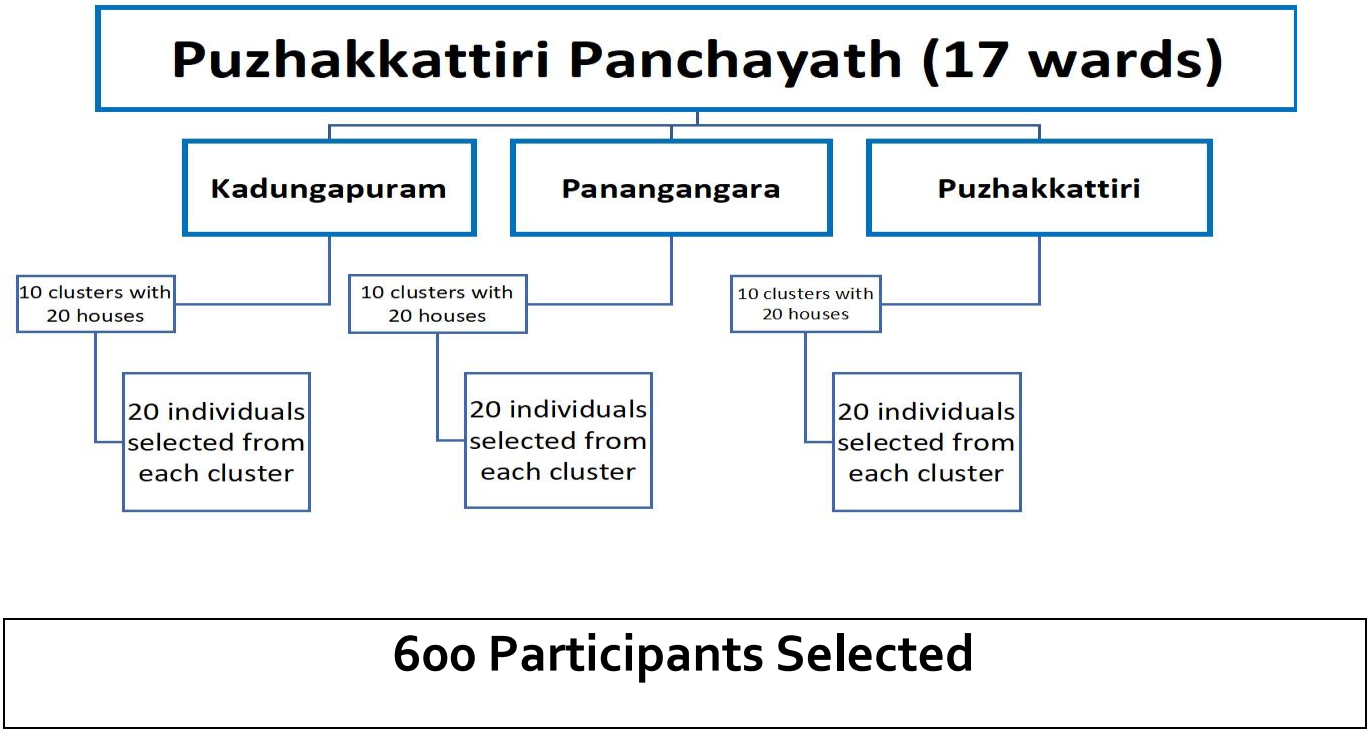

Figure 1: Flowchart illustrating the multi-stage sampling approach employed in our study.

The participant selection process involved three distinct stages employing multistage sampling.

Stage 1: Puzhakkattiri panchayath consisted of 17 wards divided into 3 zones, namely Kadungapuram, Panangangara, and Puzhakatiri, based on the distribution of houses.

Stage 2: Comprised of selecting 10 clusters from each of the 3 zones, each cluster consisting of 20 houses, employing convenient sampling methods.

Stage 3: Entailed constructing a sample frame comprising all individuals above 18 years from the 30 clusters. From this frame, 20 individuals were systematically selected from each cluster using a random method and invited to attend the camp. However, 18 individuals opted out due to various reasons such as inconvenience in attending the camp, illness, or infection. Thus finally, 582 participants were included in the study ie, twice the minimum sample size calculated.

2.3. Method of data collection

A camp was organized at the Government school, Puzhakkatiri in collaboration with the panchayath office to facilitate data collection. Participants were instructed to attend the camp between 6 am and 10 am. In addition to glucose testing, BMI and waist-to-hip ratio measurements were conducted during the camp. Following their consent, fasting blood sugar (FBS) and postprandial blood sugar (PPBS) levels were measured. Diabetic status was defined as FBS values exceeding 126mg/dl and PPBS values surpassing 200mg/dl. Individuals with FBS levels between 110-125mg/dl and PPBS levels between 140-200mg/dl were categorized as having impaired glucose tolerance. [9] Sociodemographic data was gathered through face-to-face interviews utilizing a pre-designed and pretested questionnaire.The gathered data underwent categorization into percentages and cross-tabulation across multiple variables. Analysis was conducted using Version 26 of the SPSS software. Bivariate analysis included the generation of chi-square values, with statistical significance set at a p-value of 0.05 or lower.

2.4. Ethical consideration

All study participants were assured of complete confidentiality and anonymity, and their involvement was entirely voluntary. Prior to participation, potential participants were provided with comprehensive information regarding the study's objectives and nature, and written informed consent was obtained from each individual. Ethics clearance with reference number No.IEC/MES/13/2023 was obtained before commencing the study from the Institutional Review Board.

3. RESULTS

3.1. Sociodemographic features (n=582)

Our study included participants ranging in age from 18 to 85 years, with a mean age of 39.13 +/- 12.56 years. The largest proportion fell within the age range of 40 to 49 years, comprising 23.4% of the sample. Gender distribution was diverse, with females constituting 62.5% of the participants. Occupation varied among participants, with 58.4% being unemployed, primarily homemakers, 15% working as unskilled laborers, and 3.6% holding semi-professional positions. Education levels varied, with 36% having completed high school and nearly 18% having attained a degree. The majority of participants came from nuclear families (44.8%), were married (80%), and identified as Muslim (75.4%). Under BMI, the majority fell within the pre-obese category at 30.5%, overweight and obese participants represent 19.3% and 11.3% of the sample, respectively. The majority of participants (91.7% males and 89.3% females) had a high waist-hip ratio (Table -1)

Table 1:Sociodemographic characteristics of the study population (n=582)

SOCIODEMOGRAPHY		Frequency (n)	Percentage (%)
GENDER	Male	218	37.5
	Female	364	62.5
RELIGION	Hindu	143	24.6
	Islam	439	75.4
MARITAL STATUS	Unmarried	43	07.4
	Married	466	80.1

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	Legally divorced	2	0.30
	Separated	9	01.5
	Widow/widower	62	10.7
EDUCATION STATUS	Illiterate	49	08.4
	Primary school	94	16.2
	Middle school	113	19.4
	High school	210	36.1
	Degree	103	17.7
	Professional degree	13	02.2
OCCUPATION	Professional	21	03.6
	Clerical/shop/farm	30	05.2
	Skilled worker	27	04.6
	Semiskilled worker	40	06.9
	Unskilled worker	87	14.9
	Student	37	06.4
	Unemployed	340	58.4
TYPE OF FAMILY	Nuclear	261	44.8
	Joint	99	17.0
	Three generation	222	38.1
AGE GROUP	19-29	82	14.1
	30-39	116	19.9
	40-49	136	23.4
	50-59	103	17.7
	60-69	86	14.8
	>70	59	10.1
BMI	Underweight	52	09.5
	Normal	162	29.5
	Overweight	106	19.3
	Pre-obese	168	30.5
	Obese	62	11.3
WHR MALE	Normal	18	08.3
	High	200	91.7
WHR FEMALE	Normal	39	10.7
	High	325	89.3

3.2. Prevalence of diabetes (n=582)

The prevalence of diabetes among the study participants was 30% (95% CI: 26.28% - 33.72%), with 174 individuals identified as diabetic. Impaired glucose tolerance(IGT) was more common, accounting for 47.4% of the sample, with 276 participants falling into this category. Those classified as having normal glucose levels represent 22.7% of the total, comprising 132 individuals. These findings underscore the significant burden of impaired glucose regulation within the population, with nearly three-quarters of participants exhibiting abnormal glucose metabolism- either impaired glucose tolerance or diabetes.

3.3. Risk factors of diabetes (n=582)

Participants aged more than 40 years had the highest proportion of diabetes (37.2%), compared to those less than 40 years (15.7%). The p-value of 0.0001 and an odds ratio (OR) of 3.196 suggested a statistically significant and substantially increased risk of diabetes for individuals over 40 years old. Participants who were divorced/widowed or separated had the highest proportion of diabetes at 46.5%, compared to their counterparts, while 71% of married participants were

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non-diabetic, showing a highly statistically significant association. Additionally, 40% proportion of participants with below higher secondary education had diabetes, in contrast to 22% among those with higher education, with a p-value of 0.001, indicating a significant relationship between education level and diabetes. Furthermore, 34.4% of participants in unskilled or lower occupations had diabetes, compared to 11.8% in skilled or higher occupations, also showing a highly significant association. Those living in nuclear and three-generation families had higher proportions of diabetes at 35% and 32%, respectively, compared to those in joint families, with a statistically significant relationship. In our study, a higher proportion of diabetes was found among those in the overweight and above BMI category (33%), compared to a lower proportion (24.3%) in the normal and below BMI category. The odds ratio was 1.537, with a statistically significant p-value of <0.0001. In the current study, 34.5% of male participants with a high waist-to-hip ratio were diabetic, compared to 11.0% of those with a normal waist-to-hip ratio. This demonstrates a higher prevalence of diabetes among males with a high waist-to-hip ratio. The association between the waist-to-hip ratio and diabetes was statistically significant, with a p-value of 0.043. (Table-2)

Table 2: Risk factors and its association with diabetes mellitus (n=582)

Risk Factors		DIABETIC STATUS		Total	P value and risk
		DIABETIC n(%)	NOT DIABETIC n(%)		
Age	>40	143 (37.2)	241 (62.8)	384	**0.0001**
	<40	31 (15.7)	167 (84.3)	198	**(OR= 3.196)**
Religion	Hindu	37 (25.9)	106 (74.1)	143	0.226
	Muslim	137 (31.2)	302 (68.8)	439	
Gender	Male	71 (32.6)	147 (67.4)	218	0.276
	Female	103 (28.3)	261 (71.7)	364	
Marital status	Unmarried	5 (11.6)	38 (88.4)	43	**0.001**
	Married	135 (29.0)	331 (71.0)	466	
	Others	34 (46.5)	39 (53.5)	73	
Education	Below high school	104 (40)	152 (60)	256	**0.001**
	Above high school	70 (22)	256 (78)	326	
Occupation	Skilled and above	14 (11.8)	104 (88.2)	118	**0.0001**
	Unskilled and below	160 (34.4)	304 (65.6)	464	
Type of family	Joint	11 (11.1)	88 (88.9)	99	**0.0003**
	Nuclear	92 (35.0)	169 (65.0)	261	

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	Three generation	71 (32.0)	151 (68.0)	222	
BMI	Overweight and above	111 (33.0)	225 (67.0)	336	**0.029 (OR=1.537)**
	Normal and below	52 (24.3)	162 (75.7)	214	
WHR Male	Normal	2 (11.0)	16 (89.0)	18	**0.043 (OR= 0.237)**
	High	69 (34.5)	131 (65.5)	200	
WHR Female	Normal	10 (25.6)	29 (74.4)	39	0.697
	High	93 (28.6)	232 (71.4)	325	

4.DISCUSSION

Diabetes is a critical and multifaceted disease, gaining significance due to its iceberg phenomenon and the numerous complications it can cause. Despite extensive research on diabetes prevalence and contributing factors, awareness remains insufficient in many rural areas. Providing these communities with accurate research findings is essential for increasing awareness of their condition and encouraging proactive measures to prevent diabetes and its associated complications.

The prevalence of diabetes varies significantly across different studies conducted in various regions and populations. In our study, the prevalence of diabetes was found to be 30%, which falls within the range of the reported prevalence rates. In our study, more proportion of diabetes was found among the male population. According to NFHS-5, the prevalence of diabetes in India is 14.5%, with 15.6% in males and 13.5% in females. In rural areas, the prevalence rate is slightly lower at 13.4%. [15] In contrast, our study found a significantly higher prevalence of diabetes at 30%. This discrepancy may be due to differences in the age group selected, lifestyle factors, or healthcare access in the specific population we studied. According to recent statistics by ICMR, the prevalence of diabetes in Kerala is 23.6%. [5] The NFHS-5 district data sheet reported a diabetes prevalence of 22.7% among the population 15 years and above in Malappuram, closely aligning with the overall state prevalence. [16] Although our study found a higher prevalence rate of 30%, it remains relatively consistent with these reported figures, suggesting regional variations and similarities in diabetes prevalence.

Several studies have reported lower prevalence rates than ours, including Usha Menon et al in Central Kerala (19%), S Ashwathy et al in the coastal areas of southern Kerala (7.4%), V Ramankutty et al in Trivandrum (16.3%), C R Soman et al in Southern Kerala (6%), P S Sharma et al in Kerala (19.2%), Ramachandran et al in South India (12.1%), Mathur et al in India (9.3%), Gupta et al in North India (2.6%), Shora et al in Jammu (8.9%), and Kokiwar et al in North India (3.67%). [17-26] Similarly, international studies like those by Alireza et al in Iran (7.7%), Limin Wang et al in China (12.4%), Witcher et al in the United Kingdom (7.1%), and Reis et al in Brazil (7.6%) also reported lower prevalence rates compared to our study. [27-30] Conversely, studies by Sachin Athre et al in South Indian states (1.9% to 25.2%), Vijayakumar et al in Kerala (22%), V Mohan et al in Kerala (20.2%), Magliano et al in districts of Australia (35%), Yousef et al in Jordan (71%), Vasanthakumar et al in Belgavi, Karnataka (60%), B Zhou et al in American Samoa (>30%), and Sathyan M et al in Bangalore (33%) reported higher prevalence rates of diabetes. [31-37] These discrepancies are often attributed to behavioral traits linked to socioeconomic status, as well as regional, dietary, and cultural variations among different populations. In the present study, we observed a higher percentage of IGT at 47.4%. Various other studies reported lower prevalences, such as Usha Menon et al (4.1%), [17] Ramankutty et al (3%), [19] Ramachandran et al (4.6%), [22] Mathur et al (24.5%), [23] Kokiwar et al (13.6%), [26] Alireza et al (16.8%), [27] Wang et al (38.1%), [28] and Vijayakumar et al (45%). [32] The ICMR INDIAB study reported an IGT prevalence of around 15.3%. [5] The differences in results may stem from varying age group selections, as many studies, including NFHS-5, included

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individuals aged 15 and above, along with cultural and geographic differences.

In our study, a higher proportion of diabetes was observed in individuals over the age of 40. This finding aligns with the WHO report, which predicts that India and other developing countries will see the most significant increase in diabetes cases among those aged 41-60 years and older. [38] Studies by Usha Menon et al, S. Ashwathy et al, Ramankutty et al, and Ramachandran et al also support this trend. This higher prevalence in older age groups is likely due to the cumulative effects of prolonged exposure to risk factors such as poor diet, sedentary lifestyle, and genetic predisposition. Our study found a higher proportion of diabetes among divorced or separated individuals. Research by Inas Pellon et al supports this, showing that divorced people have a higher incidence of chronic conditions like hypertension and diabetes compared to married individuals. [39] Concurrently, Oliveira et al found that those who remained married were less likely to develop diabetes, despite weight gain, than their divorced counterparts. [40] Further, Cornellis et al also found higher relative risks (RR) for developing T2D in divorced or separated individuals compared to those who are married. [41] This may be due to the increased stress and lifestyle changes associated with marital separation. Our study found that individuals with lower education and occupational levels tend to have a higher proportion of diabetes. This finding is supported by studies conducted by S Aswathy et al, [18] R Mehrotra et al and Yuwei Qui et al. [42, 43] This may be due to limited access to health information, lower health literacy, and fewer resources for maintaining a healthy lifestyle in these populations.

Contrary to our finding of a higher proportion of diabetes in nuclear families, Kittima et al found no statistical significance between family type and diabetes in their research. [44] However, Saranya Ravi et al reported that joint families with strong support networks tend to reduce the incidence of diabetes among members. [45] Similarly, a study by Suzanne et al found that larger families with good communication can help decrease diabetes and other disease conditions. [46] In our research, a BMI over 23.5 and a high waist-to-hip ratio in males were identified as risk factors for diabetes. This finding is consistent with several studies across India, which have also found that an above-normal BMI and abdominal obesity, including high WHR, are significant risk factors for diabetes. Research by Usha Menon et al, [17] Ramankutty et al, [19] Gupta et al, [24], and Ramachandran et al [22] supported this conclusion. The increased risk of diabetes associated with high BMI and WHR is likely due to the accumulation of visceral fat, which leads to insulin resistance and inflammation, thereby increasing the likelihood of developing diabetes.

Overall, the results of our study demonstrated a higher prevalence of diabetes which is influenced by factors such as age, education, occupation, marital status, type of family, BMI category, and WHR. These variables can be addressed through focused interventions, resulting in good clinical practices and better healthcare results in the rural village.

5. CONCLUSION

Our study revealed a high prevalence of diabetes among the participants, with 30% identified as diabetic. Impaired glucose tolerance was even more common, affecting 47.4% of the sample. These findings highlighted the significant burden of impaired glucose regulation within the population, indicating that nearly three-quarters of participants exhibited abnormal glucose metabolism, either in the form of impaired glucose tolerance or diabetes. Several risk factors for diabetes were identified in this study. Age over 40 years, marital status (divorced, widowed, or separated), lower education, unskilled occupations, living in nuclear or three-generation families, being overweight, and having a high waist-to-hip ratio were identified as significant risk factors for diabetes. These findings highlight the complex interplay of sociodemographic, educational, and lifestyle factors in diabetes risk. Targeted interventions are needed to promote responsible medication practices, and improve public awareness, healthcare provider education, and patient-centered care. Enhancing the availability and accessibility of professional healthcare services can reduce reliance on self-medication and improve healthcare outcomes.

6. LIMITATIONS

The study's limitations include its reliance on a single geographic location, which may not be representative of broader regional or national populations. Also, the study may not be generalizable to other cultural or regional contexts, which would reduce the external validity of the findings. Despite

these limitations, the study provides valuable insights into the prevalence and risk factors of diabetes, laying a strong foundation for future research in this critical area.

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Declarations

The authors of this article declare that they have no financial or personal relationships with other individuals or organizations that could inappropriately influence or bias their work. There are no employment affiliations, consultancies, stock ownership, honoraria, paid expert testimonies, patent applications/registrations, or any other financial or personal relationships that could be perceived as a conflict of interest in connection with this research.Furthermore, there are no non-financial relationships, such as partnerships, collaborations, or affiliations of any nature, that could potentially affect the objectivity, integrity, or impartiality of this study. The authors have not been involved in the development of any system or technology under evaluation in this study. This article is presented with full transparency and adherence to ethical standards, and the authors affirm that there are no conflicts of interest that could compromise the credibility or validity of the research presented herein.

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