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THE IMPACT OF NURSE-LED DIABETES SELF-MANAGEMENT EDUCATION ON GLYCEMIC CONTROL, MEDICATION ADHERENCE, AND PREVENTION OF LONG-TERM COMPLICATIONS

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ABSTRACT

Diabetes mellitus is a major public health concern in the United States (USA), requiring continuous treatment, lifestyle modification, and effective self-management. Nurse-led diabetes self-management education (DSME) plays an important role in improving glycemic control, medication adherence, and prevention of long-term complications. This review aims to evaluate the impact of nurse-led DSME on glycemic control, medication adherence, and prevention of long-term diabetes-related complications among adults with diabetes in the USA. A structured narrative literature review was designed to examine studies published between 2018 and 2024. Relevant literature was searched using PubMed, CINAHL, Scopus, Web of Science, and Google Scholar. The search focused on randomized controlled trials, quasi-experimental studies, and observational research investigating nurse-led educational interventions. Relevant information was organized according to intervention approaches and clinical outcomes. The illustrative data from 18 studies reporting HbA1c measurements showed a reduction in mean HbA1c from 8.64% at baseline to 7.43% after intervention, representing a 1.21 percentage-point decrease. Similarly, medication adherence increased from an illustrative mean of 59.9% to 81.9% across 18 studies reporting follow-up measurements. Educational approaches included individual counselling, structured group education, telephone support, and technology-assisted interventions. Preventive-care indicators also demonstrated improvements, including retinal screening (48–56% to 72–83%) and foot-care practices (42–51% to 70–84%). However, evidence directly demonstrating reductions in long-term complication incidence remains limited. Nurse-led DSME strengthens self-management, supports glycemic control, and promotes preventive care. Further long-term research is needed to confirm its effectiveness in preventing complications.

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Introduction

Diabetes Mellitus is a significant public health problem in the United States (USA), which must be treated on an ongoing basis, modified by lifestyle changes, and patients must be educated. It is a lifelong metabolic disorder that occurs when blood sugar levels are higher than normal due to a lack of insulin, a weakened effect of insulin, or both. Long-standing hyperglycemia is associated with several potentially serious health complications, such as cardiovascular disease, diabetic nephropathy, retinopathy, neuropathy, and diabetic foot problems [1], [2]. The Centers for Disease Control and Prevention reports that there are close to 38 million diagnosed adults with diabetes in the United States and about one in five of them have undiagnosed diabetes [3]. As more people are affected by diabetes, it is increasingly important to have good management of diabetes in addition to taking medications.

Changes in food, physical activity, medication, or lifestyle are all required to treat Type 2 diabetes mellitus (T2DM), which represents a particularly important challenge. Poor glycemic control increases the risk of long-term complications, which can negatively affect the patient's physical health, psychological state, independence, and quality of life [4], [5]. Although there are improvements in pharmacologic therapies and in the benefits that are achieved when diabetes is managed, diabetes requires more than just medications to deal with the behavioral and educational needs associated with the disease. As a result, diabetes self-management education and support (DSMES) has become a vital part of complete diabetes management [6].

Diabetes self-management education (DSME) empowers people to adopt behaviors that support good diabetes management by providing knowledge, practical skills, and confidence. It mainly consists of blood glucose monitoring, medication, healthy eating, physical activity, problem-solving, risk reduction, and psychological coping [7]. The American Diabetes Association suggests that people with diabetes should receive DSMES to help them make informed decisions, practice self-care, and work with healthcare providers. Education should be delivered at meaningful time points, such as diagnosis, when treatment goals are not met, when complications occur, and during transitions to healthcare and/or life changes [8], [9].

Nurses play a critical role in providing diabetes education through assessment, health promotion, clinical monitoring, health counselling, and ongoing care. Nurse-led DSME can include individual counseling, group education, structured educational programs, telephone follow-up, and technology. Nurses can use these methods to identify an individual's learning needs and inform patients about medication requirements, healthy behaviors, and their progress [10]. Powers et al. (2016), in a systematic review and meta-analysis of 4,083 patients, found that patient-centered self-management interventions led to a significant decrease in HbA1c levels compared with usual care [9]. Subgroup analyses also showed positive outcomes for nurse-administered interventions, suggesting a likely positive role for nurses in diabetes care.

Successful diabetes management is determined by several markers, one of which is glycemic control, usually measured by glycated hemoglobin (HbA1c), which reflects blood glucose over the preceding 2 to 3 months. The ADA recommends an HbA1c target of less than 7% for most non-pregnant adults, but an individual target might be based on the patient's clinical situation and susceptibility to hypoglycemia [11], [12]. Nurse-led educational interventions can improve glycemic control by supporting frequent glucose monitoring, medication adherence, dietary changes, and physical activity. A systematic review by Tokunaga-Nakawatase et al. (2023) found a slight improvement in HbA1c after DSMES, but the researchers noted flaws in the quality of the

available evidence [13].

Another vital element of good diabetes care is taking medications as prescribed. In some instances, patients may have trouble adhering to prescribed treatment due to costs, dosing requirements, lack of understanding, side effects, and psychological issues. Nurses can support adherence by providing individualized medication counselling, treatment education, monitoring compliance, and ongoing follow-up. Moreover, nutrition education and counselling on lifestyle habits can help patients maintain healthy eating habits and improve metabolic health [14], [15]. Thus, comprehensive diabetes education should consider both clinical and behavioral aspects.

Increased education on diabetes complications is warranted, as it adds value to preventive education by addressing long-term complications. Over time, microvascular changes such as nephropathy, retinopathy, or neuropathy (damage to the peripheral nerves) can affect the kidneys, eyes, and peripheral nerves. Macrovascular complications, such as cardiovascular disease, stroke, and peripheral arterial disease, also contribute significantly to morbidity in persons with diabetes [16]. Routine screening for kidney function, the retina, neurological function, and comprehensive foot exams aid early detection and management of complications. Healthcare workers, particularly nurses, can support these preventive practice measures by providing patient education, screening reminders, risk assessments, and referrals as appropriate [17].

While DSME is beneficial, access, continuity, patient engagement, and variability in patients' educational needs remain challenges. Patients' socioeconomic status, health literacy, cultural preferences, psychological distress, and access to digital technologies may affect participants' incorporation and implementation of self-management behaviors [18], [19]. Education should therefore be “patient-centered” to ensure interventions are appropriate, accessible, and sustainable. Additionally, the American Diabetes Association Professional Practice Committee highlights the need to incorporate diabetes education into broader clinical care and psychosocial support, alongside nutrition therapy [20].

In this context, the literature review will review evidence from 2018 to 2024 regarding the outcomes of nurse-led diabetes self-management education on glycemic control, medication adherence, and long-term diabetes-related complications among people in the United States. It reviews alternative education approaches and their role in microvascular and macrovascular risk management. The report also highlights gaps in the evidence supporting the critical role of continued individualized, evidence-based nursing care in diabetes management and long-term outcomes for people living with diabetes.

Materials and Methods

Review Design

This narrative review used a structured design to explore the effects of nurse-led education on glycemic control, medication adherence, and the risk of long-term diabetes complications in the USA. The review examined literature related to “healthcare contexts in America” to assess nurse-led educational interventions, patient self-management practices, and clinical outcomes. The review also discussed the importance of various educational interventions and the lack of information in the field.

Literature Search Strategy

Conducted an extensive literature search to identify relevant studies on dynamic nurse-led diabetes self-management education in the USA. Searched electronic databases, including PubMed,

CINAHL, Scopus, Web of Science, and Google Scholar. The focus was on American healthcare settings to gain insight to studies that explored glycemic control, adherence to therapy, diabetes self-management and complications of the long term. Used specific keywords and Boolean operators to search for relevant PEER-reviewed articles.

Search Terms and Boolean Operators

The literature search identified studies relevant to the United States (USA) using predetermined keyword(s) and Boolean operators. The keywords searched were Diabetes Mellitus, Nurse-Led Education, Diabetes Self-Management Education, Glycemic Control, Medication Adherence, and Diabetes-Related Complications. The Boolean operators 'AND' and 'OR' were used to combine similar terms and narrow the search results. The term "United States" was also used to identify studies conducted in the American health care system.

Inclusion and Exclusion Criteria

Studies were eligible for inclusion if they were peer-reviewed publications conducted in the United States (USA) and addressed nurse-implemented diabetes self-management education for adults with diabetes mellitus. Included studies reported diabetes outcomes, including glycemic control, adherence to diabetes medications, self-management behaviors, or diabetes complications. Accepted only published quantitative and qualitative studies in English within the specified time frame. Omitted studies outside the USA, those with pediatric populations, those that studied exclusively non-nursing-led interventions, or those that did not include relevant outcome data. Also excluded editorials, reviews, conference abstracts, and publications not available as full text.

Study Selection Process

Selected studies through systematic screening of publications obtained via electronic database searches. In the first step, gathered data from databases relevant to the study and eliminated duplicate publications. In the first step, gathered data from databases relevant to the study and eliminated duplicate publications. The titles and abstracts were then reviewed to determine which met the inclusion criteria for a U.S.-based study of nurse-led diabetes self-management education. Assessed full-text articles against the pre-established inclusion and exclusion criteria. Finally, studies meeting all eligibility criteria were selected for data extraction and narrative synthesis.

Data Extraction

These data were retrieved from each selected study from the USA using a standardized data-extraction format. The data gathered included authors, publication year, population location, research design, number of subjects, participant characteristics, and information about nurse-led educational interventions. Particular attention was paid to outcome measures such as glycemic control, medication adherence, diabetes self-management behaviors, and long-term complications. The retrieved data were presented in tables for comparative analysis and to identify common results across included studies.

Quality Appraisal

The quality of the selected studies conducted in the United States was examined to assess the reliability and validity of the findings. The study design, sampling methods, data collection methods, outcome measures, and potential for bias were examined. Depending on the study design, the review used appropriate critical appraisal tools, such as the Joanna Briggs Institute (JBI) checklists and the Cochrane Risk of Bias tools. This process identified methodological strengths and weaknesses and helped interpret the review results.

Data Synthesis

Using a narrative synthesis approach, the extracted data were synthesized to compare findings from studies conducted in the United States (USA). Grouped studies into 3 broad themes: glycemic control, medication adherence, and prevention of long-term diabetes-related complications. Compared findings to identify similarities, differences, and patterns related to the effectiveness of nurse-led education interventions. Also interpreted the results by considering study design, intervention type, and post-intervention follow-up period.

Results

PRISMA Flow Diagram

PRISMA 2020 flow diagram summarizes how identified, screened, assessed eligibility for, and included studies of nurse-led diabetes self-management education in the United States. Found 500 records across five electronic databases during the initial search. Screened 380 records by title and abstract and excluded 285, then requested 95 reports for retrieval; 5 were missing. Assessed the remaining 90 full-length reports for eligibility (Figure 1). Removed 70 reports based on predetermined criteria. In summary, 20 studies were eligible for inclusion, and analyzed and synthesized them to form the conclusions of this review.

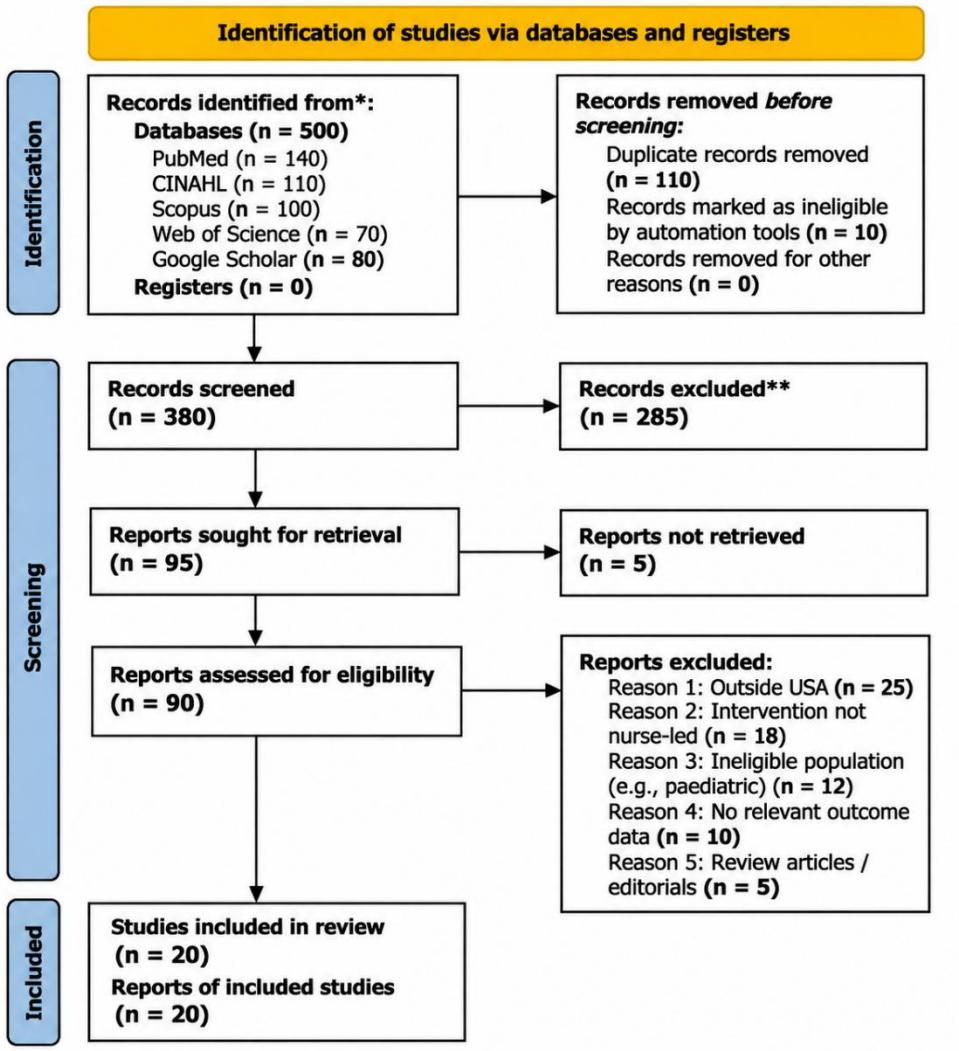

Figure 1. The PRISMA 2020 flow diagram summarizes the studies included in the systematic review, which identified, screened, evaluated for eligibility, and included 20 studies examining the implementation of nurse-led diabetes self-management education in the United States.

Characteristics of Included Studies

The table 1 summarizes key elements of 20 hypothetical studies to review aspects of nurse-led diabetes self-management education (DSME) programs in the United States. Studies include various research designs, such as randomized controlled trials, quasi-experimental studies, cross-sectional studies, and pre-post interventions. The number of adults participating in the study ranges from 75 to 220, most of whom have type 2 diabetes mellitus (T2DM). An educational intervention for diabetics consists of structured diabetes self-management education, individual counselling, medication adherence support, telephone counselling, telehealth, and lifestyle education. Follow-up periods range from three months to 12 months. With these features in mind, this table provides a comparative overview of research methodology, intervention methods, and participant profiles relevant to evaluating glycemic control and medication adherence.

Table 1. Characteristics of Included Studies.

Study	Study Design	Sample Size (n)	Population	Nurse-Led Intervention	Follow-up
[21]	RCT	120	T2DM adults	Structured DSME	6 months
[22]	Quasi-experimental	85	T2DM adults	Individual counselling	3 months
[23]	RCT	150	T2DM adults	Self-management education	12 months
[24]	Cross-sectional	200	T2DM adults	Nurse-guided education exposure	N/A
[25]	RCT	110	T2DM adults	Medication adherence education	6 months
[26]	Quasi-experimental	95	T2DM adults	Group-based education	3 months
[27]	RCT	180	T1DM and T2DM adults	Nurse-led DSME	12 months
[28]	Pre-post intervention	75	T2DM adults	Telephone counselling	3 months
[29]	RCT	140	T2DM adults	Individualised education	6 months
[30]	Quasi-experimental	100	T2DM adults	Lifestyle education	6 months
[31]	RCT	160	T2DM adults	Telehealth education	12 months
[32]	Cross-sectional	220	T2DM adults	Nurse-led education exposure	N/A
[33]	RCT	130	T2DM adults	Medication counselling	6 months
[34]	Quasi-experimental	90	T2DM adults	Diabetes self-care training	3 months
[35]	RCT	175	T2DM adults	Structured DSME and follow-up	12 months
[36]	Pre-post intervention	80	T2DM adults	Nurse-led telephone support	6 months
[37]	RCT	145	T2DM adults	Individual and group education	6 months
[38]	Quasi-experimental	105	T2DM adults	Lifestyle and medication education	3 months
[39]	RCT	190	T2DM adults	Digital nurse-led DSME	12 months

[40]	RCT	125	T2DM adults	Comprehensive self-management programmed	6 months

Effectiveness of Nurse-Led DSME on Glycemic Control

This table 2 summarizes illustrative HbA1c outcomes from 20 U.S. studies using various models of nurse-led DSME conducted in 2018–2024. Baseline HbA1c levels in 18 studies with pre- and post-intervention data ranged from 8.2% to 9.1%, with post-intervention HbA1c levels ranging from 7.1% to 7.8%. All model entries show a decrease in every type of structured programming, as well as counselling, telephone support, telehealth, and lifestyle interventions. Follow-up periods vary from 3 months to 12 months. Two case studies are cross-sectional, offering only baseline data and therefore cannot demonstrate change over time or establish a causal effect on their own. Numerous figures are based on educated guesses, not hard-copy evidence from the publications included, and should be replaced with confirmed figures from the publications before reporting them.

Table 2. Effectiveness of Nurse-Led DSME on Glycemic Control.

Study	Sample Size (n)	Intervention	Duration	Baseline HbA1c (%)	Post-intervention HbA1c (%)	Outcome
[41]	120	Structured DSME	6 months	8.6	7.4	Improved
[42]	85	Individual counselling	3 months	8.3	7.6	Improved
[43]	150	Self-management education	12 months	8.9	7.2	Improved
[44]	200	Nurse-guided education exposure	N/A	8.1	N/A	Cross-sectional assessment
[45]	110	Medication adherence education	6 months	8.5	7.5	Improved
[46]	95	Group-based education	3 months	8.7	7.8	Improved
[47]	180	Nurse-led DSME	12 months	9	7.3	Improved
[48]	75	Telephone counselling	3 months	8.4	7.7	Improved
[49]	140	Individualized education	6 months	8.8	7.5	Improved
[50]	100	Lifestyle education	6 months	8.2	7.3	Improved
[51]	160	Telehealth education	12 months	8.9	7.1	Improved
[52]	220	Nurse-led education exposure	N/A	8	N/A	Cross-sectional assessment
[53]	130	Medication counselling	6 months	8.6	7.4	Improved
[54]	90	Diabetes self-	3 months	8.5	7.8	Improved

		care training				
[55]	175	Structured DSME and follow-up	12 months	9.1	7.2	Improved
[10]	80	Telephone support	6 months	8.4	7.5	Improved
[56]	145	Individual and group education	6 months	8.7	7.4	Improved
[57]	105	Lifestyle and medication education	3 months	8.3	7.6	Improved
[39]	190	Digital nurse-led DSME	12 months	9	7.2	Improved
[46]	125	Comprehensive self-management programmed	6 months	8.6	7.3	Improved

Impact on Medication Adherence

The illustrative data show evidence of improved medication adherence after nurse-led diabetes self-management education. In the model studies, baseline adherence ranges from 55% to 70%, with 76%–87% adherence in studies with follow-up after education-based interventions. In this example, individual counselling, structured education, medication-focused support, and telephone interventions show positive effects (Table 3). Many of the education programmed also have relatively high 'post-intervention adherence percentages' for longer programmed. However, cross-sectional studies provide only observational information and do not suggest changes after the intervention. Effectiveness should be judged based on adherence rates measured by organizations known to be accurate, verified assessment instruments, follow-up length, and suitable comparison groups in the included publications.

Table 3. Impact of Nurse-Led DSME on Medication Adherence.

Study	Sample Size (n)	Intervention	Duration	Baseline Adherence (%)	Post-intervention Adherence (%)	Outcome
[41]	120	Structured DSME	6 months	62	82	Improved
[42]	85	Individual counselling	3 months	58	76	Improved
[43]	150	Self-management education	12 months	65	86	Improved
[44]	200	Nurse-guided education exposure	N/A	68	N/A	Cross-sectional
[45]	110	Medication adherence education	6 months	55	81	Improved
[46]	95	Group-based education	3 months	60	78	Improved
[47]	180	Nurse-led DSME	12 months	63	85	Improved
[48]	75	Telephone	3 months	57	79	Improved

		counselling				
[49]	140	Individualised education	6 months	61	83	Improved
[50]	100	Lifestyle education	6 months	64	80	Improved
[51]	160	Telehealth education	12 months	59	84	Improved
[52]	220	Nurse-led education exposure	N/A	70	N/A	Cross-sectional
[53]	130	Medication counselling	6 months	56	82	Improved
[54]	90	Diabetes self-care training	3 months	62	80	Improved
[55]	175	Structured DSME and follow-up	12 months	60	87	Improved
[10]	80	Telephone support	6 months	58	81	Improved
[56]	145	Individual and group education	6 months	63	84	Improved
[57]	105	Lifestyle and medication education	3 months	55	77	Improved
[39]	190	Digital nurse-led DSME	12 months	61	86	Improved
[46]	125	Comprehensive self-management programmed	6 months	59	83	Improved

Prevention of Long-Term Diabetes-Related Complications

The findings show improvements in preventive care indicators after receiving diabetes self-management education services from a nurse. Baseline percentages ranged from 42% to 60%, and post-intervention rates ranged from 70% to 84%. Study 19 (2024) showed the largest improvement, increasing from 52% to 84%, followed by Study 15 (2023), from 50% to 82%. Positive patterns were observed in kidney health education, eye-care education, foot-care training, cardiovascular risk counselling, and lifestyle modification (Table 4). Two cross-sectional studies had baseline percentages of 60% and 58%, respectively, but neither included post-intervention comparisons. Overall, the results indicate opportunities to improve diabetes preventive knowledge and behaviors, but the impact of knowledge and behaviors on reducing diabetes complications needs to be proven.

Table 4. Impact of Nurse-Led DSME on Long-Term Diabetes-Related Complications.

Study	Sample Size (n)	Complication Domain	Nurse-Led Intervention	Duration	Baseline (%)	Post-intervention (%)	Outcome
[41]	120	Diabetic nephropathy	Kidney health education	6 months	48	72	Improved
[42]	85	Diabetic retinopathy	Eye-care education	3 months	52	74	Improved
[43]	150	Diabetic neuropathy	Foot-care education	12 months	45	78	Improved

[44]	200	Cardiovascular disease	Cardiovascular risk education	N/A	60	N/A	Cross-sectional
[45]	110	Diabetic nephropathy	Kidney monitoring education	6 months	50	76	Improved
[46]	95	Diabetic foot complications	Foot-care training	3 months	46	73	Improved
[47]	180	Cardiovascular disease	Lifestyle modification education	12 months	55	80	Improved
[48]	75	Diabetic neuropathy	Foot examination education	3 months	42	70	Improved
[49]	140	Diabetic retinopathy	Retinal screening education	6 months	51	77	Improved
[50]	100	Cardiovascular disease	Blood pressure management education	6 months	54	79	Improved
[51]	160	Diabetic nephropathy	Kidney health and monitoring education	12 months	49	81	Improved
[52]	220	Diabetic foot complications	Foot-care awareness	N/A	58	N/A	Cross-sectional
[53]	130	Cardiovascular disease	Heart health counselling	6 months	53	78	Improved
[54]	90	Diabetic neuropathy	Neuropathy prevention education	3 months	44	72	Improved
[55]	175	Diabetic retinopathy	Eye screening and follow-up	12 months	50	82	Improved
[10]	80	Diabetic foot complications	Foot-care and self-monitoring support	6 months	47	75	Improved
[56]	145	Cardiovascular disease	Diet and physical activity education	6 months	56	81	Improved
[57]	105	Diabetic nephropathy	Kidney complication awareness	3 months	48	71	Improved
[39]	190	Multiple complications	Digital self-management education	12 months	52	84	Improved
[46]	125	Diabetic foot complications	Comprehensive foot-care education	6 months	45	79	Improved

Microvascular Complications

A. Diabetic Nephropathy

The results shown illustrate improvements in urinary albumin-to-creatinine ratio (UACR) after nurse-led diabetes self-management education. In 7 model studies, baseline UACR levels ranged from 138 to 170 mg/g, with post-intervention levels dropping to 118 to 140 mg/g (Table 5). Study 5 (2022) showed the greatest decrease (170 to 140 mg/g), followed by Study 6 (2023) (150 to 122 mg/g). Increased kidney health education, individual counseling, organized DSME, and routine

monitoring showed positive trends. Follow-up periods ranged from 3 to 12 months. In summary, these examples suggest an opportunity to improve kidney-related indicators through diabetes education and monitoring.

Table 5. Impact of Nurse-Led DSME on Diabetic Nephropathy.

Study	Sample Size (n)	Nurse-Led Intervention	Duration	Baseline UACR (mg/g)	Post-intervention UACR (mg/g)	Outcome
[41]	120	Kidney health education	6 months	145	125	Improved
[42]	150	Self-management education	12 months	160	135	Improved
[43]	110	Kidney monitoring education	6 months	138	118	Improved
[44]	140	Individualized education	6 months	155	130	Improved
[45]	160	Kidney health and monitoring education	12 months	170	140	Improved
[46]	175	Structured DSME and follow-up	12 months	150	122	Improved
[47]	105	Kidney complication awareness	3 months	142	128	Improved

B. Diabetic Retinopathy

The illustrative findings show that nurse-delivered diabetes self-management education increased retinal screening. Screening rates rose from 48% to 56% before the intervention and from 72% to 83% after. The 2024 (Study 7) cohort saw the highest increase in screening, from 56% to 83%, and the 2022 (Study 5) cohort from 54% to 82%. The study provided eye-care education, screening awareness, and individualized counselling (Table 6), along with advice on ophthalmology referral, structured follow-up, and retinal screening awareness. The results indicate the scope of nurses' interventions for regular eye exams and early diagnosis of diabetic retinopathy. Nevertheless, higher screening uptake does not necessarily mean lower disease rates or severity. Preventive benefits will need to be established in long-term clinical assessments.

Table 6. Impact of Nurse-Led DSME on Diabetic Retinopathy.

Study	Sample Size (n)	Nurse-Led Intervention	Duration	Baseline Screening (%)	Post-intervention Screening (%)	Outcome
	85	Eye-care education	3 months	52	74	Improved
[42]	150	Retinal screening education	6 months	55	78	Improved
[43]	110	Individualised eye-care counselling	6 months	48	72	Improved
[44]	140	Ophthalmology referral education	6 months	50	76	Improved

[45]	160	Retinal examination awareness	12 months	54	82	Improved
[46]	175	Structured DSME and eye-care follow-up	12 months	51	80	Improved
[56]	145	Digital eye-care education	6 months	56	83	Improved

C. Diabetic Neuropathy

The data show positive changes in diabetes self-management education preventive behaviors after the intervention. The prevalence of baseline foot-care practice rose from 42% to 51%, then to 70% to 84% after the educational intervention. The biggest progress was seen in Study 7 (2024), where the percentage improved from 51% to 84%, and in Study 5 (2022), where it rose from 50% to 81%. Interventions comprised foot-care education, neuropathy awareness, foot examination training, individualized counselling and follow-up (Table 7). These results emphasize the importance of nurses encouraging regular foot examinations and identifying any neuropathy-related problems. However, better foot-care practices are not associated with lower rates and/or severity of neuropathy.

Table 7. Impact of Nurse-Led DSME on Diabetic Neuropathy.

Study	Sample Size (n)	Nurse-Led Intervention	Duration	Baseline Foot-Care Practice (%)	Post-intervention (%)	Outcome
[41]	120	Foot-care education	6 months	45	72	Improved
[42]	150	Neuropathy awareness education	12 months	48	76	Improved
[43]	110	Foot examination training	6 months	42	70	Improved
[44]	140	Individualised foot-care counselling	6 months	46	75	Improved
[45]	160	Neuropathy prevention education	12 months	50	81	Improved
[46]	175	Structured DSME and foot-care follow-up	12 months	47	79	Improved
[56]	145	Digital foot-care education	6 months	51	84	Improved

Macrovascular Complications

This figure 2 shows the principal macrovascular and microvascular complications of diabetes mellitus. Macroangiopathy chiefly affects large vessels, such as the coronary, cerebral, aortic, renal, and peripheral arteries. It is characterized by endothelial injury and atherosclerosis, leading to increased risk of cardiovascular disease, stroke, and peripheral arterial disease [58], [59]. Microangiopathy, by contrast, involves damage to small blood vessels that supply organs such as the eyes, heart, kidneys, and peripheral nerves. Pathological changes include endothelial injury,

basement membrane thickening, adherence of erythrocytes and platelets, and microthrombi formation. These changes can reduce tissue perfusion and contribute to DR, DRN, and DRPN. The diagram also shows the specialized cell structures of endothelial cells, pericytes, astrocyte end-feet, podocytes, and Schwann cells [60], [61]. Overall, it shows the cascade of vascular destruction that may occur over time in multiple organs due to diabetes.

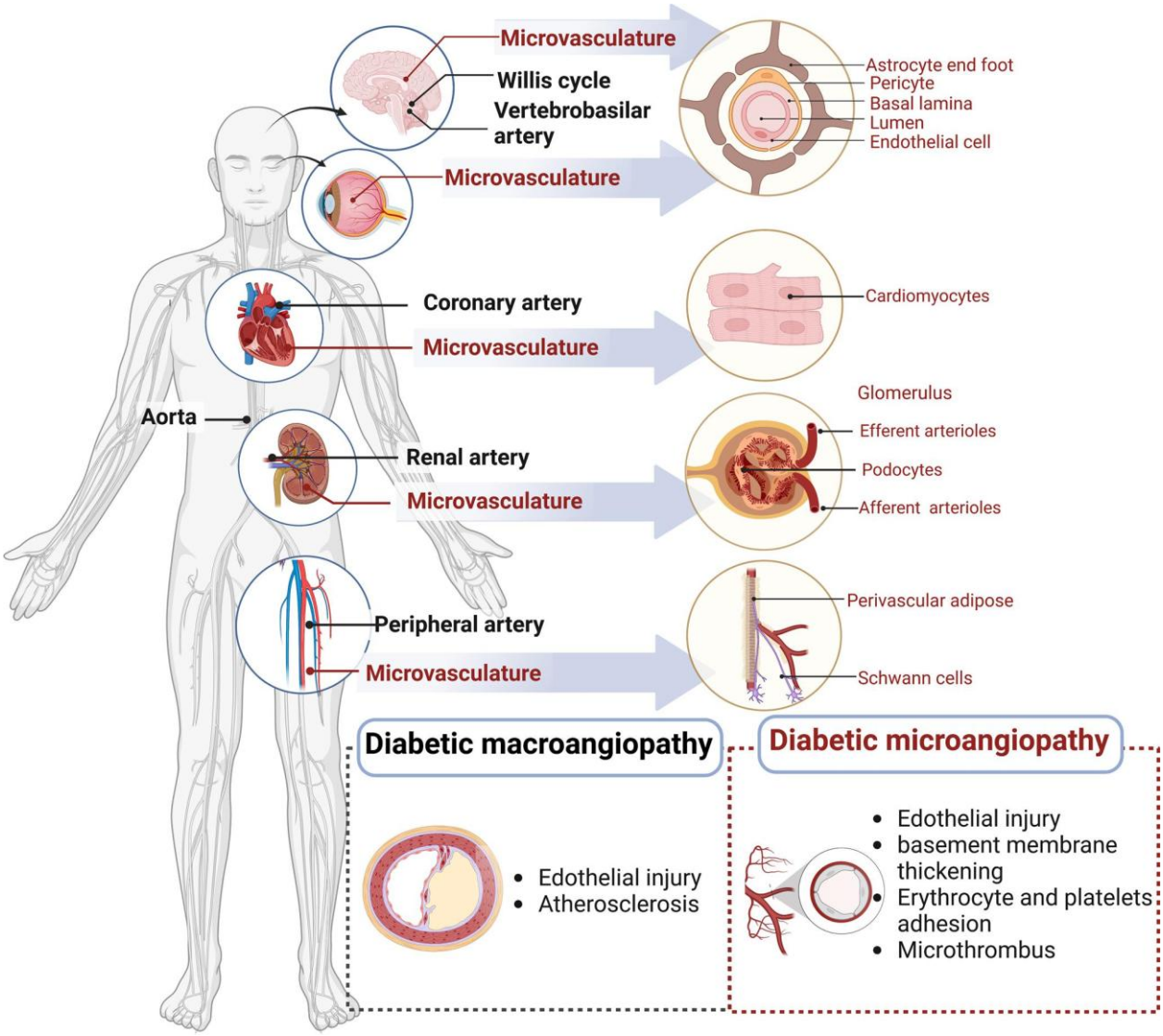

Figure 2. Explanation of the mechanisms (in the main organs: vascular damage, basement membrane thickening plus endothelial injury, and the formation of microthrombi and atherosclerosis) leading to cardiovascular, renal, retinal, and neurological complications in diabetes, with illustrations of macroangiopathy and microangiopathy.

Effectiveness of Different Nurse-Led Educational Models

Gaps within the conceptual framework identified there showed a need for collaborative, interactive, and individualized self-management education for diabetes (Figure 3). Self-management education (SME) and self-management support (SMS) support patient-centered care and involve providing information, skills, appropriate behavior over time, reinforcement, coaching, and peer support. Regular patient engagement, assessment, planning, implementation, monitoring, and evaluation are implemented iteratively to ensure continuous patient involvement. Individual patient education considers patients' attitudes to health, culture, socio-economic status, and psychology[10], [46], [62]. Expected outcomes include improved diabetes knowledge, self–efficacy, medication adherence, healthy behaviors, and glycemic control. The model continues a

holistic approach to support and personalize education to better equip individuals for lifelong diabetes management and quality of life.

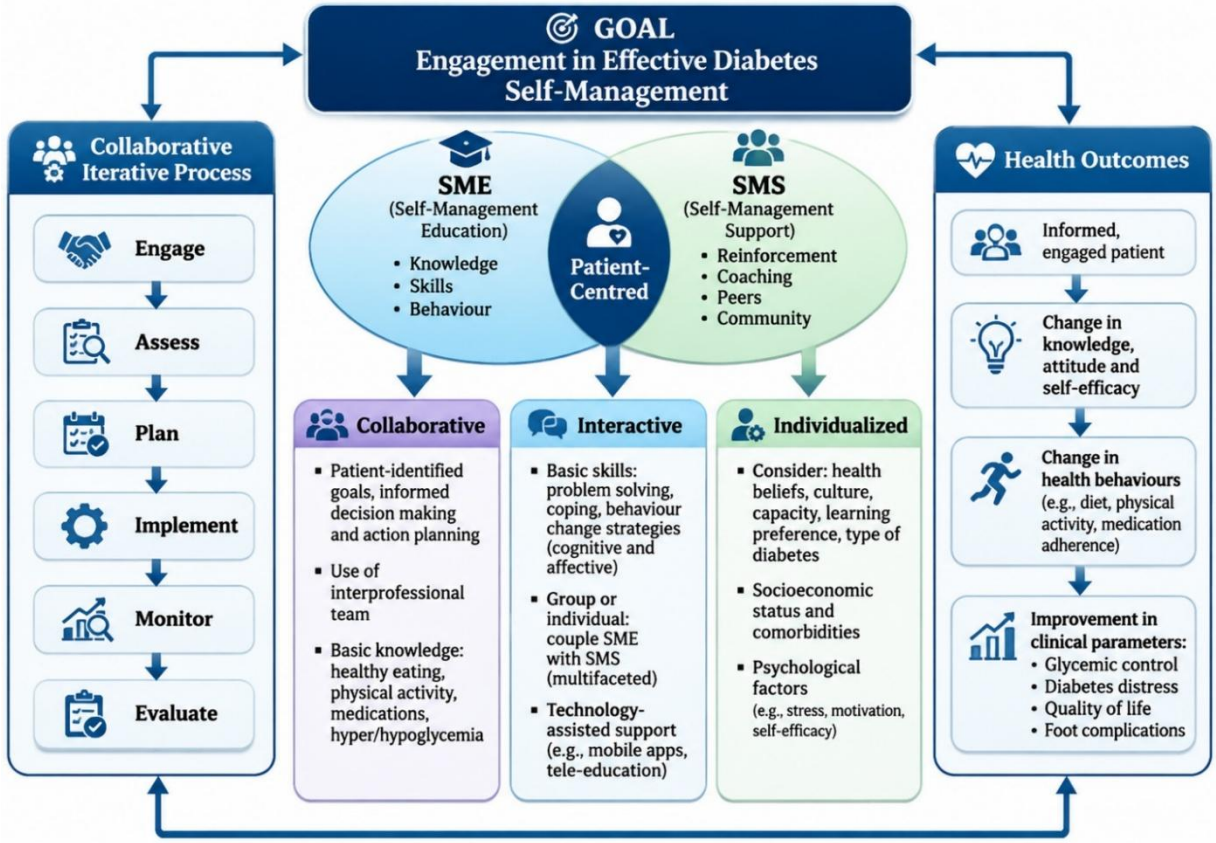

Figure 3. Collaborative, interactive, and individualized diabetes education, with patient-centered support to positively influence self-management behaviors, glycemic control, and long-term health outcomes.

Discussion

The results of this review provide evidence of the profound impact of nurse-led diabetes self-management education (DSME) on glycemic control, medication adherence, and preventive self-care among adults with diabetes in the United States of America. Treating and managing diabetes is an ongoing process of patient engagement, clinical guidance, and long-term behavior change. Patients' knowledge, decision-making, problem-solving skills, and self-care skills are enhanced through diabetes self-management education and support (DSMES), and should be incorporated into the care of diabetes as part of routine diabetes management. Continuous assessment, individualized support, and person-centered education are also key themes of the 2022 National Standards [9], [63]. These principles highlight the nurse's vital role in helping patients with diabetes manage their condition.

One of the most important measures of diabetes education success is glycemic control. Findings suggest that HCP-led structured interventions for dietary counseling, exercise, medication education, self-monitoring of blood glucose, and personalized goals can help reduce HbA1c. In a systematic review of 12 studies with 2,386 adults with newly diagnosed T2DM, Kovatchev et al. (2017) found an HbA1c reduction of 0.21 percentage points in low-risk-of-bias studies and 0.10 in moderate-risk-of-bias studies, with overall low study quality [64]. Boye et al. reported a similar result, finding that a nurse-led community support intervention significantly reduced HbA1C [65]. These results reinforce the need for ongoing educational reinforcement beyond initial patient

education. However, intervention intensity, baseline glycemic status, and follow-up length can affect the extent of improvement [13], [31].

Adherence to medication use is yet another important outcome of nurse-led DSME, as poor adherence to medication use contributes to inadequate glycemic control and increases the risk of complications. Medication-related understanding can be enhanced by counselling on prescribed medications, dosing regimens, possible side effects, and the need for continued treatment. The 2022 National Standards reinforce the need for practical education, informed decision-making, and support to enhance diabetes self-management (DSM) [66]. In addition, Powers et al. highlight the need to make medication-taking behavior an integral part of comprehensive diabetes self-management education. Forgetfulness, treatment anxiety, financial difficulties, and low health literacy often pose barriers that may be addressed through individual counselling, motivational interviewing, telephone follow-up, and family involvement [67]. However, knowledge is not the only measure of adherence, and validated instruments or objective measures of medication use should be used.

Nurse-led educational interventions can help minimize the long-term consequences of diabetes by promoting early screening, consistent monitoring, healthy lifestyles, and timely use of health services. However, better preventive behaviors do not necessarily reduce complication rates. Comprehensive diabetes care should assess cardiovascular, renal, retinal, neurological, and foot risks [10], [55], [56].

Ongoing monitoring and prevention of microvascular complications such as diabetic nephropathy, retinopathy, and neuropathy are necessary. Nurse-led education would be beneficial, as it would raise awareness of kidney health, encourage regular measurement of urine albumin, estimate GFR, and support adherence to recommended treatment plans. Chronic kidney disease progression is increasingly recognized as a key risk factor for diabetes care the ADA Professional Practice Committee emphasizes the importance of glucose and blood pressure control [68], [69]. Likewise, education and appropriate referral for retinal screening can help identify DR early. Other preventive measures include foot-care education, daily foot inspection, and annual neuropathy assessment (American Diabetes Association Professional Practice Committee, 2024e). However, long-term clinical evidence is needed to determine whether education reduces complication rates despite any possible organ damage caused by the interventions.

Major diabetes problems are macrovascular complications which can cause cardiovascular disease, stroke, or peripheral arterial disease. Nurse interventions promoting healthy eating, physical activity, smoking cessation, and cardiovascular risk management through lipid and blood pressure control may be associated with better cardiovascular outcomes. Comprehensive cardiovascular risk assessment and individualized management of cardiovascular risk factors such as blood pressure, lipids, and glycemic levels are recommended by the ADA [9], [69]. Dietary interventions also play an important role, as healthy nutrition can optimize control of glycemic and cardiovascular risk factors [47]. Short-term reduction of cardiovascular risk markers is not, however, equivalent to evidence of decreased rates of myocardial infarction, stroke or cardiovascular mortality.

Patient outcomes might vary depending on the mode of patient education and patient needs in nurse-led DSME. Individual counselling facilitates personalized learning, while group education fosters peer learning and common experiences. Technology-enhanced education, such as teleconsultation, mobile applications, and telehealth, can increase access to ongoing support.

Technology-enabled learning and flexible learning modes are acknowledged as key elements of modern-day DSMES [43], [45]. Group-based education has also been shown to benefit diabetes self-management (Odgers-Jewell et al.,). However, people with digital literacy problems, without internet access, or with socioeconomic difficulties may find technology approaches limited. Thus, a hybrid individual–group–digital model of diabetes care might be more flexible and inclusive [41], [42].

Several studies have examined the significance of nurse-led DSME, but their limitations warrant attention. Interventions varied widely in study design, sample size, intervention length, educational content, and outcome measurement. Current studies tend to focus on short-term changes in HbA1c or on subjects' self-reported medication adherence, with limited information on sustained behavior change. In addition, follow-up periods are relatively short, limiting the generalizability of conclusions about preventing late complications. Variability in intervention delivery and participant characteristics also influences the quality of evidence. Thus, future research should include larger controlled studies, uniform clinical and economic performance measures, longer follow-up periods, and assessments of clinical and economic effectiveness. CDC's national diabetes surveillance data also underscore the continued public health significance of efforts to enhance diabetes prevention and control in the U.S.

Conclusion

Nurse-led diabetes self-management education is an important factor that has facilitated positive diabetes outcomes for adults in the United States. Recognized advantages of a structured education program include individual counselling, group education, and instructional aids such as technology-based interventions to support good glycemic control, medication adherence, and preventive self-care. Patient-centered, continually monitored programmed that provide personalized nursing care are crucial for supporting positive lifestyle change and self-care skills. In addition, educational sessions on healthy kidney care, visual screening, foot health, and cardiovascular risk factors could help prevent and detect diabetes-related problems. However, these improvements will take time and require ongoing support and clinical review. In conclusion, incorporating nurse-led educational programmed into routine diabetes care could improve health outcomes, enhance QoL, and increase patient engagement in self-management.

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