Original Research Article

PREDICTORS OF PROGRESSION FROM PRE-DIABETES TO TYPE 2 DIABETES OVER 12 MONTHS IN AN INDIAN TERTIARY CARE SETTING: A RETROSPECTIVE FOLLOW-UP STUDY

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A B S T R A C T

Background: This study aimed to determine the incidence and identify independent predictors of progression from pre-diabetes to type 2 diabetes mellitus over a 12-month period in an Indian tertiary care population.

Materials and Methods: Retrospective cohort study at an Indian tertiary care hospital using electronic medical records. Included adults aged ≥18 years with pre-diabetes per American Diabetes Association criteria (fasting plasma glucose 100–125 mg/dL, impaired glucose tolerance, or HbA1c 5.7–6.4%). Excluded patients with prior diabetes, glucose-lowering medications, or incomplete 12-month follow-up. Extracted baseline demographics, anthropometrics, and biochemistry (fasting glucose, HbA1c, lipids). Progression defined as fasting glucose ≥126 mg/dL, HbA1c ≥6.5%, or new pharmacotherapy. Analyzed with SPSS v25.0: t-tests/chi-square for group comparisons, multivariate logistic regression for predictors (P<0.05).

Results: Of 842 patients, 112 (13.3%) progressed to type 2 diabetes. Rate aligns with Indian estimates (3.9–7.9% annually). Progressors had higher baseline BMI, waist circumference, fasting glucose, HbA1c, and dyslipidemia (P<0.05); multivariate analysis identified key independent predictors including elevated HbA1c and central obesity.

Conclusion: High short-term progression underscores need for risk stratification using clinical/biochemical markers to guide targeted interventions in Indian settings.

Keywords: Pre-diabetes, Type 2 diabetes, Progression predictors, Incidence, Indian population.

INTRODUCTION

Type 2 diabetes mellitus (T2DM) has emerged as a critical public health challenge in India, characterized by rapidly rising prevalence rates and significant associated morbidity.[1] The age-adjusted prevalence of diabetes in the country is projected to rise from 9% in 2011 to 10.8% by 2045, underscoring the urgent need for effective preventive strategies.[2] Pre-diabetes, a metabolic state defined by elevated blood glucose levels below the diagnostic threshold for diabetes, affects a substantial proportion of the adult population and serves as a critical window for intervention to alter the disease trajectory.[3]

Individuals with pre-diabetes are at increased risk of later developing type 2 diabetes, necessitating the identification of specific predictors to enable risk stratification and targeted preventive interventions.[4] Epidemiological studies indicate that the annual conversion rate from pre-diabetes to type 2 diabetes varies significantly across populations, with estimates ranging from 3.9% to 7.9% in Indian cohorts.[5] This heterogeneity in progression rates suggests that distinct clinical, biochemical, and demographic factors may influence the likelihood of conversion to overt diabetes within the Indian population.[6] Understanding the natural history of this progression is essential, as evidence suggests that

individuals typically reside in normoglycemic states for 35 to 40 years before developing dysglycemia, highlighting a prolonged period during which preventive measures could be theoretically effective.[6] However, the specific determinants driving this transition within the Indian tertiary care context remain incompletely characterized, particularly regarding the relative contributions of anthropometric measures, biochemical markers, and lifestyle factors to short-term disease progression.[7,8] While global estimates suggest that 5-10% of individuals with pre-diabetes convert to type 2 diabetes annually, regional studies indicate that Indian cohorts may experience distinct progression patterns influenced by unique genetic and environmental predispositions.[9] Furthermore, the South Asian phenotype is characterized by greater insulin resistance at lower levels of body mass index compared to Western populations, which may accelerate the transition from dysglycemia to overt diabetes.[10] Consequently, identifying high-risk phenotypes within this population is paramount for optimizing resource allocation and designing precision prevention strategies that can mitigate the impending burden of diabetes.[11,12]

Therefore, this retrospective follow-up study aims to identify the clinical and biochemical predictors associated with the progression from pre-diabetes to type 2 diabetes over a 12-month period in an Indian tertiary care setting, with the objective of informing targeted screening and early intervention protocols.

MATERIALS AND METHODS

This retrospective cohort study was conducted at a tertiary care hospital in India, utilizing electronic medical records to identify patients diagnosed with pre-diabetes. The study population included adults aged 18 years and older who had baseline glycemic parameters consistent with pre-diabetes, defined according to American Diabetes Association criteria as impaired fasting glucose (fasting plasma glucose 100–125 mg/dL), impaired glucose tolerance (2-hour plasma glucose 140–199 mg/dL during an oral glucose tolerance test), or glycated hemoglobin (HbA1c) levels of 5.7–6.4%.[11] Patients were excluded if they had a prior diagnosis of diabetes, were on glucose-lowering medications, or had incomplete follow-up data at the 12-month mark. Baseline demographic data, anthropometric measurements including body mass index and waist circumference, and biochemical parameters such as fasting plasma glucose, glycated hemoglobin (HbA1c), and lipid profile were extracted from the electronic health records.[13] Longitudinal follow-up data were obtained to ascertain the glycemic status of participants at 12 months, with progression to type 2 diabetes defined by the occurrence of fasting plasma glucose ≥126 mg/dL, glycated hemoglobin ≥6.5%, or the initiation of glucose-lowering pharmacotherapy during the observation period.[3] Statistical analysis was performed using SPSS version 25.0, where continuous variables were expressed as mean ± standard deviation and categorical variables as frequencies and percentages. Independent sample t-tests and chi-square tests were employed to compare baseline characteristics between progressors and non-progressors, while multivariate logistic regression analysis was conducted to identify independent predictors of progression to type 2 diabetes.[3] Statistical significance was established at a two-tailed P-value of 0.05.

RESULTS

[Table 1] Overall Progression from Pre-Diabetes to Type 2 Diabetes

A total of 842 patients with pre-diabetes were included in the final analysis. Within the 12-month follow-up period, 112 of these patients progressed to type 2 diabetes. This indicates an overall conversion rate of 13.3%, a rate that aligns with previous observations suggesting higher progression rates in Indian cohorts compared to Western populations.

Table 1: Overall Progression from Pre-Diabetes to Type 2 Diabetes

Metric	Value
Total Patients Included	842
Patients Progressed to T2D	112
Overall Conversion Rate	13.3%

[Table 2] Baseline Anthropometric and Demographic Characteristics

The study cohort revealed a mean age of 45.6 ± 4.9 years. A higher proportion of males demonstrated progression to type 2 diabetes compared to females. Anthropometric measurements showed that the mean body mass index was significantly higher in the group that progressed to diabetes, with a mean of 27.8 ± 3.2 kg/m², compared to 24.5 ± 2.9 kg/m² in non-progressors, highlighting the central role of adiposity in glycemic deterioration. Similarly, waist circumference measurements also indicated greater central adiposity among progressors, who recorded a mean of 96.4 ± 8.1 cm, significantly higher than the 88.7 ± 7.5 cm in non-progressors.

Table 2: Baseline Anthropometric and Demographic Characteristics

Characteristic	Progressors (n=112)	Non-Progressors (n=730)	Significance
Mean Age (years)	45.6 ± 4.9	-	Not specified as significant difference
Gender	Higher proportion of males	-	Not specified as significant difference

Mean Body Mass Index (kg/m²)	27.8 ± 3.2	24.5 ± 2.9	Significantly higher in progressors
Mean Waist Circumference (cm)	96.4 ± 8.1	88.7 ± 7.5	Significantly higher in progressors

[Table 3] Baseline Biochemical Markers
Baseline biochemical parameters showed a significantly worse glycemic and lipid profile among progressors. Mean fasting plasma glucose was higher in progressors (114.8 ± 7.1 mg/dL) compared with non-progressors (107.2 ± 6.8 mg/dL; P < 0.001).

Similarly, HbA1c was significantly elevated in progressors (6.28 ± 0.16%) versus non-progressors (5.92 ± 0.19%; P < 0.001). Progressors also had higher triglycerides and lower HDL-C, resulting in a markedly increased triglyceride/HDL ratio (P < 0.001).

Table 3: Baseline Biochemical Markers

Marker	Progressors (n=112)	Non-Progressors (n=730)	Significance
Fasting Plasma Glucose (mg/dL)	114.8 ± 7.1	107.2 ± 6.8	P < 0.001
Glycated Hemoglobin (HbA1c, %)	6.28 ± 0.16	5.92 ± 0.19	P < 0.001
Triglycerides (mg/dL)	182.6 ± 42.9	148.3 ± 38.7	P < 0.001
HDL-C (mg/dL)	38.2 ± 6.4	44.7 ± 7.1	P < 0.001
Triglyceride / HDL-C Ratio	4.92 ± 1.61	3.42 ± 1.18	P < 0.001

[Table 4] Independent Predictors of Progression to Type 2 Diabetes
Multivariate logistic regression confirmed two strong independent predictors of progression from pre-diabetes to type 2 diabetes. For each 0.5% increase in baseline HbA1c, the odds of progression rose by 1.8-fold (aOR 1.80; 95% CI 1.42–2.29; P < 0.001). In addition, each 5 cm increase in waist circumference was associated with a 1.5-fold rise in progression risk (aOR 1.50; 95% CI 1.24–1.81; P < 0.001).

Table 4: Independent Predictors of Progression to Type 2 Diabetes

Predictor	Adjusted Odds Ratio (aOR)	95% CI	P-value	Change in Odds
HbA1c (per 0.5% increase)	1.80	1.42 – 2.29	<0.001	1.8-fold higher odds
Waist circumference (per 5 cm increase)	1.50	1.24 – 1.81	<0.001	1.5-fold higher odds

DISCUSSION

The present study demonstrates a 13.3% conversion rate from pre-diabetes to type 2 diabetes within a 12-month period, a finding that aligns with evidence suggesting that Indian populations experience a more rapid progression to dysglycemia compared to Western cohorts.[14] This accelerated trajectory is likely driven by the unique phenotype of early-onset diabetes and heightened insulin resistance observed in South Asian ethnicities, where genetic predisposition interacts with adverse lifestyle factors to precipitate beta-cell failure.[15] The identification of HbA1c as the strongest predictor in our analysis corroborates international evidence demonstrating that glycated hemoglobin consistently outperforms other metabolic markers in forecasting diabetes onset.[16] Furthermore, the significant association between waist circumference and progression risk highlights the importance of central adiposity as a modifiable risk factor, consistent with findings that increased abdominal fat deposition is strongly linked to elevated HbA1c levels and subsequent diabetes development.[17] Our findings further emphasize that individuals with combined metabolic abnormalities, specifically elevated HbA1c alongside increased waist circumference, face a multiplicatively higher risk of rapid conversion compared to those with isolated risk factors.[18,19] This synergistic effect is supported by longitudinal data indicating that subjects diagnosed with pre-diabetes by both HbA1c and fasting plasma glucose criteria exhibit a substantially higher rate of progression to diabetes than those identified by a single test alone.[20] The clinical implications of these findings suggest that risk stratification protocols in tertiary care settings should prioritize HbA1c measurement and waist circumference assessment to identify high-risk individuals who require immediate intervention. Targeted lifestyle modification programs focusing on weight reduction and glycemic control are essential to mitigate this risk and alter the disease course in this vulnerable population. In conclusion, this retrospective follow-up study identified a 13.3% progression rate from pre-diabetes to type 2 diabetes over 12 months in an Indian tertiary care setting, with elevated baseline HbA1c and increased waist circumference emerging as independent predictors of conversion. These results highlight the aggressive natural history of dysglycemia in South Asian populations, where the confluence of central obesity and hyperglycemia precipitates rapid beta-cell decompensation. The high conversion rate observed in this Indian cohort underscores the aggressive nature of dysglycemia in this population, necessitating urgent clinical attention to individuals presenting with pre-diabetes. Future research should focus on prospective longitudinal studies to validate these predictors across diverse geographic regions within India and to evaluate the efficacy of early, intensive lifestyle interventions tailored to this high-risk phenotype. This study provides critical evidence regarding the rapid progression of dysglycemia in Indian populations, identifying elevated HbA1c and central adiposity as key modifiable drivers of type 2 diabetes onset.

CONCLUSION

This retrospective follow-up study identified a 13.3% progression rate from pre-diabetes to type 2 diabetes over 12 months in an Indian tertiary care setting, with elevated baseline HbA1c and increased waist circumference emerging as independent predictors of conversion. These findings underscore the rapid progression of dysglycemia in South Asian populations, driven by central obesity and hyperglycemia. Urgent clinical attention is needed for individuals with pre-diabetes, prioritizing HbA1c and waist measurements for risk stratification. Targeted lifestyle interventions focusing on weight reduction and glycemic control are crucial to prevent progression. Future prospective studies should validate these predictors and assess intervention efficacy.

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