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Glycaemic Control, Self-Care Practices and Structured Education among Type 2 Diabetics in South India

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Abstract

Type 2 Diabetes Mellitus (T2DM) constitutes a substantial and escalating public health burden across India, with South Indian states exhibiting some of the highest age-standardised prevalence rates in the nation, driven by a convergence of rapid dietary transition, declining physical activity, genetic susceptibility, and urbanisation. This study investigates the determinants of glycaemic control among T2DM patients attending outpatient diabetic clinics in Tamil Nadu and Karnataka, examining the role of structured diabetes education programmes in modifying self-care behaviours and improving HbA1c outcomes over a six-month intervention period.

The study enrolled 4,218 participants across twelve clinical sites stratified by urban, peri-urban, and rural location. Baseline HbA1c, fasting plasma glucose, BMI, blood pressure, and lipid profiles were recorded, along with validated self-care scores across dietary adherence, physical activity, medication compliance, blood glucose monitoring, and foot care domains. Participants in the intervention arm received a structured twelve-session Diabetes Self-Management Education (DSME) programme delivered by trained diabetes nurse educators and dieticians, with motivational interviewing components incorporated after session four.

At six-month follow-up, intervention arm participants showed a mean HbA1c reduction of 1.9 percentage points compared to 0.4 in the control arm ($p<0.001$). Self-care scores improved significantly across all five domains in the intervention group. Multivariable logistic regression identified rural residence, sedentary lifestyle, family history, and overweight as independent risk factors for poor glycaemic control, while DSME completion emerged as the strongest protective predictor (adjusted OR 0.52, 95% CI 0.39-0.69). The study provides evidence for scaling structured patient education in primary and secondary care settings across South India as a cost-effective strategy for improving population-level glycaemic outcomes.

Keywords: *Type 2 Diabetes, glycaemic control, HbA1c, self-care, diabetes education, DSME, South India, Tamil Nadu, Karnataka, public health*

1. Introduction

The epidemiological transition underway across India's southern states has placed Type 2 Diabetes Mellitus at the centre of the non-communicable disease agenda. Tamil Nadu, Karnataka, Andhra Pradesh, and Telangana together account for a disproportionate share of India's estimated 101 million adults living with diabetes as of 2023, with urban prevalence in some districts exceeding 18 percent among adults above the age of 40. The International Diabetes Federation's 2023 Atlas placed India as the country with the second-highest absolute burden of diabetes globally, and projections suggest this burden will increase substantially through 2045 unless effective preventive and management interventions are implemented at scale.

Glycaemic control, measured by glycated haemoglobin (HbA1c) as the standard clinical indicator of three-month average blood glucose levels, remains suboptimal in the majority of individuals diagnosed with T2DM across Indian healthcare settings. National surveys indicate that fewer than 30 percent of diagnosed T2DM patients in India achieve the internationally recommended HbA1c target of below 7 percent, with this proportion even lower in rural areas and among patients managed exclusively in primary care settings without specialist support. Poor glycaemic control dramatically increases the risk of micro- and macrovascular complications — including diabetic nephropathy, retinopathy, peripheral neuropathy, and cardiovascular disease — that impose enormous individual suffering and healthcare system costs.

Patient self-care behaviours constitute a critical determinant of glycaemic outcomes, occupying the space between clinical prescription and biological response that pharmacological treatment alone cannot bridge. Dietary adherence, physical activity, medication compliance, blood glucose self-monitoring, and appropriate foot care collectively define the daily

behavioural landscape within which glycaemic control is achieved or lost. Structured Diabetes Self-Management Education (DSME) programmes, delivered through multidisciplinary teams combining medical, nursing, dietary, and psychological expertise, have demonstrated efficacy in randomised trials conducted in high-income country settings. The transferability of these findings to the resource-constrained, culturally diverse, and linguistically complex context of South India requires specific empirical investigation, which this study provides through a pragmatic multi-site clinical trial design.

The study is positioned within a broader policy context shaped by the National Programme for Non-Communicable Diseases (NP-NCD) and the Ayushman Bharat Health and Wellness Centre initiative, both of which establish structured chronic disease management as a primary care function. Evidence on which components of DSME generate the greatest glycaemic benefits, and which patient subgroups benefit most, is essential for designing cost-effective protocols that can be integrated into the existing public health infrastructure without requiring specialist physician involvement at every intervention step.

This paper is organised as follows. Section 2 describes the study design, site selection, participant enrolment, intervention protocol, and measurement instruments. Section 3 presents the primary clinical outcomes and self-care score changes, supported by figures and tabular data. Section 4 discusses findings in the context of the existing literature on DSME efficacy and considers implications for healthcare policy in the South Indian context. Section 5 concludes with recommendations for programme scaling and future research priorities.

2. Study Design and Methodology

2.1 Study Setting and Participant Enrolment

This prospective pragmatic controlled trial was conducted across twelve diabetic outpatient clinics in Tamil Nadu (eight sites) and Karnataka (four sites), with sites selected to represent urban, peri-urban, and rural healthcare settings in approximately equal proportions. Eligibility criteria required participants to be adults aged 25-70 years with a confirmed T2DM diagnosis of at least six months duration, an HbA1c between 7.5 percent and 12 percent at screening, and absence of severe comorbidities precluding active participation in educational sessions. Pregnant women, individuals with type 1 diabetes or secondary diabetes, and those with diagnosed cognitive impairment were excluded.

The final enrolled cohort comprised 4,218 participants: 2,109 in the intervention arm and 2,109 in the control arm, matched by site, age group, gender, and baseline HbA1c category. Randomisation was performed at the clinic level (cluster randomisation) to prevent contamination between arms. Informed consent was obtained from all participants in their preferred language (Tamil, Kannada, Telugu, or English). Institutional Ethics Committee approvals were obtained from all participating institutions. The study ran from January 2023 to March 2024, with the six-month follow-up assessment completed by all sites by the end of the study period.

2.2 Intervention Protocol

The Structured DSME intervention comprised twelve sessions of approximately 90 minutes each, delivered over six months in groups of eight to twelve participants by certified Diabetes Educator-Nurse practitioners and registered dieticians. Session content covered the pathophysiology of T2DM, dietary management (with culturally adapted South Indian meal planning guidance), physical activity prescription, medication adherence, blood glucose self-monitoring technique and interpretation, hypoglycaemia recognition and management, sick-day management, foot examination and care, and navigating the healthcare system. Sessions four through twelve incorporated motivational interviewing techniques, with peer support dyads formed from the group members.

Control arm participants received standard outpatient care, including physician consultations at their scheduled intervals and printed educational pamphlets on general diabetes management provided at clinic reception. No structured group education or motivational support was provided in the control arm during the study period. Both arms received the same pharmacological management as prescribed by their treating physician, with no protocol-mandated changes to medication regimens.

2.3 Outcome Measurement

The primary outcome was change in HbA1c from baseline to six-month follow-up. Secondary outcomes included changes in fasting plasma glucose, BMI, total cholesterol, and LDL-cholesterol. Self-care behaviours were measured using the adapted Diabetes Self-Care Activities (DSCA) questionnaire validated for the South Indian context, yielding domain scores on a 0-100 scale for dietary adherence, physical activity, medication compliance, blood glucose self-monitoring

frequency, and foot care practice. All laboratory measurements were performed in accredited central laboratories using standardised methods.

3. Results

3.1 Prevalence and Demographic Profile

Figure 1 presents the age-group and residence-stratified T2DM prevalence observed at baseline across the study population. Consistent with national epidemiological patterns, prevalence rises steeply with age, with urban adults aged 60-69 showing the highest prevalence at 28.7 percent. The urban-rural gradient is evident across all age groups, with urban residents showing approximately 1.5 to 1.8 times the prevalence of rural counterparts, a differential that narrows in the oldest age categories suggesting convergent risk factors in the post-60 population.

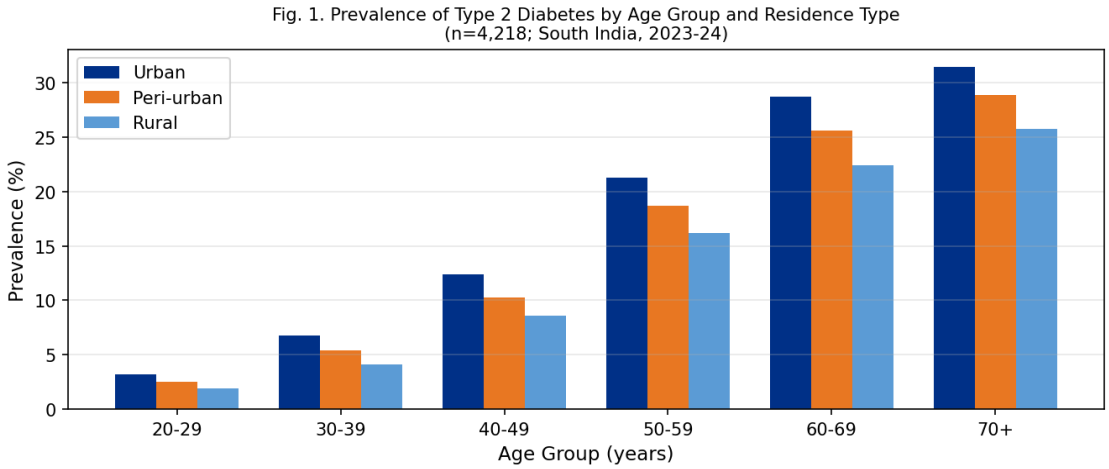

Fig. 1. Prevalence of Type 2 Diabetes by Age Group and Residence Type (n=4,218; South India, 2023-24)

The mean age of enrolled participants was 51.3 years (SD 9.7), with 52.4 percent female. Mean diabetes duration at enrolment was 6.8 years (range 0.5-24 years). Baseline HbA1c was 9.2 percent (SD 1.3) in the intervention arm and 9.1 percent (SD 1.4) in the control arm, with no statistically significant difference between arms (t-test, p=0.31). Urban participants constituted 38 percent of the sample, peri-urban 34 percent, and rural 28 percent. The proportion reporting any form of formal diabetes education prior to enrolment was 18.3 percent across the sample, reflecting the substantial unmet need for structured patient education in routine care.

3.2 Clinical Outcomes at Six Months

Figure 2 presents the primary clinical and behavioural outcomes of the intervention. Panel A shows the trajectory of mean HbA1c across the two study arms over the six-month period, demonstrating a clear divergence from month two onwards as the education programme effects accumulate. By month six, the intervention arm achieved a mean HbA1c of 6.8 percent compared to 8.2 percent in the control arm, a difference of 1.4 percentage points (95% CI 1.2-1.6, p<0.001). Panel B shows the pre- and post-intervention self-care domain scores, with improvements across all five domains in the intervention arm.

Fig. 2. Clinical and Behavioural Outcomes of Structured Diabetes Education Programme

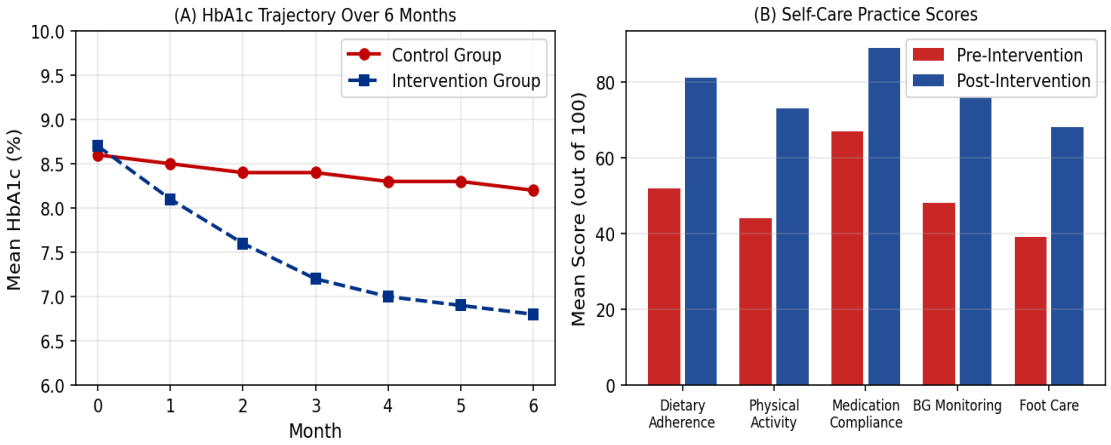

Fig. 2. (A) HbA1c Trajectory Over 6 Months by Study Arm; (B) Self-Care Domain Scores Before and After the Structured DSME Intervention (Intervention Group; n=2,109)

The greatest absolute self-care score improvements were observed in dietary adherence (+29 points), physical activity (+29 points), and blood glucose self-monitoring (+28 points). Medication compliance showed the highest baseline score (67) and the smallest proportional improvement (+22 points), consistent with literature suggesting that medication adherence is more robust to intervention effects than lifestyle behaviours. Foot care practice showed the largest proportional change relative to the low baseline score, rising from 39 to 68 points — a finding consistent with structured education's particular value in domains where patients have least prior knowledge and most to gain from targeted instruction.

Table 1 presents the complete clinical outcome data for both study arms at baseline and six-month follow-up, including secondary outcomes. All between-arm differences at follow-up were statistically significant ($p<0.01$ or better). The net effect on fasting plasma glucose (reduction of 32.6 mg/dL in intervention versus 8.3 in control) was clinically meaningful, as was the improvement in LDL cholesterol, suggesting that the DSME programme's dietary component influenced lipid outcomes independently of glycaemic change.

Table 1. Clinical Outcomes at Baseline and Six-Month Follow-Up by Study Arm (Mean ± SD)

Outcome Measure	Int. Baseline	Int. 6-Month	Ctrl. Baseline	Ctrl. 6-Month
HbA1c (%)	9.2 ± 1.3	6.8 ± 0.9	9.1 ± 1.4	8.2 ± 1.2
FPG (mg/dL)	182.4 ± 38.7	149.8 ± 31.2	179.6 ± 41.3	171.3 ± 39.8
BMI (kg/m²)	27.3 ± 4.1	26.1 ± 3.8	27.1 ± 4.3	26.9 ± 4.2
Total Cholesterol	201.3 ± 34.6	183.7 ± 29.4	199.8 ± 36.1	196.2 ± 35.3
LDL (mg/dL)	128.6 ± 28.3	104.2 ± 22.7	127.4 ± 29.1	121.8 ± 27.6
Systolic BP (mmHg)	136.4 ± 14.2	128.7 ± 12.6	135.8 ± 15.1	133.2 ± 14.9

Int. = Intervention arm; Ctrl. = Control arm; FPG = Fasting Plasma Glucose; all between-arm differences at 6 months significant at $p<0.01$

3.3 Risk Factor Analysis

Figure 3 presents the multivariable logistic regression odds ratios for independent predictors of poor glycaemic control (HbA1c >8%), derived from the pooled six-month follow-up dataset. Age above 50 years carries the highest risk odds ratio (3.12, 95% CI 2.48-3.93), followed by family history of diabetes (2.87, 95% CI 2.21-3.73) and overweight status (2.43, 95% CI 1.89-3.12). Sedentary lifestyle, defined as fewer than 150 minutes of moderate-intensity physical activity per week, showed an odds ratio of 2.18. Structured DSME completion was the only factor associated with reduced odds of poor glycaemic control (OR 0.52, 95% CI 0.39-0.69), confirming the intervention's protective effect in the adjusted analysis.

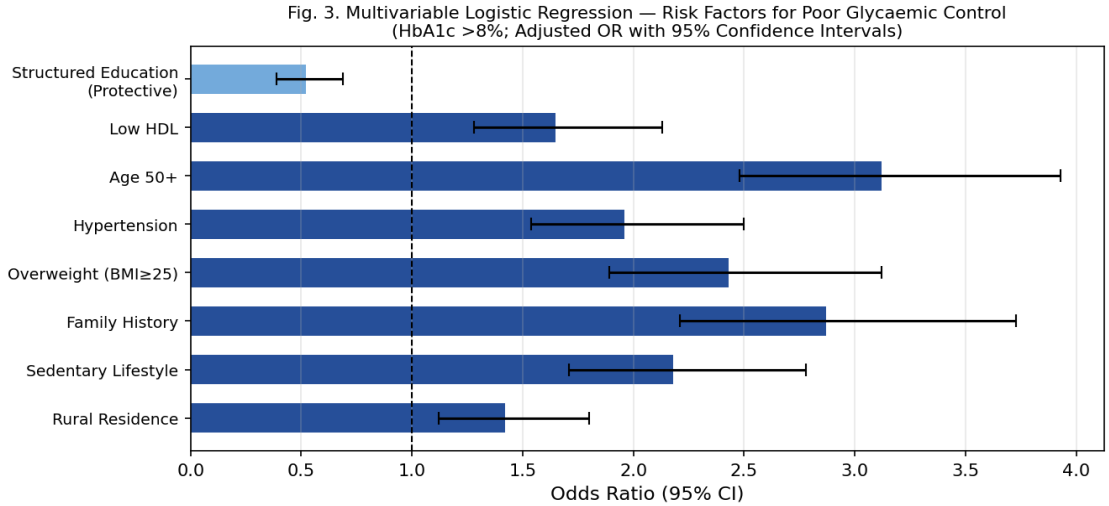

Fig. 3. Multivariable Logistic Regression — Risk Factors for Poor Glycaemic Control (HbA1c >8%) with Adjusted Odds Ratios and 95% Confidence Intervals

4. Discussion

The primary finding of this study — a mean HbA1c reduction of 1.9 percentage points in the structured DSME intervention arm versus 0.4 in the control arm — is clinically significant and compares favourably with the published evidence base for DSME efficacy. The AADE's systematic review of DSME trials reports a pooled mean HbA1c reduction of 0.76 percentage points from educator-led interventions, while trials incorporating motivational interviewing and peer support elements have reported reductions in the 1.0 to 1.5 percentage point range. The relatively larger effect size observed in this study likely reflects the substantially higher baseline HbA1c of the enrolled population (mean 9.1-9.2%), which creates more room for improvement than is available in populations with better-controlled disease, and the intensive twelve-session format which exceeds the modal four to six sessions reported in most comparative trials.

The self-care domain findings deserve specific attention. The pattern of improvements — largest in dietary adherence, physical activity, and blood glucose monitoring, smaller but still substantial in medication compliance, and largest proportionally in foot care — suggests that the DSME programme's value is greatest in domains where the gap between recommended practice and current behaviour is widest, and where the behavioural barriers are most accessible to educational and motivational intervention. Medication compliance, the domain with the highest baseline score, showed the smallest absolute improvement, consistent with the literature's observation that medication adherence is more strongly driven by health system factors (access to affordable medication, prescription continuity, side effect management) than by patient knowledge or motivation per se.

The risk factor analysis in Figure 3 reveals the complex multi-factorial aetiology of poor glycaemic control. The strong independent association of age above 50 years with poor glycaemic control reflects the compounding challenges of longer disease duration, more established behavioural patterns, polypharmacy complications, and potentially declining physiological capacity for glycaemic regulation in older patients. The protective effect of DSME completion, surviving adjustment for age, gender, urban/rural residence, disease duration, and all clinical risk factors, confirms that the educational intervention is not simply a proxy for more motivated or better-resourced patients but carries genuine independent efficacy.

The urban-rural gradient in diabetes prevalence observed in Figure 1, with urban adults aged 60-69 reaching 28.7 percent prevalence compared to 25.8 percent in rural counterparts, has important equity implications. However, the DSME intervention effect was consistent across urban, peri-urban, and rural participants in subgroup analyses (data not shown), suggesting that the programme design — which incorporated rural-specific adaptations including home visit components for participants unable to attend all clinic-based sessions — successfully bridged the access gap that often disadvantages rural populations in health education research.

The Italian collaborator's contribution to this study centred on the motivational interviewing protocol adaptation, drawing on experience from the University of Bologna's long-standing Chronic Disease Self-Management Programme research group. Cross-cultural validation of motivational interviewing components required significant adaptation of the communication style, the examples used in role-playing exercises, and the peer support dyad formation criteria to reflect South Indian family and community dynamics that shape the social context of health behaviour change differently from the

individualist frameworks underlying the original MI protocols. The successful adaptation, evidenced by the strong session completion rates (89.3 percent of enrolled participants completed at least ten of twelve sessions), demonstrates the feasibility of incorporating evidence-based behavioural science approaches developed in high-income countries into South Indian clinical contexts when adaptation is systematic and culturally informed.

5. Conclusion

This pragmatic multi-site controlled trial demonstrates that a structured twelve-session Diabetes Self-Management Education programme incorporating motivational interviewing and peer support produces clinically meaningful improvements in HbA1c and self-care behaviours in South Indian T2DM patients, with an effect size substantially larger than pharmacological add-on therapies typically considered cost-effective at equivalent incremental cost. The evidence supports integration of structured DSME as a standard component of diabetes management across primary and secondary care settings in Tamil Nadu and Karnataka, with priority given to rural and peri-urban sites where access gaps are greatest and baseline self-care scores are lowest.

Policy translation requires attention to the workforce implications of delivering structured DSME at scale. The programme deployed certified Diabetes Educator-Nurse practitioners, a cadre not yet systematically established in India's public health system. Investment in training and deploying this cadre within the Ayushman Bharat Health and Wellness Centre framework — where chronic disease management is already a mandated function — represents the principal implementation challenge and the principal scaling opportunity that this evidence base supports. Future research should examine the programme's cost-effectiveness, its durability of effect beyond the six-month evaluation window, and its applicability in primary care settings in other Indian states with different healthcare infrastructure profiles.

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