ORIGINAL RESEARCH ARTICLE

Effectiveness of a Community-Based, Peer-Led, Literacy-Sensitive Diabetes Self-Management Education Program among Low-Literacy Adults with Type 2 Diabetes: A Non-Randomized Mixed-Methods Field Trial

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ABSTRACT

Background: Peer-led and literacy-sensitive diabetes self-management education (DSME) has shown promise in improving outcomes among underserved populations with low literacy. The objective was to assess the observed effectiveness of a peer-led, literacy-sensitive DSME program on glycemic control and self-management behaviors among low-literate adults with type 2 diabetes.

Methods: An explanatory sequential mixed-methods design was employed. In the quantitative phase, 160 adults with type 2 diabetes participated in a non-randomized controlled field trial conducted in community settings, with service-based allocation to intervention (n = 80) and usual care (n = 80). HbA1c was the primary outcome. Self-care behaviors, diabetes knowledge, and body mass index were secondary outcomes assessed at baseline and six months. Analysis of covariance and multivariable linear regression were applied.

Results: At six months, the intervention group showed a greater reduction in HbA1c compared with usual care (adjusted mean difference -0.60%, 95% CI -0.95 to -0.25). Improvements in self-care behaviors and diabetes knowledge were also observed. Qualitative findings indicated that spoken and visual learning, teach-back, shared experiences, and peer accountability supported behavior change.

Conclusion: The findings suggest that peer-led, literacy-sensitive DSME is associated with improved diabetes-related outcomes among low-literate adults when implemented under real-world community conditions.

Keywords: Type 2 diabetes, DSME, Peer education, Low literacy, Health literacy

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INTRODUCTION

Type 2 diabetes mellitus (T2D) is a major and growing global public health concern. Effective self-management measures, which include dietary changes, medication adherence, physical activity, blood glucose monitoring, and proactive complication prevention, are essential for optimal glycemic regulation and complication reduction. Nonetheless, the demands of self-management, which necessitate health literacy, numeracy, and problem-solving skills, may present difficulties for persons with low reading. Health literacy has been clearly connected to diabetes self-management practices[1], and it is influenced by socioeconomic factors such as poverty, a lack of formal education, and limited access to reliable health information.

Traditional diabetic self-management education (DSME) frequently uses a clinic-centered, text-intensive style, which can be inconvenient for patients with low literacy abilities. Peer-led interventions, on the other hand, can effectively transform medical standards into contextually appropriate practices using oral communication, narrative storytelling, practical demonstrations, and social learning approaches. Existing trials and systematic reviews consistently report modest but clinically meaningful improvements in HbA1c and self-management behaviors following peer-led and literacy-sensitive DSME, particularly when interventions are culturally adapted and delivered with adequate intensity. However, much of this evidence is derived from randomized or tightly controlled study designs, often with enhanced resources, structured follow-up, and limited exposure to real-world constraints. Consequently, the generalizability of these findings to routine community settings, especially among low-literacy populations facing socioeconomic barriers, remains insufficiently explored.[2-4]

Although randomized controlled trials have demonstrated the efficacy of peer-led and literacy-sensitive diabetes self-management education, much of this evidence has been generated under controlled research conditions. There remains limited evidence on how such interventions perform when implemented under routine, real-world community settings, particularly among adults with low literacy in resource-constrained environments. Furthermore, few studies have integrated qualitative inquiry to explain how contextual, social, and structural factors influence observed outcomes outside trial conditions. This gap underscores the need for pragmatic, mixed-methods field evaluations that assess real-world effectiveness alongside implementation-relevant insights.

Literacy-sensitive pedagogical approaches, particularly the teach-back method and the use of pictorial aids, have been proven to improve knowledge acquisition and adherence in patients with low health literacy.[1,5] Despite these advances, variation in results persists. Comprehensive reviews show that peer selection criteria, training quality, adherence to program protocols (fidelity), intervention intensity, and prevailing contextual limitations all play a role in explaining the variability in results.[6,7] Furthermore, mixed-methods research conducted in resource-constrained environments emphasizes the impact of socioeconomic determinants such as poverty, food insecurity, social stigma, and conflicting health advice on the successful translation of acquired knowledge into sustainable health practices.[8]

In low-literacy community settings, randomized allocation of educational interventions may raise ethical and practical challenges, including limited participant understanding of randomization, risk of contamination within closely connected communities, and constraints in withholding potentially beneficial peer support. Additionally, real-world implementation of DSME programs in resource-constrained environments often follows service-based or geographical delivery models. In this context, a non-randomized controlled field design was considered appropriate to balance ethical considerations, logistical feasibility, and ecological validity while evaluating intervention effectiveness under routine community conditions.

This study used an explanatory sequential mixed-methods research design to statistically evaluate the effectiveness of a peer-facilitated, literacy-sensitive DSME intervention.

Objectives: To determine the efficacy of a peer-led, literacy-sensitive DSME program in improving HbA1c levels and self-management behaviors among low-literate persons with type 2 diabetes (T2D).

METHODOLOGY

An explanatory sequential mixed-methods design was employed. The quantitative component was reported in accordance with the TREND (Transparent Reporting of Evaluations with Nonrandomized Designs) guidelines. The intervention description followed the TIDieR (Template for Intervention Description and Replication) checklist, and the qualitative component was reported in line with the COREQ (Consolidated Criteria for Reporting Qualitative Research) guidelines." The quantitative component consisted of a non-randomized controlled field trial conducted in community settings, with allocation based on service catchment areas to minimize contamination between groups. This was followed by a qualitative inquiry to explore underlying mechanisms and contextual factors influencing the quantitative findings. Integration of quantitative and qualitative data was undertaken during the interpretation stage.

Participants and recruitment: Participants were recruited from primary care catchment areas serving low-income communities through clinic records,

community health worker referrals, and outreach conducted by peer educators. Eligible individuals were approached during routine clinic visits or community meetings and screened for inclusion criteria, including low health literacy. Group allocation was non-randomized and service based. Participants residing in catchment areas where the peer-led DSME program was implemented were assigned to the intervention group, while participants from comparable neighbouring catchment areas receiving routine diabetes care were assigned to the usual care group. Baseline characteristics were assessed to evaluate comparability between groups and potential selection bias.

Intervention: The intervention was a peer-led, literacy-sensitive diabetes self-management education (DSME) program delivered over six months in community settings. Peer educators were adults with type 2 diabetes from the same communities, selected based on communication skills and community trust, and trained over five days by diabetes educators. The program consisted of nine group sessions (10 participants per group), delivered biweekly for three months followed by three monthly booster sessions (Table 1). Core components included spoken instruction with minimal text, pictorial flipcharts and demonstrations, teach-back to confirm understanding, peer storytelling, collaborative goal setting, and peer accountability. Sessions focused on diabetes understanding, diet and portion control, medication adherence, physical activity, foot care, and relapse prevention. The intervention was delivered in local language, with fidelity supported through standardized materials and monthly supervision. Participants in the control group received routine diabetes care.

Table 1: Peer-led DSME curriculum and delivery dose

Session block	Key content	Literacy-sensitive methods	Planned frequency
Sessions 1-2	Understanding diabetes, targets, myths	Storytelling; teach-back; pictorial flipchart	Biweekly
Sessions 3-4	Diet and portion control	Plate model; household measures; visual food cards	Biweekly
Sessions 5-6	Medication adherence and hypoglycemia	Demonstration; timing charts; teach-back	Biweekly
Booster 1	Physical activity planning	Problem-solving; peer commitments	Monthly
Booster 2	Foot care and complication prevention	Demonstration; checklist; role play	Monthly
Booster 3	Maintaining routines and relapse prevention	Goal review; peer accountability	Monthly

Table 2: Measures and scoring used in the study

Measure	Construct	Scale and scoring	Timepoints
HbA1c	Glycemic control	Percent (%)	Baseline, 6 months
SDSCA	Self-care behaviors	0 to 7 days per week (domain or total)	Baseline, 6 months
SKILLD (or equivalent)	Diabetes knowledge (low-literacy format)	Percent or total score	Baseline, 6 months
BMI	Body mass index	kg/m^2	Baseline, 6 months
Optional: diabetes distress	Psychosocial burden	Instrument-specific score	Baseline, 6 months

Setting: The study was implemented as a community-based field trial within primary care catchment areas serving low-income households. Clinic visits, prescription refills, and brief advice from physicians or nurses were all part of standard diabetic care. Allocation to study groups was non-randomized and based on clinic service catchment areas linked to program availability. Participants residing in communities served by clinics where the peer-led DSME program was implemented were assigned to the intervention group, while participants from neighbouring clinics providing routine diabetes care were assigned to the usual care group. To minimize contamination between groups, intervention and control participants were drawn from distinct clinic service catchment areas. Peer educators were assigned exclusively to intervention communities, group sessions were conducted separately, and intervention materials were not distributed within control areas during the study period.

Participants & Eligibility: Adults aged 18 years and older who had been diagnosed with T2D at least 6 months earlier were eligible if they scored low on a validated health literacy measure. Pregnancy, severe cognitive impairment, inability to participate in group sessions, and participation in structured DSME within the past year were all exclusion factors.

Outcome and measures: The primary outcome of the study was glycaemic control, assessed using glycosylated hemoglobin (HbA1c), measured as a percentage at baseline and at six months using standardized laboratory procedures. Secondary outcomes included diabetes self-management behaviors, diabetes-related knowledge, and body mass index (BMI). Self-management behaviors were assessed using the Summary of Diabetes Self-Care Activities (SDSCA) instrument, which measures the number of days (range: 0-7) participants engage in key self-care practices such as diet adherence, physical activity, blood glucose monitoring, and medication use. The SDSCA was administered through interviewer-led questioning and is suitable for populations with limited literacy. Diabetes knowledge was assessed using a low-literacy, orally administered diabetes

knowledge tool, with responses scored as the percentage of correct answers. This approach minimized reliance on reading and writing skills and was administered in the local language. Body mass index was calculated as weight in kilograms divided by height in meters squared (kg/m^2), based on anthropometric measurements obtained using calibrated instruments. All measurement tools were selected for their prior use or adaptability in low-literacy and community-based settings (table 2).

Sample size: The sample size was estimated to support comparison of observed differences in HbA1c levels between study groups under real-world conditions, informed by prior trials reporting reductions of approximately 0.7-1.05 percentage points[4,9-11]. Assuming an expected mean difference of 0.7%, a standard deviation of 1.6, a two-sided alpha of 0.05, and 80% power, a minimum of 64 participants per group was required. To account for potential attrition of up to 20%, 80 participants were recruited in each group, yielding a total sample size of 160. This estimation was intended to support comparative effectiveness assessment rather than causal inference, given the non-randomized field trial design.

Quantitative analysis plan: Baseline characteristics were summarized using descriptive statistics. To address the non-randomized allocation and potential baseline imbalance, the primary analysis employed analysis of covariance (ANCOVA) or multivariable linear regression, with 6-month HbA1c as the outcome and study group as the primary predictor, adjusting for baseline HbA1c and prespecified covariates including age, sex, duration of diabetes, and insulin use. Secondary outcomes were analyzed using comparable adjusted modeling approaches. Results are presented as adjusted mean differences with 95% confidence intervals, following the intention-to-treat principle. Missing data were handled using data-structure-appropriate methods, including multiple imputation where assumptions were met. Exploratory analyses examined potential effect modification by baseline HbA1c categories and intervention exposure, as measured by session attendance.

Qualitative sampling and data collection: Data collection for the qualitative component continued until thematic saturation was reached, defined as the point at which no new themes or sub-themes emerged from successive interviews and focus group discussions. Saturation was assessed through ongoing concurrent analysis, with regular team discussions to review emerging codes and confirm redundancy of concepts. Once additional data yielded repetition of previously identified themes without novel insights, data collection was concluded.

Qualitative analysis plan: Data were examined thematically using an iterative approach that comprised initial open coding, the creation of a codebook, the structuring of codes into subthemes and overarching themes, and team-based evaluation with an audit trail. Double coding, peer debriefing, and transparent documenting of analytic judgments all contributed to increased rigor.

Integration: Quantitative and qualitative components were combined by connecting qualitative sampling to quantitative outcomes and attendance, creating interview guides to help explain quantitative findings, and synthesizing results through joint displays that linked outcomes to underlying mechanisms and contextual barriers.

Ethics: The institutional ethics committee provided ethical clearance (Ref no. PSG/IHEC/2024/Appr/FB/005). Informed consent was obtained in either written form or by thumbprint, if applicable. Participants were assured of secrecy and advised that their participation was purely voluntary.

RESULTS

Participant flow and baseline characteristics: A total of 160 participants were included in the quantitative analysis, with 80 allocated to the intervention group and 80 to the usual care group. Participant recruitment, allocation, intervention exposure, follow-up, and analysis are summarized in Figure 1 (Participant Flow Diagram). Baseline sociodemographic and clinical characteristics were comparable between the two groups, including age, sex distribution, duration of diabetes, baseline HbA1c, body mass index, insulin use, and prevalence of hypertension (Table 3).

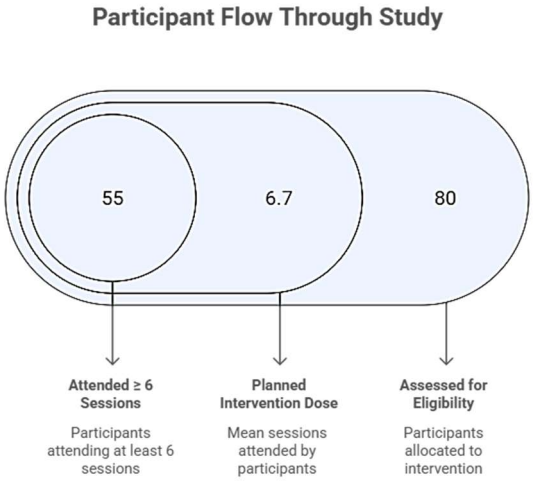

Figure 1: Participant flow diagram showing recruitment, allocation, intervention dose, session exposure, follow-up, and analysis for the non-randomized controlled community field trial

Table 3: Baseline characteristics by study arm

Characteristic	Intervention (n = 80)	Control (n = 80)
Age (years), mean (SD)	52.6 (9.8)	51.9 (10.2)
Female, n (%)	44 (55.0)	42 (52.5)
Diabetes duration (yrs), mean (SD)	6.8 (4.1)	6.6 (4.3)
HbA1c (%), mean (SD)	9.1 (1.4)	9.0 (1.5)
BMI (kg/m^2), mean (SD)	27.3 (4.5)	27.0 (4.3)
On insulin (± OADs), n (%)	21 (26.3)	19 (23.8)
Hypertension diagnosis, n (%)	38 (47.5)	36 (45.0)

Table 4: Primary and Secondary Outcomes — Baseline, 6-Month Values, Within-Group Change, and Adjusted Intervention Effects

Outcome	Baseline (mean ± SD)		6 months (mean ± SD)		Change (mean ± SD)		Adjusted Mean Difference (Int – Con) (95% CI)	p
	Intervention	Control	Intervention	Control	Intervention	Control		
HbA1c (%)	9.1 ± 1.4	9.0 ± 1.5	8.2 ± 1.3	8.8 ± 1.5	−0.90 ± 1.10	−0.20 ± 1.0	−0.60 (−0.95 to −0.25)	0.001
SDSCA total	2.8 ± 1.1	2.7 ± 1.0	4.3 ± 1.2	3.2 ± 1.1	+1.50 ± 1.10	+0.50 ± 1.0	+1.05 (+0.62 to +1.48)	<.001
Knowledge*	41.5 ± 9.8	42.1 ± 10.2	57.8 ± 10.5	47.9 ± 10.1	+16.3 ± 10.2	+5.8 ± 9.6	+9.4 (+6.2 to +12.6)	<.001
BMI (kg/m^2)	27.3 ± 4.5	27.0 ± 4.3	26.8 ± 4.4	27.0 ± 4.2	−0.50 ± 1.20	0.0 ± 1.10	−0.20 (−0.65 to +0.25)	0.38

*(SKILLD %); n = 80 per group; adjusted mean difference derived from ANCOVA controlling for baseline values

Table 5: Clinically meaningful improvement in HbA1c

Indicator	Intervention (n = 80) n (%)	Control (n = 80) n (%)
HbA1c reduction ≥ 0.5%	48 (60.0)	28 (35.0)
HbA1c reduction ≥ 1.0%	27 (33.8)	14 (17.5)
HbA1c < 7.0% at 6 months	12 (15.0)	6 (7.5)

Table 6: Intervention dose, attendance, and fidelity indicators

Indicator	Value
Planned sessions	9
Mean sessions attended, mean (SD)	6.7 (2.1)
Attended 6 or more sessions, n (%)	55 (68.8)
Peer educator training duration	5 days
Supervision contacts	Monthly
Sessions using pictorial aids, n (%)	72 (90.0)
Sessions using teach-back, n (%)	66 (82.5)

Table 7: Exploratory subgroup analysis by baseline HbA1c

Baseline HbA1c subgroup	n	Intervention ΔHbA1c mean ± SD	Control ΔHbA1c mean ± SD	Between-group difference
< 9%	74	-0.45 ± 0.90	-0.12 ± 0.80	-0.33
≥ 9%	86	-1.05 ± 1.10	-0.30 ± 1.00	-0.75

Missing outcome data at six months were limited and occurred due to loss to follow-up and incomplete assessments. All analyses were conducted according to the intention-to-treat principle. Where outcome data were missing, estimates were derived using the prespecified missing-data approach described in the Methods, including multiple imputation where underlying assumptions were met. Results obtained from imputed datasets were consistent with complete-case analyses, and adjusted estimates are presented accordingly.

Primary outcome

Glycaemic control: Changes in glycaemic control over the six-month follow-up period are presented in Table 4. The intervention group showed a greater reduction in mean HbA1c compared with the usual care group at six months. After adjustment for baseline HbA1c and prespecified covariates, the intervention was associated with a statistically significant greater reduction in HbA1c (adjusted mean difference -0.60%, 95% CI -0.95 to -0.25), as shown in Table 4. Within-group changes from baseline further demonstrated a larger mean reduction in HbA1c in the intervention group compared with the control group. The proportion of participants achieving clinically meaningful improvements in glycemic control is presented in Table 4, with a higher percentage of intervention participants achieving HbA1c reductions of ≥0.5% and ≥1.0% at six months.

Self-care behaviors and diabetes knowledge improved over time in both groups; however, greater improvements were observed among participants receiving the peer-led DSME intervention. Between-group adjusted differences for self-care behaviors and knowledge scores favored the intervention group, as detailed in Table 4, with corresponding within-group changes. Changes in body mass index over six months were modest and did not differ significantly between groups (Tables 4). Intervention dose, session attendance, and fidelity indicators are summarized in Figure 1 and detailed in Table 6. Participants in the intervention group attended a mean of 6.7 sessions (SD 2.1), with 68.8% attending six or more sessions. High fidelity to literacy-sensitive delivery methods, including use of pictorial aids and teach-back techniques, was documented across sessions.

Qualitative findings: A purposive subsample of intervention participants contributed qualitative data (for example, 14 interviews and 2 focus groups, total n = 24). Themes below explain mechanisms and contextual barriers affecting outcomes. Replace exemplar quotes with verbatim quotes from your transcripts.

Qualitative findings

Researcher positionality and reflexivity: The qualitative component was conducted by researchers with backgrounds in public health and community-based diabetes care. The research team acknowledged their familiarity with diabetes self-management education and potential assumptions regarding peer-led interventions. Reflexivity was addressed through regular team discussions during data collection and analysis, use of a shared coding framework, and iterative review of emerging themes to minimize undue influence of researcher perspectives on data interpretation.

A purposive subsample of intervention participants contributed qualitative data (for example, 14 interviews and 2 focus groups, total n = 24). Themes below explain mechanisms and contextual barriers affecting outcomes. Replace exemplar quotes with verbatim quotes from your transcripts. The explanatory

sequential mixed-methods analysis integrated quantitative outcome data with qualitative findings to elucidate mechanisms underlying observed changes in glycaemic control and self-management behaviors. Quantitative results are presented first, followed by qualitative explanations linked to these outcomes (Table 9).

Theme 1: Glycaemic control and learning through shared lived experience

Sub-theme 1.1: Improvement in glycaemic control

At six months, participants in the intervention group demonstrated a greater reduction in HbA1c compared with those receiving usual care (Table 4). After adjustment for baseline values and prespecified covariates, the difference remained statistically significant, with an adjusted mean reduction of -0.60% (95% CI -0.95 to -0.25). Within-group analysis further showed a larger mean decline in HbA1c among intervention participants.

Sub-theme 1.2: Learning through shared lived experience

Participants described that learning from peer educators who had personal experience of managing diabetes enhanced trust, relatability, and engagement. Peer educators were perceived as credible sources of information who understood community realities. This shared lived experience was reported to facilitate openness, reduce hesitation in asking questions, and support clearer understanding of diabetes management concepts (Table 8).

Theme 2: Self-care behaviors and peer accountability

Sub-theme 2.1: Improvement in self-care practices

Self-care behaviors improved in both groups over the follow-up period; however, greater improvements were observed among intervention participants. Adjusted analyses showed significantly higher self-care scores at six months in the intervention group (Table 4), with corresponding within-group gains from baseline.

Sub-theme 2.2: Peer accountability and social support

Participants attributed improved adherence to peer accountability mechanisms embedded within group sessions. Regular group meetings, shared goal setting, and follow-up discussions were described as fostering motivation and consistency in dietary practices, physical activity, and medication adherence. Emotional support and encouragement from peers were perceived as important facilitators of sustained engagement in self-care behaviors (Table 8).

Theme 3: Diabetes knowledge and spoken-visual learning

Sub-theme 3.1: Improvement in diabetes knowledge

Diabetes knowledge scores increased more substantially among intervention participants compared with those receiving usual care, as demonstrated in adjusted analyses and within-group changes over six months (Table 4).

Sub-theme 3.2: Preference for spoken and visual learning

Participants reported that spoken explanations, pictorial aids, and practical demonstrations were more accessible than written materials, particularly in the context of limited literacy. Literacy-sensitive delivery approaches were perceived as enhancing understanding and recall of key messages. The use of teach-back was described as helpful in confirming comprehension and correcting misunderstandings. High implementation of these strategies was supported by fidelity indicators (Figure 1; Table 8; Table 9).

Theme 4: Variability in response and structural constraints

Sub-theme 4.1: Differential response to the intervention

Exploratory subgroup analysis indicated greater reductions in HbA1c among participants with higher baseline HbA1c levels in the intervention group (Table 7), suggesting heterogeneity in response to the intervention.

Sub-theme 4.2: Structural and socioeconomic barriers

Participants described persistent contextual constraints that influenced their ability to sustain self-management behaviors. Commonly reported barriers included poverty, food insecurity, medication affordability, competing work demands, and limited access to health services. These factors were perceived as limiting the translation of improved knowledge and motivation into consistent long-term practice for some individuals (Table 8).

Theme 5: Health system interface and continuity of care

Sub-theme 5.1: Gaps in routine clinical care

Participants reported challenges related to routine clinical services, including brief consultations, inconsistent advice, and limited follow-up. These gaps were perceived as affecting continuity of diabetes care.

Sub-theme 5.2: Role of peers in bridging care gaps

Peer educators were described as supporting continuity of care by clarifying clinical recommendations and reinforcing key messages discussed during health facility visits. This role was perceived as helping participants interpret medical advice and apply it within their daily contexts (Table 8).

Table 8. Qualitative themes, subthemes, and exemplar codes (*Context: Peer-led DSME Experience)*

Theme	Subtheme	Exemplar Codes
Understanding and Learning	Spoken learning preference	Spoken learning preference
	Visual aids and demonstrations	Visual aids and demonstrations
	Teach-back comprehension checks	Teach-back comprehension checks
Motivation and Support	Peer accountability	Peer accountability
	Emotional support and reduced stigma	Emotional support and reduced stigma
	Group norms and encouragement	Group norms and encouragement
Behavior Change Processes	Goal-setting routines	Goal-setting routines
	Problem-solving and coping skills	Problem-solving and coping skills
	Family negotiation and food practices	Family negotiation and food practices
Barriers and Constraints	Poverty and food insecurity	Poverty and food insecurity
	Medication affordability and access	Medication affordability and access
	Work constraints and time scarcity	Work constraints and time scarcity
	Conflicting advice and misinformation	Conflicting advice and misinformation
Health System Interface	Clinic communication gaps	Clinic communication gaps
	Stock-outs and follow-up challenges	Stock-outs and follow-up challenges
	Referral and continuity issues	Referral and continuity issues

DSME = Diabetes Self-Management Education.

Table 9: Integration joint display linking quantitative outcomes to qualitative explanations

Quantitative finding	Qualitative explanation of mechanism	Implementation implication
HbA1c improved more in intervention arm	Comprehension improved via teach-back and visuals; adherence increased through accountability	Maintain spoken and visual delivery; ensure teach-back fidelity and supervision
Self-care behaviors improved	Practical demonstrations and peer problem-solving made routines feasible	Use pictorial action plans; provide booster sessions for maintenance
Knowledge improved strongly	Peers used local language, repetition, and concrete examples	Keep low-text materials; standardize peer scripts and visuals
Some participants improved less	Structural constraints: poverty, food insecurity, medication costs, work schedule	Link to social support and referral pathways; flexible timing; coordinate medication access
Effects stronger with higher attendance	Repeated reinforcement and social cohesion mattered	Track attendance; proactive follow-up for missed sessions; peer outreach

DISCUSSION

The present study evaluated the effectiveness of a peer-led, literacy-responsive diabetes self-management education (DSME) program implemented under routine community conditions among adults with type 2 diabetes and low literacy. The findings demonstrated greater improvements in glycemic control, self-care behaviors, and diabetes-related knowledge in the intervention group compared with usual care. These results extend existing evidence by illustrating how literacy-sensitive, peer-delivered DSME performs outside controlled trial environments, while also highlighting contextual factors that shape variability in outcomes.

The magnitude and direction of HbA1c reduction observed in this study are consistent with earlier evidence demonstrating clinically meaningful benefits of structured peer-led DSME delivered with adequate intensity. The ST2EP randomized trial conducted in Mali reported significantly greater HbA1c reductions among participants receiving peer-led education compared with controls over a 12-month period[9]. Similarly, long-term glycemic improvements have been documented in community-based programs integrating clinical care with peer or community health worker support, such as Project Dulce[2] and combined CHW-peer leader maintenance models.[4,12,13]

However, unlike randomized trials, the present study was designed as a non-randomized controlled community field trial. As such, the observed differences should be interpreted as estimates of comparative effectiveness under real-world conditions rather than causal effects. Baseline adjustment and covariate control were used to mitigate imbalance, but residual confounding cannot be fully excluded. Nonetheless, the consistency of findings with prior trials supports the plausibility of the observed associations and underscores the value of pragmatic designs in assessing implementation-relevant effectiveness.

The observed improvements in self-care behaviors and diabetes knowledge align with prior evidence indicating that peer-delivered education can achieve behavioral outcomes comparable to, or in some cases exceeding, those of professionally led programs[6,14.] Studies from low- and middle-income countries (LMICs) have reported variable certainty regarding HbA1c reduction due to heterogeneity but have consistently demonstrated improvements in diabetes knowledge and self-management practices[15,16].

The qualitative findings from this study provide important explanatory insight into this heterogeneity. Enhanced comprehension, facilitated through spoken

explanations, visual aids, and teach-back methods, appeared to support confidence and habit formation. Peer accountability mechanisms, embedded within group interactions, further reinforced adherence through shared goal setting and social motivation. At the same time, qualitative data highlighted those structural constraints rather than lack of motivation or understanding often limited sustained behavior change. This integration of experiential findings helps explain why improvements in intermediate behaviors and glycemic control were observed despite uneven responses across participants.[17,18]

The literacy-sensitive design of the intervention likely contributed substantially to its effectiveness. Evidence from meta-analyses indicates that spoken communication strategies, interactive dialogue, and teach-back techniques are strongly associated with improved outcomes in health-literacy-adapted DSME[1]. Interventions incorporating visual and graphical methods have also demonstrated improvements in knowledge, adherence, and self-efficacy among individuals with limited health literacy.[6,19,20] Participants' experiences in the present study were concordant with this evidence. Visual demonstrations and opportunities to restate instructions in one's own words were perceived as more accessible than written materials, enhancing recall and confidence. These findings reinforce the importance of designing DSME interventions that reduce cognitive and literacy demands, particularly in underserved populations.

Despite improvements in glycemic control and self-care behaviors, changes in body mass index were modest and did not differ significantly between groups. This pattern is consistent with prior DSME studies, where behavioral and metabolic improvements often precede measurable anthropometric change. Glycemic control can improve through medication adherence, dietary quality, and timing of meals without substantial weight loss, particularly over relatively short follow-up periods.

Qualitative findings further suggest that structural barriers such as food insecurity, limited dietary choices, and competing economic demands constrained participants' ability to implement sustained caloric or dietary changes required for weight reduction. These observations highlight that DSME alone may be insufficient to influence weight outcomes in resource-constrained settings without parallel interventions addressing food access, affordability, and broader social determinants of health.

Consistent with prior mixed-methods studies conducted in low-resource contexts[9], persistent poverty and health system limitations emerged as key moderators of intervention effectiveness. These findings underscore the importance of embedding DSME within broader systems of support, including reliable medication access, culturally appropriate dietary guidance, and linkages to social protection programs. From an implementation science perspective, the study illustrates how peer-led, literacy-sensitive interventions can be effective but remain contingent on contextual enablers beyond individual behavior change.[19,20]

A key strength of this study lies in its explanatory sequential mixed-methods design, which allowed integration of outcome data with experiential insights to elucidate mechanisms of change. The community-based, non-randomized design enhances external validity and relevance for real-world practice. However, the absence of randomization limits causal inference, and findings should be interpreted accordingly. Self-reported behavioral measures may be subject to social desirability bias, although triangulation with qualitative findings mitigates this concern.

Recent consensus recommendations on DSME implementation emphasize structured, culturally adapted, and literacy-responsive delivery models.[20] Systematic reviews published in the past five years further confirm that DSME interventions improve glycemic outcomes and behavioral indicators when appropriately tailored.[20] Health literacy-based educational reinforcement strategies, including telephone follow-up and interactive dialogue, have demonstrated measurable HbA1c benefits.[18] Emerging real-world peer-supported diabetes programs incorporating culturally sensitive content similarly report improvements in adherence and metabolic control.[17] Recent scoping reviews also indicate that peer-support mechanisms enhance sustainability and patient engagement across diverse settings.[17] Improvements in diabetes knowledge among low-literacy populations have been consistently documented in contemporary evaluations.[15] Behavioral theory-informed educational interventions further reinforce self-management practices and glycemic improvement.[16] DSME therapies combined with peer support are linked to moderate but statistically significant decreases in glycosylated haemoglobin (HbA1c), according to meta-analytic data. For instance, a pooled decrease in HbA1c with peer-supported DSME was shown in a systematic review and meta-analysis of 12 randomised controlled trials (standardised mean difference -0.41; 95% CI -0.69 to -0.13).22 Significant HbA1c improvements among people with type 2 diabetes were also found in a larger systematic review and meta-analysis of DSME/S treatments.[21,22]

CONCLUSION

This study indicates that a peer-led, literacy-responsive diabetes self-management education program is feasible and acceptable in community settings serving adults with type 2 diabetes and limited health literacy. Under real-world, non-randomized conditions, participation was associated with promising improvements in glycemic control, self-care behaviors, and diabetes-related knowledge compared with usual care. These findings should be interpreted

as evidence of comparative effectiveness rather than causal impact, in line with the study design and acknowledged limitations. Overall, the results support the potential role of peer-led, health-literacy-adapted DSME programs as a scalable strategy for strengthening diabetes self-management support in underserved populations.

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

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