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PREVALENCE OF PREDIABETES AND UNDETECTED DIABETES MELLITUS AND ITS RISK FACTORS IN RURAL TAMIL NADU, INDIA

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ABSTRACT

Background: Prediabetes and undetected diabetes contribute substantially to the growing burden of diabetes in India, particularly in rural communities where community-based epidemiological data remain limited. This study aimed to estimate the prevalence of prediabetes and undetected diabetes and to identify their associated risk factors among adults residing in rural Tamil Nadu.

Methods: In a community-based analytic cross-sectional study, 330 adults aged ≥30 years from four rural villages in Villupuram district, Tamil Nadu were screened for prediabetes and diabetes, between June and August 2017 using Indian Council of Medical Research (ICMR) criteria of fasting blood glucose level and oral glucose tolerance test. Multivariable binary logistic regression analysis was performed to identify its independent predictors.

Results: The prevalence of prediabetes was 15.5% and newly diagnosed diabetes was 14.8%. Increasing age, higher body mass index, and living in a joint family were independently associated with prediabetes. Increasing age, higher body mass index, living in a joint family, and family history of diabetes mellitus were independently associated with diabetes.

Conclusion: A substantial burden of prediabetes and undetected diabetes was observed among adults in rural Tamil Nadu. Strengthening community-based screening and targeted lifestyle interventions among high-risk individuals may facilitate early detection and reduce the future burden of type 2 diabetes.

KEYWORDS: Type 2 Diabetes Mellitus; Prediabetes; Risk Factors.

INTRODUCTION

Diabetes mellitus is one of the most rapidly escalating public health issues of the 21st century. According to the World Health Organization (WHO), the global prevalence of diabetes has surged sharply, increasing from about 200 million individuals in 1990 to an estimated 830 million by 2022, with the most significant growth occurring in Low and Middle-Income Countries (LMICs).[1] Diabetes mellitus is not only common, but it also contributes significantly to premature death. Over 2 million deaths worldwide were attributed to diabetes and related kidney disease in 2021, and over 11% of all cardiovascular deaths were associated with elevated blood glucose levels.[1] According to the International Diabetes Federation's Diabetes Atlas (10th Edition, 2021), the number of adults with diabetes between the ages of 20 and 79 is expected to increase from 537 million to around 783 million by 2045, underscoring the urgent need for targeted preventive and early detection initiatives.[2]

The landmark ICMR-INDIAB national cross-sectional study (ICMR-INDIAB-17), published in *The Lancet Diabetes & Endocrinology* in 2023, found that roughly 101 million people in India are currently living with diabetes, significantly higher than the 77 million estimated in 2019 and that another 136 million adults are in a prediabetic state.[3] Alarmingly, nearly 57% of those with diabetes remain undiagnosed, pointing to a large, underserved population at risk of avoidable complications.[3] The National Centre for Disease Control (NCDC), under the Ministry of Health and Family Welfare (MoHFW), has termed diabetes as a priority non-communicable disease (NCD) within the National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases and Stroke (NPCDCS), underscoring the urgent need for state-level monitoring and community-driven interventions.[4]

Prediabetes, defined as Impaired Fasting Glucose (IFG) or Impaired Glucose Tolerance (IGT), is a significant factor in the development from normal glucose levels to type 2 diabetes mellitus. People with prediabetes already have an elevated risk of cardiovascular disease, microvascular complications, and death from any cause, and they have a yearly chance of developing type 2 diabetes mellitus (T2DM) of approximately 5–10% if they do not make prompt lifestyle or medical treatment modifications.[2,5] In situations with limited resources, screening people to identify this high-risk category is one of the most economical methods available to healthcare organizations.

Tamil Nadu, one of India's most urbanized and economically advanced states, continues to bear a substantial burden of diabetes. The ICMR-INDIAB national study estimated the prevalence of diabetes in Tamil Nadu at 14.4% (95% CI: 7.9–21.2) and prediabetes at 10.2% (95% CI: 4.4–16.1), placing the state among those with a high burden of dysglycaemia in India.[3] Although the urban diabetes crisis in the state has drawn considerable research focus, the rural population of Tamil

Nadu remains relatively under studied, even though it is experiencing a swift epidemiological and nutritional shift marked by rising sedentary lifestyles, high consumption of refined carbohydrates (especially white rice as a staple), overweight and obesity, hypertension, and decreased physical activity.[6] These lifestyle-related risk factors, exacerbated by low health awareness, limited access to diagnostic services, and widespread undiagnosed cases, foster an environment ripe for a hidden diabetes epidemic in rural communities.

Community-based studies in South India indicate that both diabetes and prediabetes are increasing in rural populations at a rate similar to that in urban areas, but reliable, population-representative data from rural districts of Tamil Nadu are still limited. In this context, the current study aimed to assess the prevalence of prediabetes and newly diagnosed diabetes, as well as to determine their associated risk factors, among adults in rural Tamil Nadu.

1. METHODS

1.1 Study setting and design

A community-based, analytic cross-sectional study was conducted in four villages (Keerimedu, Semmar, Sithalingamadam, and Periyasevalai) under the field practice areas of the Rural Health Training Centre (RHTC), Department of Community Medicine in a tertiary care centre at Puducherry. The RHTC is situated in Thiruvennainallur, Villupuram district, Tamil Nadu.

1.2 Study participants

Adults aged ≥30 years residing in the study villages were eligible for inclusion. Individuals already having diagnosed as a case of diabetes mellitus, critically ill patients, and pregnant women were excluded from the study.

1.3 Sample size

Based on an estimated prevalence of undetected diabetes of 15.3% in rural community settings, an absolute precision of 4%, a design effect of 1, and a 95% confidence interval, the required sample size was calculated as 312 using Open Epi (version 3.01)[7]. Accounting for a 5% non-response rate, the final sample size was set at 330.

The formula used was:

Sample size (n) = $[DEFF \times N \times p(1-p)] / [d^2/Z^2_{1-\alpha} \times (N-1) + p(1-p)]$

where N= population size; p= hypothesized prevalence (15.3%); d= absolute precision (4%); DEFF = design effect (1); $Z_{1-\alpha} = 1.96$.

1.4 Sampling procedure

A three-stage systematic random sampling strategy was employed. The total population of the four study villages was 15,862, comprising 2,710 households. The village-wise population was 1,574 (Keerimedu), 2,320 (Semmar), 5,684 (Sithalingamadam), and 6,284 (Periyasevalai), with corresponding household counts of 350, 490, 770, and 1,100, respectively. The total sample size of 330 was equally allocated across the four villages, with 82 participants selected from each of the first three villages and 84 participants from the fourth village.

At the second stage, households within each village were selected using systematic random sampling. The sampling interval (k) was calculated separately for each village by dividing the total number of households by the required sample size, yielding sampling intervals of approximately 4, 6, 9, and 13 households for Keerimedu, Semmar, Sithalingamadam, and Periyasevalai, respectively. A random starting household within the selected direction was identified using a random number, following which every k^{th} household was visited until the required sample size for each village was achieved.

At the third stage, all eligible adults aged ≥30 years available for the study from each selected household were included in the study.

1.5 Operational definitions

Prediabetes: Fasting blood glucose (FBG) of 110–125 mg/dL or a 2-hour post-glucose load blood glucose of 140–199 mg/dL (ICMR).[8]

Undetected Diabetes Mellitus: An individual with no prior physician-confirmed diagnosis of diabetes but whose plasma glucose values satisfied established criteria — FBG ≥126 mg/dL or 2-hour post-glucose load blood glucose ≥200 mg/dL. Normoglycaemia: FBG <110 mg/dL and 2-hour post-glucose load blood glucose <140 mg/dL.[8]

1.6 Data collection tool

A structured, pre-tested, interviewer-administered questionnaire was developed following a comprehensive literature review to identify previously studied variables relevant to prediabetes and diabetes. Questions were arranged in a logical sequence and grouped thematically. Content validity was assessed by faculty with expertise in diabetes management. The questionnaire was pre-tested on 22 asymptomatic adults aged ≥30 years residing outside the study villages, and after required corrections to improve clarity, comprehension, and question ordering, it was used for data collection.

1.7 Data collection procedure

A house-to-house visits by a trained postgraduate student in Community Medicine, assisted by medical interns. The questionnaire captured sociodemographic information, tobacco and alcohol consumption. A written informed consent was obtained from all participants prior to enrolment. Interviews using a conversational technique were conducted after 17:00 hrs to maximise respondent availability.

An appointment was fixed for the following morning around 06:00 am for blood glucose estimation. Participants were convinced to have dinner between 8-10 pm and not to have anything till the team arrived to maintain overnight fasting status. Following day morning between 6-7:30 fasting capillary blood glucose was measured using a glucometer (Accu-Chek Active, Model GB, Roche Diagnostics), with reported sensitivity 81.4%, specificity 97.8%, positive predictive value 71.4%, and negative predictive value 98.7%.[9] Fingertip was pricked using an Accu-Chek Softclix lancing device following standard aseptic technique. Participants having FBG ≥110 mg/dL were provided 75 gram of glucose dissolved in 250 mL of water orally within 10 minutes, and a second capillary blood glucose level measurement was performed using the same

method and techniques after two hours of glucose loading. Participants were instructed to remain at rest and refrain from smoking or eating between the two samples. Participants having prediabetes and diabetes conditions were referred to the NCD clinic at RHTC-SMVMCH for further evaluation, physical activity and dietary modification counselling and free medical treatment.

1.8 Ethical considerations

The study was approved by the Institutional Research Committee and Ethics Committee (Human Studies) (IEC No. 90/2016).

1.9 Statistical analysis

Data were entered in Epi_Info (version 7.2.2.6) and analysed using SPSS (version 24.0). The dataset was cleaned for missing values and typographical errors prior to analysis. Categorical variables are presented as frequencies and percentages; the normally distributed continuous variable age is expressed as mean ± standard deviation. Age, body mass index, and waist-hip ratio were entered into the logistic regression models as continuous variables, while all other variables were analysed as categorical variables. Un-adjusted odds ratios (OR) with 95% confidence intervals (CI) were computed to examine associations between 12 independent variables (age, sex, occupation, educational status, marital status, family type, monthly income, waist-hip ratio, BMI, alcohol use, smoking, and family history of diabetes) and two dependent variables, prediabetes and newly diagnosed diabetes. Sparse categories were merged before analysis. Multivariate binary logistic regression (Enter method) was then performed to identify independent predictors of each outcome; multicollinearity was assessed by the tolerance statistic and model fit by R^2. Statistical significance was set at $p < 0.05$.

RESULTS

The results of the study are presented in table 1-4.

The average age of participants was 49.4 ± 13.4 years and 64.5% of them were females. Most of the participants were Hindu, belonging to nuclear families. Slightly more than half had monthly family income Rs five thousand or more.

Of the 330 participants, 15.5% (95% CI: 11.9–19.8%) were detected as prediabetics, while 14.8% (95% CI: 11.3–19.2%) as diabetics. Prediabetes was more prevalent among males 17.1% as compared to females 14.5% while undetected diabetes was almost equally prevalent in both the genders.

In multivariate analysis revealed increasing age and Body Mass Index and living in the joint family independently associated with prediabetes. One-year of increase in age led to increase of prediabetes increased 4% (AOR 1.04; 95% CI: 1.01–1.06; p=0.05) and for one-unit increase in BMI led to increase, prediabetes by 12% (AOR 1.12; 95% CI: 1.03–1.22; p<0.05). Joint family had higher odds 2.77 (95%CI: 1.26–6.08, p<0.05) compared to the nuclear family. The Naglekerke pseudo- R^2 value for the final model was 19 percent. There was no multicollinearity among the variables.

In multivariate analysis, four variables emerged as significant predictors of diabetes and the risk for unit increase in age was found to increase diabetes by 1.07 times (95%CI: 1.04–1.10, p=0.001). Similarly, one unit increase in BMI led to increase in diabetes by, 1.16 times (95%CI: 1.06–1.26, p=0.00). Joint family had 2.24 times (95%CI: 1.01–5.57, p=0.04) higher risk of diabetes as compared to nuclear family and positive family history had 3.3 times higher risk of diabetes (95% CI: 1.20–9.30; p = 0.02). The Naglekerke pseudo-R^2 value for the final model was 22.4 percent. There was no multicollinearity among the variables.

DISCUSSION

The prevalence of prediabetes in the present study was 15.5%, which was comparable to the national prevalence of 15.3% reported by the ICMR-INDIAB-17 survey.[3] However; it was higher than the Tamil Nadu-specific prevalence of 10.2% reported in the same survey. In contrast, a higher prevalence of 21.8% was reported by Baburaj et al. in a rural community in Chengalpattu district in 2025[10]. The differences in prevalence across these studies may be attributed to variations in the study population, sampling methodology, geographical location, and study period. The higher prevalence reported by Baburaj et al. may also reflect the ongoing epidemiological transition in rural Tamil Nadu over time[10].

Similar to earlier community-based studies from Tamil Nadu, Bengaluru, Bangladesh, and Iran, our study found that increasing age and a greater body mass index were independent predictors of prediabetes[11-15]. However, our investigation revealed that "living in a joint family" was an unexplained factor that was independently linked to prediabetes. This finding requires additional research and correlation analysis.

The prevalence of undiagnosed diabetes in the present study was 14.8%, which was considerably higher than the 8.9% reported for Tamil Nadu among adults aged more than 20 years in the ICMR-INDIAB Phase I study.[16] This difference may be partly explained by the inclusion of adults aged ≥30 years in the present study, resulting in a study population with a higher baseline risk of diabetes, in addition to the temporal gap between the two studies during which the burden of diabetes has continued to increase. A community-based study from rural Thanjavur reported a comparable prevalence of 12.85%, suggesting a growing burden of undiagnosed diabetes across rural Tamil Nadu.[17] The ICMR-INDIAB-17 study also highlighted the continuing burden of undiagnosed diabetes in India, providing further context to the present findings.[3] Differences in study design, diagnostic criteria, study period, and sampling methodology should be considered while interpreting these comparisons.

A multivariate analysis after adjusting potential confounders depicted that increasing age, higher body mass index, family history of diabetes mellitus and living in a joint family were an independent predictor of newly diagnosed diabetes. However, association of joint family as an independent predictor of diabetes could not explained and need further exploration. Rest of the factors BMI, increasing age and family history as an independent predictor of diabetes are in conformity with a community-based study from rural Tamil Nadu, Sosale et al in a multicentric hospital-based study, a study from United Kingdom and a community-based study from East Africa.[18-21]

CONCLUSION

Present study revealed considerable burden of prediabetes and undetected diabetes among adults of rural Tamil Nadu. Increasing age, higher body mass index, and living in a joint family were independently associated with prediabetes, however in addition to those factors associated with prediabetes, an additional factor i.e. family, and family history of diabetes mellitus was a significant predictor of diabetes.

Limitations of the study: The findings may not be generalizable to urban populations or other regions with different demographic and lifestyle characteristics. However, the cross-sectional study design precludes establishing temporal or causal relationships between the identified risk factors and dysglycaemia.

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TABLES AND FIGURES

Table 1. Socio-demographic details of the respondents (N=330)

Variables	n (%)
Age (Years)	
30 - 59	270 (81.8)
≥ 60	60 (18.2)

Variables	n (%)
Gender	
Male	117 (35.5)
Female	213 (64.5)
Occupation	
Involves more physical activity (Agricultural work, Labour, Animal Rearing)	239 (72.4)
Involves less physical activity (House work, Business, Profession)	91 (27.6)
Educational status	
Illiterate	181 (54.8)
Literate	149 (45.2)
Religion	
Hindu	327 (99.1)
Muslim	3 (0.9)
Marital status	
Married	290 (87.9)
Never married	8 (2.4)
Widowed	31 (9.4)
Divorced	1 (0.3)
Type of family	
Joint	62 (18.8)
Nuclear	256 (77.6)
Three generation family	6 (1.8)
Living alone	6 (1.8)
Monthly family income (Indian Rupees)	
< 5000	148 (44.8)
≥ 5000	182 (55.2)

Table 2. Prevalence of Prediabetes and newly diagnosed diabetes among respondents

Variables	Cut off value		Male n=117	Female n=213	Total N=330
Prediabetes	Fasting Plasma Glucose ≥ 110 and <126 mg/dl	2 hour Post Glucose ≥ 140 and <200 mg/dl	20 (17.1)	31 (14.6)	51 (15.5)

Variables	Cut off value		Male n=117	Female n=213	Total N=330
Newly diagnosed diabetes	Fasting Plasma Glucose ≥ 126 mg/dl	2 hour Post Glucose ≥ 200 mg/dl	17 (14.5)	32 (15)	49 (14.8)

Figures in parenthesis are percentages

Table 3. Multivariate logistic regression analysis for the determinants of Prediabetes

Variables	Total N=281	Prediabetes n (%)	Adjusted OR (95% CI)	p value
Age ≥ 30 years	281	51	1.04 (1.01 – 1.06)*	0.05*
Gender				
Male	100	20 (20)	1.24 (0.50 – 3.06)	0.64
Female	181	31 (17.1)	1	
Occupation				
Involves less physical activity	73	18 (24.6)	0.50 (0.24 – 1.03)	0.61
Involves more physical activity	208	33 (15.9)	1	
Educational status				
Literate	128	29 (22.6)	0.55 (0.26 – 1.15)	0.11
Illiterate	153	22 (14.4)	1	
Marital status				
Married	250	48 (19.2)	2.9 (0.77 – 11.2)	0.11
Others	31	3 (9.6)	1	
Type of family				
Joint	49	15 (30.6)	2.77 (1.26 – 6.08)*	0.01*
Nuclear	232	36 (15.5)	1	
Monthly family income (Indian Rupees)				
≥5000	156	29 (18.6)	1.00 (0.49 – 1.98)	0.97
< 5000	125	22 (17.6)	1	
Waist Hip Ratio	281	51	0.08 (0.0 – 5.30)	0.15
Body Mass Index	281	51	1.12 (1.03 – 1.22)*	0.01*
Ever consumers of alcohol				
Yes	44	7 (37)	0.90 (0.30 – 2.80)	0.87
No	237	44 (18.6)	1	
Ever smokers				
Yes	22	1 (4.5)	0.13 (0.02 – 1.13)	0.06
No	259	50 (19.3)	1	

Variables	Total N=281	Prediabetes n (%)	Adjusted OR (95% CI)	p value
Family history of diabetes mellitus				
Present	28	8 (28.6)	0.54 (0.20 – 1.5)	0.23
Absent	253	43 (17)	1	

N=281 – Excluded Newly Diagnosed Type 2 Diabetes Mellitus
**p <0.05 CI: Confidence Interval: OR: Odds Ratio: R^2=19%*
Age, Waist Hip Ratio, Body Mass Index = Continuous variables
Occupation involves more physical activity - agricultural work, labor, animal rearing
Occupation involves less physical activity - house work, business, profession
Others category in marital status– ever married, widowed, divorced

Table 4. Multivariate logistic regression analysis for the determinants of newly diagnosed diabetes

Variables	Total N=279	Newly diagnosed diabetes n (%)	Adjusted OR (95% CI)	p value
Age ≥ 30 years	279	49	1.07 (1.04 – 1.10)	0.00*
Gender				
Male	97	17 (17.5)	0.55 (0.20 – 1.50)	0.24
Female	182	32 (17.6)	1	
Occupation				
Involves less physical activity	72	19 (26.3)	0.65 (0.30 – 1.39)	0.27
Involves more physical activity	207	32 (15.5)	1	
Educational status				
Illiterate	159	28 (17.6)	0.92 (0.41 – 2.08)	0.85
Literate	120	21 (17.5)	1	
Marital status				
Others	37	9 (24.3)	1.35 (0.50 – 3.59)	0.55
Married	242	40 (16.5)	1	
Type of family				
Joint	47	13 (27.7)	2.24 (1.01 – 5.57)*	0.04*
Nuclear	232	36 (15.5)	1	
Monthly family income (Indian Rupees)				
< 5000	126	23 (18.3)	1.02 (0.49 – 2.12)	0.95
≥ 5000	153	26 (17)	1	
Waist Hip Ratio	279	49	1.53 (0.02 - 1.48)	0.93
Body Mass Index	279	49	1.16 (1.06 – 1.26)	0.00*
Ever consumers of alcohol				
Yes	43	6 (14)	0.71 (0.20 – 2.50)	0.60
No	236	43 (18.2)	1	
Ever smokers				
Yes	24	3 (12.5)	0.64 (0.14 – 2.55)	0.49

Variables	Total N=279	Newly diagnosed diabetes n (%)	Adjusted OR (95% CI)	p value
No	255	46 (18.03)	1	
Family history of diabetes mellitus				
Present	29	9 (31)	3.30 (1.20 – 9.3)	0.02*
Absent	250	40 (16)	1	

N=279, Excluded Prediabetics
**p <0.05 CI: Confidence Interval: OR: Odds Ratio: R^2=22.4%*
Age, Waist Hip Ratio, Body Mass Index = Continuous variables
Occupation involves more physical activity - agricultural work, labor, animal rearing
Occupation involves less physical activity - house work, business, profession
Others category in marital status– ever married, widowed, divorced