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ORIGINAL RESEARCH

Effectiveness of Diabetes Self-Management Education on Glycemic Control in Adults with Type 2 Diabetes: Evidence from Juba County, South Sudan.

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Abstract

Background: Type 2 diabetes (T2D) is a growing health challenge, affecting over 6% of the global population and contributing to rising mortality rates. In South Sudan, the burden is intensified by fragile health systems, limited resources, and poor access to education and care, making the effective management of chronic conditions difficult. Diabetes self-management education (DSME) is widely appreciated for its role in improving glycemic control. Although its efficacy has been demonstrated in various global contexts, it remains underutilized in South Sudan, and its impact has not been systematically evaluated. **Objective**: This study evaluated the effectiveness of a culturally adapted DSME program in improving glycemic control among adults (45+ years) with T2D attending the Malakia Primary Health Care Centre in Juba County. **Methods**: A randomized controlled trial (RCT) was conducted involving 132 participants. The intervention group received structured DSME sessions, while the control group received general health education (GHE). The outcomes included clinical and self-care behaviors, diabetes knowledge, and quality of life among adults. Data were analyzed using paired and independent t-tests, ANCOVA, logistic and linear multivariate regressions. **Results**: The intervention group showed statistically significant improvements in fasting blood glucose levels (−16.6 mg/dL), body mass index (−2.18 kg/m²), and blood pressure (−4.51 mmHg systolic, −2.28 mmHg diastolic), all at $p<0.001$. Both Diabetes knowledge and quality of life improved (+1.75, $p < 0.001$; -1.82, $p < 0.001$; respectively). Results of ANCOVA demonstrated the effectiveness of the intervention, significantly improving glycaemic control, BMI, blood pressure, self-care behavior, dietary knowledge, and quality of life after adjusting for baseline differences ($P<0.01$); the largest intervention effects were observed for dietary knowledge and quality of life. **Conclusion**: The findings demonstrate that DSME is a feasible, impactful, and scalable intervention for South Sudan.

Key words: Diabetes Self-Management Education (DSME), Glycemic Control, Type 2 Diabetes, Randomized Controlled Trial (RCT)

Introduction

Type 2 diabetes (T2D) is a growing global health crisis, affecting approximately 539 million adults worldwide, with the fastest increases occurring in low- and middle-income countries (1). Initial signs of DM include increased thirst (polydipsia), increased hunger (polyphagia), and increased urination (polyuria) (2). This may be accompanied by blurred vision, skin infection/irritation, and dehydration. If left uncontrolled, it can progressively deteriorate, leading to water and electrolyte imbalance, causing microalbuminuria (nephropathy), nervous system damage (neuropathy), and retinopathy (the leading cause of new cases of blindness in adults). Cardiovascular diseases (CVDs) are also a major cause of death among people with DM, occurring two to four times more than in the normal population (3). These complications impose economic burdens on individuals, households, health systems, and society (4). South Sudan is one of many countries where the management of diabetes is poor, and resources are lacking; therefore, prevention is of utmost importance, as a study in Juba city reported a prevalence of 11.8% (5), though national data remain limited. (5). Knowledge of and adherence to management guidelines are important for improving health outcomes. This study focused on type 2 diabetes (T2D), a chronic condition that is typically managed with oral hypoglycemic agents. Generally, DM is an expensive condition to treat due to the range of complications it can cause, making it prohibitively expensive and insufficiently addressed by local communities in South Sudan. Given these limitations, there is an urgent need to explore more affordable and sustainable interventions, such as educating the general public, including schoolchildren, and increasing the availability of low-cost healthy foods. Diabetes self-

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management education (DSME), a critical component of DM management, has emerged as a globally endorsed strategy that empowers individuals with T2D. Specifically, DSME enhances self-management behaviors such as medication adherence, blood glucose monitoring, dietary management, and physical activity (6-7), by contributing to better glycemic control, reflected by significant reductions in HbA1c levels and fasting blood sugar, especially in patients with type 2 diabetes mellitus (T2DM) (8 - 10), thus improving glycemic control, reducing complications, and enhancing quality of life, especially if implemented alongside standard medical care (11).

As in other resource-limited settings, DSME remains underutilized in South Sudan, underscoring the need to personalize and adapt it to local cultural settings, literacy levels, and health system capabilities. This discourse suggests that in South Sudan, DSME utilization faces fundamental barriers, including limited health infrastructure, educational resources, and program standardization, because specific country-level studies are lacking (12, 13). More focused intensive research within South Sudan's context could document current DSME practices and optimize their use.

This study therefore aimed to evaluate the effectiveness of a culturally adapted DSME intervention on clinical outcomes (Fasting Blood Glucose Level - FBGL; Body Mass Index - BMI; Blood Pressure BP as Systolic Blood Pressure SBP and Diastolic Blood Pressure DBP); behavioral changes like Self-Care Behavior - SCB, Dietary Knowledge changes - DK; and quality of life - QoL among T2D adults (45+ years) exposed to DSME. No randomized controlled trial has evaluated culturally adapted DSME in South Sudan. The study is therefore crucial as it addresses gaps in NCD management in a resource-limited, conflict-affected setting. It provides evidence that structured education improves glycemic control and offers practical insights for integrating patient-centered care into South Sudan's health system. The findings can guide national NCD policy by highlighting DSME as a cost-effective intervention to reduce complications, enhance quality of life, and ease healthcare burdens. Incorporating this evidence will support healthcare capacity building, community engagement, and prioritize diabetes within broader NCD prevention and control efforts.

The findings of the intervention were tested against the hypotheses; there are no changes in clinical outcomes, behavioral patterns, knowledge, or quality of life among T2D adult patients aged 45+ years, exposed to DSME at Malakia PHCC, Juba County, South Sudan. The health belief model (HBM), developed by social psychologists (14, 15), informed the design and intervention of the current study.

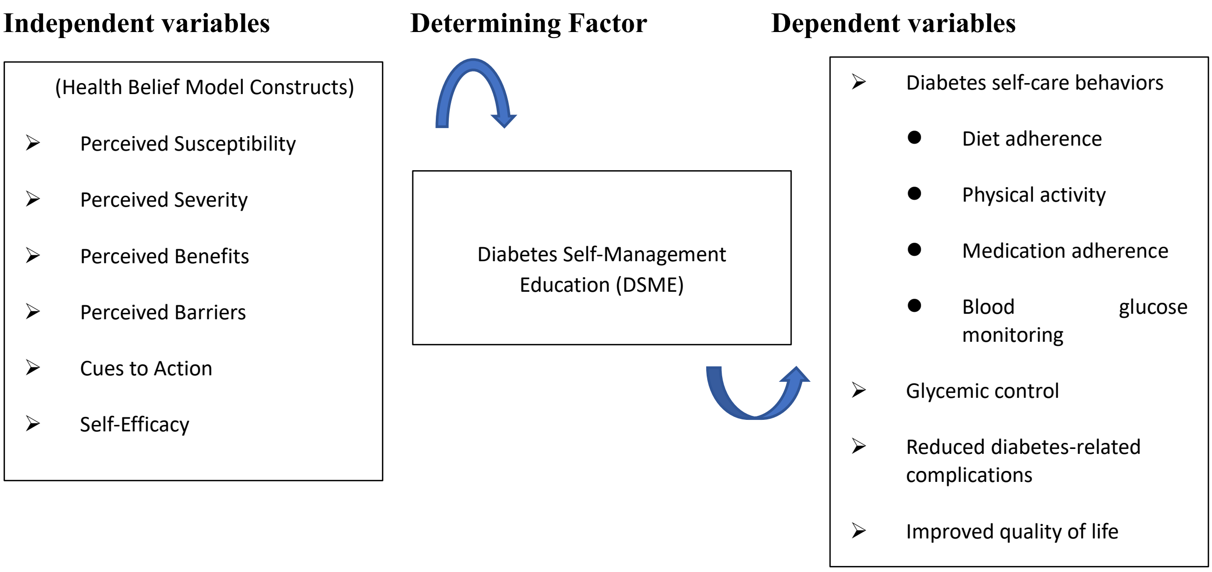

Figure 1*:* Conceptual framework showing the influence of Health Belief Model constructs on Diabetes Self-Management Education and diabetes self-management (DSME) outcomes. Adapted from Albelbisi (16), with slight modifications

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Materials and Methods

Juba County, the capital and largest city of South Sudan, is the main town in Central Equatoria, one of the ten states in the Republic of South Sudan. It covers 52 km^2, with a metropolitan area of 336 km^2. It is connected to highways in Uganda, Kenya, and the DRC (17). Juba's population was estimated at 163,442 in 2005, but the 5th Sudan Population and Housing Census in 2008 reported 372,413, with the majority of the population in Juba. Therefore, the exact population of Juba County is unknown, but it is known to be rapidly growing due to rural-to-urban and international migration, with a projected population of 372,410 in 2011 and a 4.23% growth rate in 2013, as illustrated in (18).

Study Design:

This study was conducted as a parallel-group randomized controlled trial (RCT) to evaluate the effectiveness of the DSME program. Adults (≥45 years) who were diagnosed with T2D from four health facilities were recruited, and Malakia Primary Health Care Center (PHCC) was used as the setting for the intervention, with three other comparable facilities serving as controls. Malakia PHCC was selected as an intervention site due to the high patient volume and relatively well-equipped infrastructure, which limits the generalizability to other regions of South Sudan.

Participants (n = 132) were randomly assigned to either the intervention or control group at a 1:1 ratio. Randomization was performed using a computer-generated block sequence, and allocation concealment was maintained using sealed opaque envelopes. The intervention was conducted between January and April 2025, with outcomes assessed at baseline and immediately post-intervention, as shown in the flow diagram (Figure 2). Those with a documented diagnosis of T2D, aged ≥45 years, and the ability to provide informed consent were eligible for selection to participate in the study. Type 1 diabetics, or those with gestational diabetes, severe co-morbidities, cognitive impairment, and inability to attend scheduled sessions, were ineligible to participate. The intervention group received structured DSME sessions (24 contact hours over three months) covering nutrition, physical activity, medication adherence, glucose monitoring, and coping strategies. The delivery was in Arabic, translated from the original WHO DSME guidelines, and visual aids were adapted to local dietary practices. The control group received general health education of equal frequency and duration, focusing on hygiene, communicable disease prevention, and basic first aid, commonly used in the facility for diabetic education. Both groups continued to receive their routine clinical care.

Primary outcomes included fasting blood glucose level (FBGL), body mass index (BMI), and blood pressure (BP) measured as systolic and diastolic blood pressure (SBP/DBP, respectively. Secondary outcomes included self-care behavior (SCB), knowledge of diabetes (DK), and quality of life (QoL). Validated instruments included the Diabetes Knowledge Questionnaire (DKQ-24), the Summary of diabetes self-care activities (SDSCA), and the World Health Organization Quality of Life-BREF (WHOQOL-BREF).

Sample size Determination:

The initial sample size was calculated using the standard finite population formula (19, 20), ensuring adequate statistical power and generalizability.

$$n=\frac{N \times Z^2 \times p \times (1-p)}{E^2 \times (N-1) + Z^2 \times p \times (1-p)}$$

Where population size (N) = 200, Confidence level (Z) = 95% (Z-score = 1.96), Estimated proportion (p) = 0.5 (maximum variability), Margin of error (E) = 5%, Power (1−β) > 80%, Significance level (α) = 0.05 and; Expected effect size (Cohen's d) = 0.5, based on prior DSME trials showing ≥0.5 mmol/L reduction in FBGL.

A total of 132 participants (66 per group) were recruited for the study, following the sampling procedure (Figure 2). After accounting for losses due to dropouts and attrition, 116 participants (57 in the intervention group and 59 in the control group) were retained for analysis. This sample size provided a 79% statistical power (α=0.05) to detect a moderate between-group effect in FBGL. Adequacy is supported by similar trials in Kenya (n=84), Sudan (n=120), Ethiopia (70-80%) and Thailand (65-75%) (21, 22).

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Four purposively selected health facilities in Juba County were used, as per the Ministry of Health records, as they were the only centers offering diabetes care services. However, Malakia PHCC was selected as the intervention site because it had trained personnel, diagnostic equipment, and consistent patient flow, while the other three facilities served as controls. The other three facilities included: Munuki PHCC, Kator PHCC and Gudele PHCC.

Eligible participants were adults aged 45 years or older, with documented T2D (which is identified as an increased risk factor for cardiovascular diseases) (23), and actively receiving care at one of the four selected facilities and had complete and continuous records of attendance. Recruitment was conducted for both groups at all the 4 health facilities consecutively in January 2025, during patients' routine visits. Screening of patient records was conducted to verify eligibility, and informed consent was obtained from patients upon request. Finally, a total of 132 participants were enrolled and randomized into intervention and non-intervention groups, using a computer-generated block sequence (block sizes of 4 and 6). Outcome assessors and data analysts were blinded in order to minimize selection and detection bias.

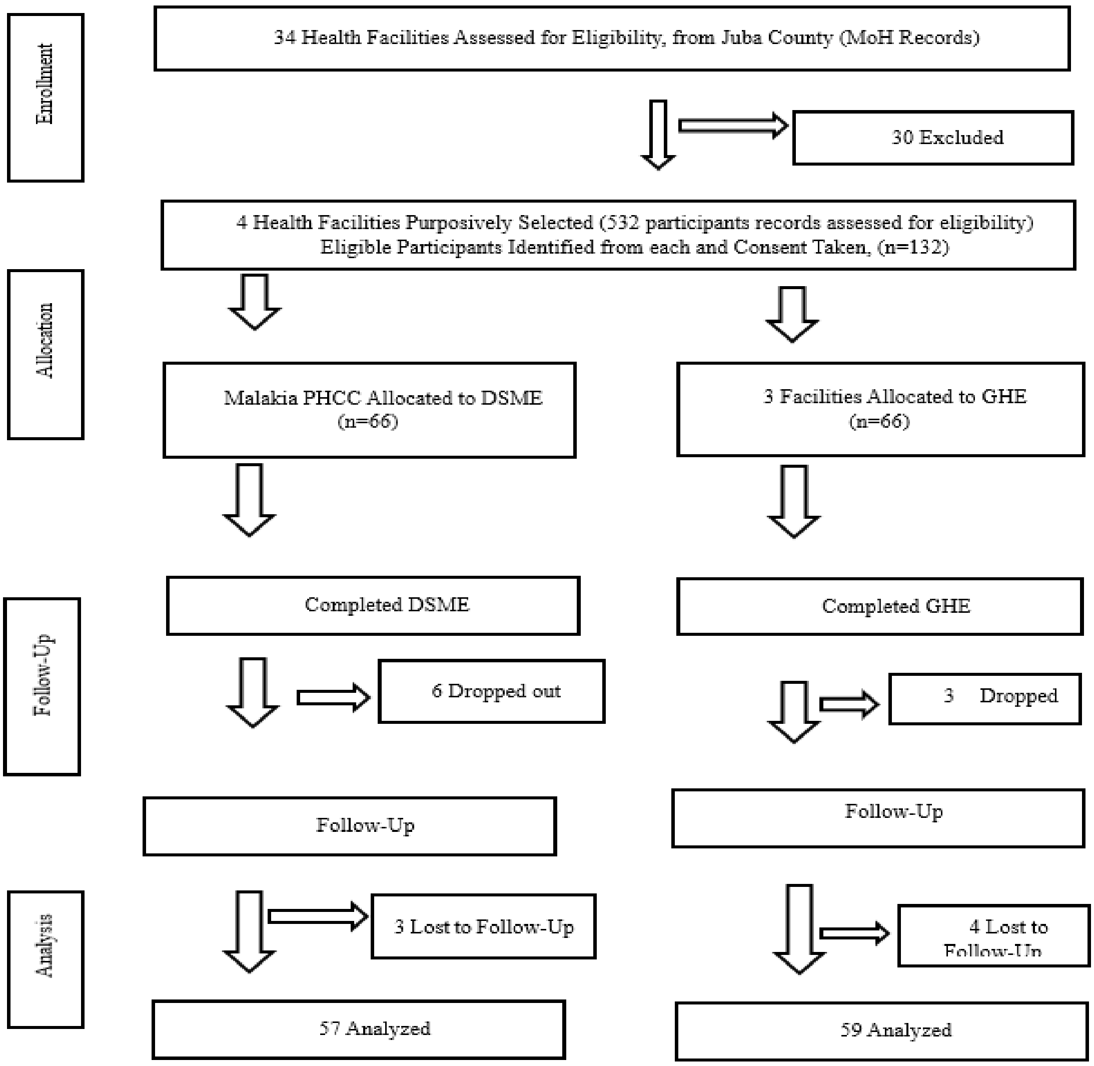

Figure 2: Research Design

From the 34 health facilities listed in the State Ministry of Health records, four health facilities providing diabetes care (including Malakia PHCC and 66 to GHE at Munuki, Kator, and Gudele PHCCs) were purposively selected, and 30 excluded (Figure 2). Out of 532 patient records screened across the four PHCCs, 400 were excluded due to age <45 years, incomplete records, severe comorbidities, and irregular attendance. The remaining 132 participants satisfied the selection criteria, i.e., age ≥45 years, diagnosis of T2D, regular follow-up attendance, complete medical records and provision of written informed consent.

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To allocate participants to study arms, each of the 132 eligible participants was assigned a unique identification code. This ensured anonymity and facilitated randomization. Randomization was conducted using a computer-generated random number sequence in Microsoft Excel. The randomization list was prepared in advance by the research statistician to ensure allocation concealment. Participants were assigned in a 1:1 ratio to either the DSME intervention group or the GHE control group. Intervention arm (DSME): (n=66) participants were allocated to Malakia PHCC, which was purposively selected as the intervention site, while the control arm (GHE): (n=66) participants were allocated across Munuki, Kator, and Gudele PHCCs. Distribution was proportional to the number of eligible patients identified in each facility.

This stratified randomization ensured balance between groups and minimized selection bias. The procedure was documented so that replication in the same facilities would yield comparable results.

The intervention group underwent a three-month Diabetes Self-Management Education (DSME) program, consisting of 24 contact hours delivered over three weekly two-hour sessions. The control group received general health education unrelated to diabetes, matched in duration and frequency but scheduled on alternate days to prevent contamination. A 12% attrition rate was realized (n=9, 7) for intervention and control groups, respectively. An intention-to-treat analysis with sensitivity checks was conducted, and the remaining sample achieved 79% power at a 5% significance level.

Data Sources

This study used both secondary and primary data sources. Secondary data were extracted from the facility diabetes registers from the four health facilities. Validated instruments were selected based on their relevance to the DSME outcomes and prior use. These included the Diabetes Knowledge Questionnaire (DKQ-24), Summary of Diabetes Self-Care Activities (SDSCA), and WHOQOL-BREF. In collaboration with public health and nutrition experts from the four participating facilities, the research team adapted these tools to the South Sudanese context.

Instruments (Table 1) were adapted and modified to suit the context of this study through simplifying technical terms, restructuring items for logical flow, and making adjustments made to reflect local dietary habits, healthcare access and social support systems. A preliminary test was conducted at the intervention site - Malakia PHCC following established standards, with 15 participants to assess understanding, order and responses, which informed the final development of the tools and ensured high data quality, reliability, and validity. This site was chosen for the pre-test because it had the largest caseload of diabetes patients, making it practical to pilot instruments, and because it was the same environment where the intervention would be implemented, allowing for validation of tools under identical conditions. However, participants involved in the pre-test were excluded from the final study sample.

Inter-rater reliability was evaluated during pilot testing, yielding a Cohen's kappa of 0.82, and substantial inter-rater reliability (Cohen's kappa = 0.82) confirmed consistency among data collectors, supporting the credibility of the collected data. All enumerators (laboratory technicians and research assistants) underwent rigorous standardized training, ethical safeguards, and blinding procedures to ensure consistency and reduce bias. Data collection was conducted at two points: baseline (pre-intervention) and after the three-month DSME intervention (post-intervention).

Prior to parametric analyses, assessments of normality and homogeneity of variances were conducted to strengthen statistical validity. Missing responses were flagged and resolved through participant follow-up. When follow-up was unfeasible, missing data were documented and addressed using multiple imputation techniques.

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Table 1: Variables assessed and procedures

Variable	Instruments	Procedure	Standard Reference
FBGL	Accu-Chek Active Glucometer	Finger-prick (after 8 hours of fasting)	ADA: Normal ≤100 mg/dL; Diabetes ≥126 mg/dL,
BP	Digital Sphygmomanometer	Two measurements taken 5 minutes apart; the mean is obtained	WHO: Normal ≤120/80 mmHg; Hypertension ≥130/80 mmHg,
BMI	Height board + digital scale	Weight (kg)/Height² (m²); measured barefoot, with minimum clothing	WHO: Normal 18.5–24.9; Overweight 25–29.9; Obese ≥30,
DK	DKQ-24 (adapted)	24-item multiple-choice questionnaire; scored from 0–24	DKQ-24 validated in DSME trials,
SCB	SDSCA (adapted)	Weekly frequency of Dietary intake, physical exercise, medication, and glucose monitoring	SDSCA validated for T2D behavior tracking,
QoL	WHOQOL-BREF (modified)	12 Likert-scale items; on stress, sleep, social support, access to care	WHOQOL-BREF adapted for chronic illness,

FBGL, fasting blood glucose level; BMI = Body mass index; BP, blood pressure; SCB, self-care behavior; DK, diabetes knowledge; QoL = Quality of life.

Intervention settings

Educational sessions (DSME for the intervention group, and health education for the non-intervention group) were conducted in separate designated areas within the facility (Malakia PHCC), each lasting 120 minutes over a three-month period, with the interaction delivered in Arabic and supported by printed visual aids. Weekly sessions were held on Mondays (first group of 22 participants), Wednesdays (second group of 22 participants), and Friday mornings (third group of 22 participants); with each participant attending only one session per week per schedule.

This curriculum is structured around the 2022 National Standards for Diabetes Self-Management Education and Support (DSMES), incorporating guidelines from the ADA and WHO DSME (21, 24, 25). It included core topics in the pathophysiology of T2D, treatment options and dietary modification, healthy coping, nutritional guidelines, the relationship between blood glucose and nutrition, physical activity, medication adherence, blood glucose monitoring, behavior change strategies, risk reduction, lifestyle integration, and sustaining self-management. The curriculum, adapted from national and international guidelines, was tailored for low-literacy audiences and local dietary contexts, covering nutrition, physical activity, medication adherence, glucose monitoring, coping, and problem-solving. Data collection involved baseline and post-intervention clinical assessments and structured questionnaires.

The intervention included a co-DSME educator and 2 research assistants, who used interactive/group-based activities (discussions, role-play, visuals). Participant engagement was assessed through structured question-and-answer segments. All participants continued to receive routine clinical care throughout the study period, with those in the control group receiving routine general health education (GHE) in the same settings and for the same duration as the intervention group. Weekly sessions were conducted on Tuesdays, Thursdays, and Friday evenings, matching the frequency and duration of the DSME sessions.

The GHE curriculum covered non-diabetes-related topics, including mental health, hygiene, emotional resilience, communicable disease prevention, risk behaviors, household sanitation, personal hygiene, environmental health, basic first aid, reproductive health, sexual health, and the prevention of sexually transmitted infections. These sessions were delivered by clinical officers, using the same interactive methods employed in the intervention arm. Participants also continued routine clinical care to ensure equal access to standard medical services across both groups.

The data were processed with SPSS Version 20 for statistical analysis, summarized using descriptive statistics (means, standard deviations, frequencies, and percentages), and paired t-tests were conducted to assess within-group changes from baseline to post-intervention. Independent t-tests were used to compare post-intervention outcomes between the DSME and control groups to assess changes. Cohen's 'd' was also calculated to measure the magnitude of change within and between groups.

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Statistical significance was set at $p < 0.05$, with 95% confidence, and statistical tests were performed with assumption checks for normality, linearity, and homogeneity of variance. Violation of assumptions led to the use of nonparametric alternatives. Predictors of DSME effectiveness were assessed using logistic regression analyses for the intervention group only (n = 57). The predictor variables included age, sex, education level, duration of diabetes, and employment status. Odds ratios (ORs), confidence intervals (CIs), and p-values were used to indicate the strength and significance of the associations. No missing data were registered.

The adopted QoL questionnaire included negatively worded items, whose scoring designated higher values for greater impairment (such as dissatisfaction, stress, depression, anxiety, and pain), while the reverse was true for better outcomes. Additionally, baseline characteristics of the study groups were compared to assess their similarity prior to intervention/exposure. At baseline, the intervention and control groups were statistically comparable for FBGL, BMI, SBP, and Dietary Knowledge ($p > 0.05$), (Table 2). However, significant baseline differences existed for DBP, SCB, and Quality of Life ($p < 0.05$), indicating that the groups were not fully equivalent on these variables before the intervention, which could confound post-intervention comparisons if not properly addressed. Adjustments were made for baseline differences using ANCOVA.

Table 2: Baseline characteristics of intervention and control groups (means, standard deviations) (n=116)

Outcome Variable	Intervention Mean ± SD	Control Mean ± SD	t-value	p-value	Statistical Difference
FBGL	127.18 ± 2.23	127.69 ± 2.16	−1.25	0.21	No significant difference
BMI	28.60 ± 6.85	28.73 ± 4.99	−0.12	0.91	No significant difference
SBP	128.58 ± 7.96	130.80 ± 6.28	−1.66	0.10	No significant difference
DBP	83.51 ± 4.81	85.76 ± 4.98	−2.48	0.01	Significant difference
SCB	4.09 ± 0.95	3.12 ± 0.69	6.27	<0.001	Significant difference
Dietary Knowledge (DK)	1.07 ± 1.10	0.85 ± 0.36	1.44	0.16	No significant difference
Quality of Life (QoL)	3.98 ± 0.74	2.03 ± 0.77	13.91	<0.001	Significant difference

Results

Table 3: Demographic characteristics of the participants (n=116)

Characteristic	*n*	%
Age (N=116)		
45-50	52	44.8
50-55	48	41.4
55-60	11	9.5
60-65	05	4.3
65-70	00	0.0
70 and above	00	0.0
Gender (N=116)		
Male	37	31.9
Female	79	68.1
Education (N=116)		
None	04	3.4
Basic	99	85.3
High School	13	11.2
Tertiary	00	0.0
Duration (N=116)		
1 year	56	48.3
2 years	28	24.1

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3 years	12	10.3
4 years	11	9.5
5 and above	09	7.8
Employment (N=116)		
Employed	107	92.2
Not employed	09	7.8

The majority (86%) of the participants were within the age range of 45-55 years, many of whom were females (68%), had attained only basic education (85%), with close to half (48%) having had the condition for a period of 1 year (Table 3).

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Changes in Clinical Outcomes

Table 4: Changes in Clinical, Behavioral, and Quality of Life Outcomes Following the Intervention, with 95% confidence intervals (CI) were calculated using paired t-tests.

Outcome Variable	Group	n	Pre-Intervention Mean ± SD	Post-Intervention Mean ± SD	Mean Change	95% CI (Lower, Upper)	t-value	Within-Group Cohen's d	Between-Group Cohen's d	p-value
FBGL (mg/dL)	Intervention	57	127.18 ± 2.23	110.58 ± 13.97	−16.60	**−20.17, −13.03**	9.31	1.23 (large)	−1.60	**<0.01**
	Control	59	127.69 ± 2.16	127.47 ± 2.10	−0.22	−0.45, 0.01	1.94	0.25 (small)	—	0.06
BMI (kg/m²)	Intervention	57	28.60 ± 6.85	26.42 ± 5.98	−2.18	**−2.62, −1.74**	9.90	1.31 (large)	−1.86	**<0.01**
	Control	59	28.73 ± 4.99	28.41 ± 4.98	−0.32	−0.72, 0.08	1.61	0.21 (small)	—	0.11
SBP (mmHg)	Intervention	57	128.58 ± 7.96	124.07 ± 6.71	−4.51	**−4.65, −4.37**	65.71	8.70 (very large)	−11.43	**<0.01**
	Control	59	130.80 ± 6.28	130.34 ± 6.32	−0.47	**−0.48, −0.46**	69.33	9.02 (very large)	—	**<0.01**
DBP (mmHg)	Intervention	57	83.51 ± 4.81	81.20 ± 3.31	−2.28	**−2.37, −2.19**	52.69	6.98 (very large)	−5.07	**<0.01**
	Control	59	85.76 ± 4.98	85.76 ± 4.98	0.00	0.00, 0.00	63.49	8.27 (very large)	—	**<0.01**
SCB	Intervention	57	4.09 ± 0.95	3.88 ± 1.14	−0.21	−0.67, 0.25	0.91	0.12 (trivial)	−0.16	0.37
	Control	59	3.12 ± 0.69	3.14 ± 0.79	+0.02	−0.10, 0.14	−0.33	0.04 (trivial)	—	0.74
Dietary Knowledge (DK)	Intervention	57	1.07 ± 1.10	2.82 ± 0.57	+1.75	**1.46, 2.04**	11.97	1.59 (large)	1.61	**<0.01**
	Control	59	0.85 ± 0.36	1.15 ± 0.74	+0.30	**0.13, 0.47**	−3.61	0.47 (medium)	—	**<0.01**
Quality of Life (QoL)	Intervention	57	3.98 ± 0.74	2.16 ± 0.67	−1.82	**−2.06, −1.58**	−15.49	2.05 (very large)	−2.55	**<0.01**
	Control	59	2.03 ± 0.77	2.37 ± 0.83	+0.34	**0.14, 0.54**	−3.34	0.43 (medium)	—	**<0.01**

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Values are presented as mean ± standard deviation (SD), and the Mean change reflects post-intervention minus pre-intervention values. Bolded CI's indicate statistically significant changes, and Cohen's d within and between groups is interpreted as: 0.2 = small, 0.5 = medium, 0.8 = large. FBGL = Fasting Blood Glucose Level; BMI = Body Mass Index; SBP = Systolic Blood Pressure; DBP = Diastolic Blood Pressure; SCB = Self-Care Behavior; DK = Dietary Knowledge; QoL = Quality of Life.

Note: Higher values for QoL and SCB mean greater impairment

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Compared to the control group, the intervention produced statistically significant and robust improvements across the majority of biomedical, behavioral, and psychosocial outcomes. The pattern of results indicates both clinical relevance and a large practical impact, particularly for metabolic and cardiovascular indicators. Negative 'between-group 'd'; specifically, for FBGL, BMI, SBP, DBP, and QoL, indicates greater improvement in the DSME intervention group.

Fasting Blood Glucose Level (FBGL): A large, significant reduction in FBGL was observed among participants in the intervention group (Table 4), (mean change = -16.60 mg/dL; 95% CI: -20.17, -13.03; p < 0.01), with a large within-group effect size (d = 1.23). Conversely, the control group exhibited no statistically significant variation (-0.22 mg/dL; p = 0.06). The between-group effect size was very large (d = −1.60), suggesting that the observed improvement can be confidently attributed to the intervention rather than to natural variation or measurement error.

Body Mass Index (BMI): Results (Table 4) show that BMI significantly reduced in the intervention group (-2.18 kg/m²; 95% CI: -2.62 to -1.74; p < 0.01), with a large effect size (d = 1.31), while no significant reduction was observed for the control group (-0.32 kg/m²; p = 0.11). Comparison of weight-related outcomes gave a substantial between-group effect size (d=-1.86), demonstrating a strong intervention impact.

Systolic and Diastolic Blood Pressure (SBP & DBP): Interestingly, both SBP and DBP also significantly decreased in the intervention group (p < 0.01) by -4.51 mmHg and -2.28 mmHg; respectively (Table 4).
The substantial reductions in SBP (-11.43) and DBP (-5.07) suggest strong sensitivity, although the magnitude may be partly driven by extraneous factors.

Self-Care Behavior (SCB) changes were small and non-significant in both groups, but the intervention group showed slightly better outcomes (-0.21; p = 0.37; d = 0.12) compared to the control group. The weak between-group effect (d = -0.16) indicates that the intervention had minimal impact on SCB, possibly because behavior change takes time or because self-reported measures did not capture actual behavioral shifts.

Dietary Knowledge (DK): While both groups showed significant, positive changes, the intervention group experienced a significantly greater increase in knowledge than the control group (1.75; 95% CI: 1.46 to 2.04; p < 0.01). The substantial effect size (d = 1.59) confirms the superiority of the intervention.

Quality of Life (QoL): (QoL) data showed a significant improvement in the intervention group compared to baseline (mean change = -1.82; p < 0.01, d=2.05) while the control group experienced a statistically significant deterioration in well-being. The large between-group effect size (d = 2.55) strongly supports the intervention's clinical efficacy.

Table 5: Between-group comparisons of post-intervention outcomes of clinical and behavioral variables (n=116)

Outcome Variable	Intervention Mean ± SD	Control Mean ± SD	t-value	p-value	Interpretation
FBGL (mg/dL)	110.58 ± 13.97	127.47 ± 2.10	-9.03	<0.001	Significant difference
BMI (kg/m²)	26.42 ± 5.98	28.41 ± 4.98	-1.94	0.054	Not significant
SBP (mmHg)	124.07 ± 6.71	130.34 ± 6.32	-5.18	<0.001	Significant difference
DBP (mmHg)	81.20 ± 3.31	85.76 ± 4.98	-5.83	<0.001	Significant difference
SCB	3.88 ± 1.14	3.14 ± 0.79	4.05	<0.001	Significant difference
Dietary Knowledge (DK)	2.82 ± 0.57	1.15 ± 0.74	13.64	<0.001	Significant difference
Quality of Life (QoL)	2.16 ± 0.67	2.37 ± 0.83	-1.50	0.136	Not significant

Where; FBGL = Fasting Blood Glucose, BMI = Body Mass Index, SBP = Systolic Blood Pressure, DBP = Diastolic Blood Pressure, SCB = Self-care Behavior DK = Diabetes Knowledge QoL = Quality of Life.

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Overall, the intervention significantly improved key clinical and knowledge outcomes (FBGL, SBP, DBP, SCB, DK) but did not significantly affect BMI or QoL in this sample (Table 5). The post-intervention comparison showed that the intervention group had significantly lower fasting blood glucose levels, systolic blood pressure, and diastolic blood pressure compared to the control group ($p < 0.001$). The intervention group also demonstrated significantly higher self-care behaviour (SCB) and dietary knowledge scores than the control group ($p < 0.001$). However, there were no statistically significant differences between groups in BMI ($p = 0.054$) and quality of life ($p = 0.136$) at post-intervention.

Analysis of covariance (ANCOVA) between groups (Table 6), indicated that the intervention had significant effects across all measured outcomes, with the intervention group showing significantly better outcomes than the control group. Fasting blood glucose was lower (5.80 ± 0.25 vs. 7.43 ± 0.25), with a large effect size (partial $\eta^2 = 0.29$), indicating that the intervention explained 29% of the variance. Additionally, body mass index reduced (24.10 ± 0.30 vs. 26.28 ± 0.30) with a moderate-to-large effect size (partial $\eta^2 = 0.14$); blood pressure improved significantly (128.40 ± 0.40 vs. 132.91 ± 0.40), with the intervention accounting for 17% of the variance (partial $\eta^2 = 0.17$); and self-care behaviour increased (3.70 ± 0.20 vs. 2.90 ± 0.20), showing a moderate effect size (partial $\eta^2 = 0.11$). Dietary knowledge exhibited a very large effect (partial $\eta^2 = 0.44$), with scores higher in the intervention group (11.80 ± 0.30 vs. 8.20 ± 0.30). Quality of life improved markedly (4.20 ± 0.10 vs. 3.40 ± 0.10), with a very large effect size (partial $\eta^2 = 0.53$), indicating over half the variance was explained by the intervention (Table 6).

Table 6: ANCOVA summary of adjusted post-intervention outcomes between study groups (n=116)

Dependent Variable	**Group**	**Adjusted Mean**	**Standard Error**	**F**	**p-value**	**Partial η^2**
FBGL	Intervention (n=57)	5.80	0.25	45.21	<0.01	0.29
	Control (n=59)	7.43	0.25			
BMI	Intervention (n=57)	24.10	0.30	18.67	<0.01	0.14
	Control (n=59)	26.28	0.30			
BP	Intervention (n=57)	128.40	0.40	22.98	<0.01	0.17
	Control (n=59)	132.91	0.40			
SCB	Intervention (n=57)	3.70	0.20	13.73	<0.01	0.11
	Control (n=59)	2.90	0.20			
DK	Intervention (n=57)	11.80	0.30	137.84	<0.01	0.44
	Control (n=59)	8.20	0.30			
QL	Intervention (n=57)	4.20	0.10	130.02	<0.001	0.53
	Control (n=59)	3.400	0.100			

FBGL = Fasting Blood Glucose Level, BMI = Body Mass Index, DBP = Diastolic Blood Pressure, SBP = Systolic Blood Pressure SD: Standard Deviation, SCB = Self-care Behavior, DK = Diabetes Knowledge, QoL = Quality of Life

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Table 7: Logistic regression comparing Socio-Demographic predictors across Outcomes

Outcome Variable	Group	Age (≥60 yrs)	Gender (Male)	Duration (>5 yrs)	Education (Educated)	Employment (Employed)	Key Finding
FBGL	DSME	NS (OR=0.94)	NS (OR=2.70)	NS (OR=1.11)	NS (OR=4.44)	NS (OR=0.71)	No socio-demographic predictor significantly influenced FBGL control
	Control	NS (OR=0.76)	NS (OR=1.86)	† Lower odds (OR=0.35)	NS (OR=0.75)	NS (OR=1.65)	Longer duration showed marginal negative effect on FBGL control
BMI	DSME	NS (OR=1.79)	NS (OR=0.31)	NS	NS	NS (OR=1.02)	No significant predictors of BMI normalization
	Control	NS (OR=0.98)	NS (OR=0.64)	NS (OR=0.59)	NS (OR=3.36)	NS (OR=0.38)	Education showed a modest but non-significant positive trend
Blood Pressure	DSME	NS (OR=0.88)	NS (OR=1.26)	NS (OR=1.15)	NS (OR=1.13)	NS (OR=0.59)	BP control not influenced by socio-demographic factors
	Control	NS (OR=3.41)	NS (OR=0.45)	NS (OR=0.79)	NS (OR=0.77)	NS (OR=0.76)	Older age showed a non-significant positive trend
SCB	DSME	NS (OR=0.83)	NS (OR=0.73)	NS (OR=0.49)	NS	NS (OR=1.15)	No predictors significantly influenced behavioral change
	Control	† Higher odds (OR=2.74)	NS (OR=0.53)	NS (OR=0.75)	NS (OR=0.87)	NS (OR=0.94)	Older age showed marginal association with improved SCB
Diabetes Knowledge	DSME	NS (OR=2.57)	NS (OR=2.08)	NS (OR=1.73)	NS	NS (OR=1.54)	Knowledge gains independent of socio-demographic factors
	Control	NS (OR=0.50)	NS (OR=0.76)	NS (OR=0.45)	NS (OR=3.12)	NS (OR=0.26)	Education showed modest but non-significant influence
Quality of Life	DSME	NS (OR=0.98)	NS (OR=0.66)	NS (OR=0.98)	NS (OR=0.74)	NS (OR=1.26)	QoL improvement not predicted by socio-demographics
	Control	NS (OR=1.24)	NS (OR=0.76)	NS (OR=2.04)	NS (OR=1.11)	NS (OR=0.94)	Duration showed a weak, non-significant positive trend

NS = Not statistically significant (p > 0.05), † = Marginal significance (p < 0.10), OR = Odds Ratio

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Sociodemographic characteristics had a negligible impact on clinical (FBGL, BMI, BP) or behavioral/quality-of-life outcomes in either group (Table 7). Despite marginal trends in the control group for age and disease duration, these were not statistically significant, suggesting that the interventions' effects were robust across different sociodemographic profiles.

Table 8: Multivariate regression

Predictor Variable	FBGL (B, p)	BMI (B, p)	BP (B, p)	SCB (B, p)	Diabetes Knowledge (B, p)	QoL (B, p)
Constant	56.84, 0.02	28.11, <0.01	132.45, <0.01	3.84, 0.01	2.74, 0.01	−1.82, 0.02
Age (years)	0.14, 0.65	−0.02, 0.81	0.22, 0.19	−0.01, 0.69	−0.08, 0.71	0.01, 0.53
Gender (Male = 1)	4.26, 0.12	−1.34, 0.07	−3.84, 0.07	0.58, 0.16	0.42, 0.18	−0.39, 0.17
Duration of Diabetes	−2.49, 0.02	−0.51, 0.07	−1.72, 0.03	0.42, 0.06	0.31, 0.01	−0.28, 0.01
Education Level	6.94, 0.05	1.13, 0.24	4.12, 0.08	0.91, 0.02	0.89, 0.02	−0.76, 0.03
Employment Status	9.29, 0.06	2.01, 0.13	5.89, 0.06	1.12, 0.03	1.02, 0.04	−0.91, 0.06
Model Summary	R^2=0.29, Adj R^2=0.25	R^2=0.21, Adj R^2=0.17	R^2=0.26, Adj R^2=0.22	R^2=0.32, Adj R^2=0.29	R^2=0.31, Adj R^2=0.28	R^2=0.27, Adj R^2=0.23

Values are presented as B coefficient and p-value.

Across the seven outcomes, multivariate regression analysis (Table 8) revealed that the duration of diabetes was a consistent predictor, with a longer duration showing a significant association with lower fasting blood glucose levels (B = -2.49, p = 0.02) and lower blood pressure (B = -1.72, p = 0.03). indicating long-term experience with disease management.

Longer disease duration was associated with better knowledge (B = 0.31, p = 0.01), but lower quality of life QoL (B = -0.28, p = 0.01), with a marginal positive association with self-care (B = 0.42, p = 0.06). Higher education significantly predicted increased FBGL, self-care, and knowledge, alongside lower QoL. Employment was significantly associated with higher self-care (B=1.12, p=0.03) and knowledge (B = 1.02, p = 0.04). Other markers (FBGL, BMI, SBP, DBP) showed non-significant positive associations, while QoL was negatively affected.

Discussion

This study evaluated the effectiveness of a structured intervention (DSME) on clinical, behavioral, and psychosocial outcomes. Taken together, these findings suggest that the intervention was highly effective in improving glycemic control, body weight, dietary knowledge, and quality of life, with large to very large effect sizes relative to the control group (Table 4). The effects on self-care behaviors were minimal, suggesting a need for longer follow-up or more behavior-focused components in the study. Due to the significant changes observed in both groups, improvements in blood pressure should be interpreted cautiously, despite the greater magnitude of change in the intervention group, which supports the added benefit of the intervention.

For Clinical Outcomes, the significant reduction in fasting blood glucose levels in the intervention group represents one of the most important findings of the study. The DSME produced statistically significant improvements in FBGL, BMI, SBP, and DBP (Table 4), consistent with findings from (26), which reported significant reductions in FBGL and BMI following structured education, and (11), which also demonstrated improved SBP and DBP among participants. At post-intervention, there were no significant differences between groups across all clinical outcomes, including fasting blood glucose level (FBGL), body mass index (BMI), systolic blood pressure (SBP), and diastolic blood pressure (DBP) (p > 0.05), (Table 5).

Regarding the control group's blood pressure (SBP) improvements noted (Table 4), these changes could be attributed to factors such as natural variability, regression to the mean, or participants' increased awareness of health behaviors due to the ongoing study, albeit with a lack of participation (Hawthorne effect). It is also possible that standard care or external influences unrelated to the intervention contributed to BP improvements in the control group. These

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considerations should be discussed to contextualize the lack of significant between-group differences in BP despite observed within-group changes.
Studies in Kenya (7) and Sudan (27), with similar short-term studies used comparable numbers (n=84 and 120, respectively), and similarly reported strong internal gains but with minimal group-level differences. On the contrary, longer trials (28, 29) with larger samples (n=462 and n=312, respectively) demonstrated significant between-group effects, suggesting that longer studies and larger scales may better capture DSME's clinical impact.

Self-Care Behaviors (SCB), At post-intervention, the DSME group had significantly lower fasting blood glucose levels, (110.6 vs 127.5 mg/dL, $p<0.01$), BMI (26.4 vs 28.4 kg/m², $p<0.01$), and better QoL (2.16 vs 2.37, $p<0.01$) compared to controls (Table 4). These are confirmed through independent t-tests and analysis of covariance (ANCOVA; Table 6), logistic regression (Table 7), and multivariate regression (Table 8). All highlight the success of the DSME curriculum in converting knowledge into practical application; a key objective of diabetes education programs globally (26, 28).

These results are consistent with the DSME outcomes observed in other African countries such as Kenya and Nigeria (30, 7), where culturally specific education led to better self-care behaviors. Despite facing structural obstacles, such as food insecurity, limited access to glucometers, and irregular medication supply, those in the DSME group adopted healthier habits. For example, they reported replacing costly foods with locally available options, increasing physical activities like walking and household chores, and using symptom awareness to manage glucose levels in the absence of monitoring tools. These adaptive behaviors demonstrate the curriculum's contextual relevance and ability to empower patients in South Sudan, supporting the theoretical basis of the intervention.

Regarding Diabetes Knowledge (DK), the study demonstrated a significant increase in diabetes knowledge (DK) with a mean difference of (Table 4). The intervention group showed significantly higher diabetes knowledge than the control group, and the multivariate regression analysis identified diabetes duration, educational level, and employment status as significant predictors of knowledge gain. As shown in the demographic profile (Table 3), 88.7% of participants had no or only basic education, underscoring the need for simplified, culturally adapted learning strategies. The adapted DSME curriculum addressed this gap through visual aids, oral instructions, and interactive group sessions tailored to participants' literacy levels and lived experiences, aligning with global best practices (28, 26) indicating that DSME improves knowledge when delivered through context-sensitive formats. It should also be noted that as disease duration increases, patients gain more knowledge through ongoing exposure to information and a heightened drive to manage potential complications. Higher education and employment status also seemed to contribute to better assimilation of DSME content, consistent with other findings (30). Borrowing from the social cognitive theory and the health belief model (14, 15), increased understanding enhances perceived benefits and reduces barriers to action. Therefore, knowledge gained in this study translated into better adherence to treatment and lifestyle modifications. Therefore, DSME bridged the gap between awareness and action.

The finding that longer diabetes duration predicts better knowledge but lower quality of life reflects a complex relationship between disease experience and patient outcomes. Over time, individuals with diabetes likely accumulate more information and understanding about their condition through ongoing education, healthcare interactions, and self-management efforts, which explains the improved knowledge with longer duration (31).

Quality of Life (QoL) improved significantly (Table 4), and a regression analysis indicated that while longer diabetes duration and lower education levels were associated with lower QoL, DSME effectively enhanced physical and mental health. This highlights how DSME serves as a comprehensive intervention that addresses psychological needs alongside traditional clinical goals. This is consistent with others (28) and is supported by behavioral theories that emphasize self-efficacy and social reinforcement as drivers of well-being, thereby reinforcing self-management behaviors and long-term health outcomes (21, 7). It is postulated here that the group-based delivery model adopted nurtured a sense of shared experiences, which may have contributed to emotional resilience and motivation, aligning with findings from Ethiopia, Nigeria, Sudan, and Thailand (30), where DSME reduced diabetes-related distress and improved the quality of life. The negative association between longer disease duration and QoL is consistent with increased awareness of complications and cumulative disease burden. Higher education levels, while associated with greater knowledge, also intensify the perception of risk and limitations, contributing to lower QoL. These results are consistent with the findings of (32), who noted that increased disease literacy can increase emotional strain. This supports the relevance of the HBM theory, which emphasizes the role of perceived control, self-efficacy, and social reinforcement in shaping quality of life.

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The chronic nature of diabetes and its cumulative complications or treatment burdens can adversely affect quality of life, as prolonged disease duration often results in physical, emotional, and social challenges (33, 34). This highlights the necessity for ongoing support that not only enhances patient knowledge but also addresses quality of life aspects such as symptom management, psychological well-being, and social functioning, particularly in patients with long-standing diabetes. The results indicate that the DSME program has a measurable positive effect on participants perceived well-being, likely reflecting increased disease awareness (Table 6). However, post-intervention between-group results (Table 5) reveal no significant physiological changes, probably because the three-month intervention period was insufficient to produce measurable differences between groups. Nonetheless, the ANCOVA findings confirm that the intervention had a significant and meaningful impact across all measured outcomes, demonstrating its effectiveness in addressing multiple dimensions of health.

Influence of Socio-demographic Factors: Across the six outcome variables analyzed (FBGL, BMI, BP, SCB, DK, and QoL), very few sociodemographic predictors demonstrated statistically or marginally significant associations with the study outcomes. While no significant effects were found at $p<0.05$ for either condition, a few non-significant trends were noted specifically for the control group (Table 7).

First, diabetes duration showed a marginally inverse association with fasting blood glucose control (OR =0.35, p = 0.06), indicating that participants with diabetes duration greater than 5 years had lower odds of achieving controlled fasting blood glucose levels in the absence of structured DSME. Second, within the control group, age showed a slightly significant positive association with self-care behavior (SCB), suggesting that individuals aged 60 years and above were more likely to report improved self-care practices than younger participants. There were no statistically or marginally significant sociodemographic predictors of body mass index (BMI), blood pressure, diabetes knowledge, or quality of life in either the intervention or control groups. Importantly, in the Diabetes Self-Management Education (DSME) intervention group, none of the socio-demographic variables reached marginal significance. This indicates that the effects of DSME on study outcomes were largely independent of these participant characteristics, suggesting that DSME's impact on diabetes management behaviors and outcomes is broadly effective across diverse sociodemographic profiles (35, 36).

This lack of association between sociodemographic variables and outcomes in the DSME group aligns with evidence from systematic reviews (37, 35) that DSME interventions generally improve self-care behaviors such as glucose monitoring and doctor visits regardless of participant characteristics and can broadly improve glycemic control and cardiometabolic risk factors. The absence of age-related differences in self-care within the DSME group, compared with the presence of such differences in the control group, suggests that diabetes self-management education (DSME) can mitigate sociodemographic differences in health practices. This might support the notion of DSME's role as an equitable intervention, capable of improving outcomes across diverse patient groups without demographic bias (35, 37). But overall, the effectiveness of DSME appears robust across sociodemographic factors, reinforcing its suitability for diverse adult populations with type 2 diabetes, including older adults, minorities, and medically underserved groups. Future interventions could further enhance the reach and maintenance of self-care behaviors by incorporating community context and long-term support, but socio-demographics per se do not substantially modulate DSME's beneficial effects (38, 39).

Multivariate regression analysis (Table 8) identified several sociodemographic factors that significantly affected post-intervention outcomes, including the duration of diabetes, level of education, and employment status, which consistently predicted changes in self-care practices, diabetes knowledge, and quality of life. These results align with those of other authors (32), who found that a longer duration of illness not only increases disease literacy, but also heightens psychosocial stress. Additionally, as expected, higher levels of education were associated with better self-care and knowledge,
indicating that greater educational attainment aids in understanding and applying the learned material.

Surprisingly, education was inversely related to quality of life, possibly due to increased awareness of disease risks and limitations, as noted by another study (30), which reports that higher health literacy can increase perceived vulnerability in restrictive environments.

Employment status emerged as a primary predictor of behavioral and knowledge-based improvements, suggesting that those in the workforce benefit from structured routines, cognitive stimulation, and greater resource access. However, the weak correlation with lower quality-of-life scores indicates that workplace stress and competing responsibilities may hinder overall well-being. Age and sex did not predict changes in any outcome area, suggesting

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that effectiveness was generally consistent across these groups, a pattern strongly supported by the lack of multicollinearity (VIFs < 2.0).

This finding is consistent with those of two previous studies (7, 28) and supports the results from African contexts, where nurse- and peer-led models have been effective (30). The intervention addressed these misconceptions by combining biomedical explanations with culturally sensitive messaging, thereby building trust and acceptance as supported by the health belief model (15, 40). Consequently, these findings highlight the need to tailor SMEs to accommodate sociodemographic diversity and incorporate flexible delivery models and psychosocial support to improve outcomes among different subgroups.

This dual outcome aligns with evidence showing that while longer diabetes duration enhances disease literacy, it also increases emotional and psychosocial distress related to the illness (41, 42).

Higher education is positively correlated with better diabetes knowledge and self-care, as it improves understanding and application of diabetes self-management education (DSME) (43, 44). Paradoxically, however, higher educational attainment is associated with a lower quality of life, likely because increased health literacy raises awareness of disease risks and perceived vulnerabilities, which negatively impacts psychosocial well-being (44). This suggests that while education enhances cognitive and behavioural management of diabetes, it may also heighten sensitivity to the disease's broader consequences (41, 43, 44).

In summary, therefore, these comprehensive findings highlight the necessity of DSME programs to accommodate diverse sociodemographic characteristics by integrating flexible delivery models and psychosocial support strategies. Tailoring interventions to address the unique challenges associated with disease duration, educational attainment, and employment-related factors may enhance self-care, knowledge, and ultimately quality of life among individuals with diabetes. Where the intervention did not significantly improve self-care behaviors (SCB), the possible explanations could be that (1) three months of the intervention may be too short for meaningful changes, (2) self-reported measures may not capture actual outcomes, or (3) contextual barriers (food insecurity, lack of glucometers) may have limited some changes.

Practical Implications: This study demonstrated that structured, culturally adapted education improves clinical outcomes, self-care behavior, diabetes knowledge, and quality of life, without requiring additional infrastructure and pharmacological inputs in the following ways: First, the intervention's success supports DSME as a feasible and scalable strategy for strengthening chronic disease management within existing health systems. By leveraging local health personnel, community spaces, and culturally relevant materials, DSME can be integrated into routine care at primary health facilities such as the Malakia PHCC. Second, this study highlights the need for policy frameworks that recognize DSME as a core component of diabetes care.
To improve continuity of care and reduce long-term complications, integrating DSME into national guidelines, training, and service packages is essential, highlighting the need for inclusion in South Sudan's NCD and strategic financing. Additionally, recognizing that sociodemographic factors such as education, employment, and disease duration impact effectiveness, DSME programs should be tailored to fit varied literacy levels, economic contexts, and psychosocial needs. Lastly, the study highlights the efficacy of theory-driven interventions, which should serve as the basis for all interventions nationwide.

Limitations: Focus on a single urban primary healthcare center (Malakia PHCC) restricts the applicability and generalizability of its findings to rural areas or other regions with varying cultural, infrastructural, or socioeconomic contexts. Self-reported behavioral outcomes may have been influenced by recall and social desirability biases, whereas resource limitations, such as food insecurity, restricted access to glucometers, and inconsistent medication availability, could have hindered participants' ability to adopt the recommended changes. Furthermore, literacy and language challenges necessitate simplifying DSME materials, which may limit the depth of understanding among more educated participants. The study primarily used fasting blood glucose as a clinical marker, which does not fully reflect long-term glycemic control, and the brief three-month intervention period may have been too short to observe lasting physiological changes.
The 45+ age cutoff also limits applicability to younger adults with T2D. It is evident that people below this age also suffer from T2D, one of the reasons for which the sample size dropped drastically during screening. Additionally, the absence of fidelity monitoring and the use of self-reporting means we cannot confirm that all sessions were delivered as intended, and due to the expensive nature of assessing for HbA1c, its assessment was dropped.

However, statistical and analytical factors also have limitations. Paired and independent sample t-tests assume normality and equal variances, are sensitive to outliers, and cannot adjust for covariates, which may oversimplify complex relationships. The effect size analysis (Cohen's d) does not consider confounders or baseline imbalances and may be exaggerated in small samples. Regression analyses were limited by sample size, potential multicollinearity, assumptions of independence, and the inability to capture interaction effects or complex behavioral pathways. These methodological and contextual limitations should be considered when interpreting study results and planning future research.

Conclusion:

This study assessed the effectiveness of a culturally tailored DSME program in enhancing clinical outcomes, self-care behaviors, diabetes knowledge, and quality of life among adults aged 45 and older with T2D in Juba County, South Sudan. The intervention led to significant improvements in key study variables, including fasting blood glucose levels, body mass index, blood pressure, self-care behavior, diabetes knowledge, and quality of life, thus rejecting the stated hypotheses that there are no changes in clinical outcomes, behavioral patterns, knowledge, or quality of life among T2D adult patients aged 45+ exposed to DSME at Malakia PHCC, Juba County, South Sudan. The study affirms the intervention's effectiveness despite contextual challenges, such as limited access to monitoring tools and economic constraints.

Declarations

Ethical Approval and Consent to Participate

This study was approved by the National Ministry of Health (Protocol No: RERB-P NO: 83/12/2024; Approval No: MOH/RERB/A 83/2024). Confidentiality was assured through anonymized coding, secure storage, and restricted access. Ethical guidelines were adhered to, and the participants were informed of their right to withdraw at any stage without consequences.

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Conflict of interest

The authors have no competing interests in relation to this research. All authors contributed to the design, data collection, analysis, and writing of the manuscript, and all authors reviewed and approved the final version for submission.

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