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Research Paper

Effectiveness of a theory-based tailored individual and family self-management education in adults with uncontrolled diabetes: A randomized controlled trial

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ABSTRACT

Objectives: This study aimed to determine the effectiveness of an individual and family self-management (IFSM) education program on triglyceride-glucose (TyG) index, self-management, and diabetes distress among adults with uncontrolled diabetes mellitus type 2 (T2DM).
Methods: A multicentre randomized controlled trial was employed. The study included 68 dyads (adults with uncontrolled T2DM and one family member) that were randomly allocated to the intervention ($n = 34$) and control groups ($n = 34$) from March to September 2024. Participants in the intervention group received an 8-week IFSM education program, whereas those in the control group received standard routine care. An automated hematology analyzer XP-100 was used to evaluate triglyceride and fasting blood glucose levels. The Diabetes Distress Scale and Diabetes Self-Management Questionnaire were used to measure diabetes distress and self-management, respectively.
Results: A total of 67 participants completed the intervention. The generalized estimating equation demonstrated a significant interaction between group and time. The IFSM education intervention group had a higher diabetes self-management ($\beta = 16.68$; 95 %$CI = 15.23, 18.09$; $P < 0.001$), lower diabetes distress ($\beta = -30.74$; 95 %$CI = -32.57, -28.90$; $P < 0.001$), and lower TyG index ($\beta = -1.97$; 95 % $CI = -2.41, -1.53$; $P < 0.001$) than the control group.
Conclusions: The findings documented the capacity of IFSM education to reduce TyG and diabetes distress, which could potentially escalate diabetes self-management among individuals with T2DM.
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What is known?

- Empowering an individual and family self-management (IFSM) education program through well-structured training is critical for effectively managing uncontrolled diabetes mellitus type 2 (T2DM).
- The triglyceride-glucose (TyG) index is an effective tool marker for evaluating glycemic regulation in individuals with T2DM and is strongly connected with glycated hemoglobin levels.
- The diabetes distress and self-management of individuals with T2DM are frequently overlooked, and it requires that nursing plans need to be developed to address this issue.

What is new?

- Our findings highlight the potential effectiveness of the IFSM education program in improving diabetes self-management and alleviating the TyG index and diabetes distress.

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- It is feasible to implement an IFSM education program among Indonesians with uncontrolled T2DM.

1. Introduction

The International Diabetes Federation (IDF) reported that 536.6 million individuals globally had diabetes mellitus (DM) by 2021, projected to increase to 783.2 million by 2045 [1]. Diabetes mellitus type 2 (T2DM) represents 90 %–95 % of all DM cases [2]. In 2019, Indonesia ranked seventh worldwide in DM prevalence, with 10.7 million, and is predicted to increase to 16.6 million by 2045 [3]. A total of 87.5 % of individuals with T2DM have uncontrolled glycemic targets [4]. Uncontrolled glycemia leads to macrovascular and microvascular complications [5]. These complications may greatly reduce the quality of life and impose a greater healthcare cost on healthcare systems [5,6]. Consequently, it is essential to maintain effective glycemic control to prevent complications and improve the quality of life among individuals with T2DM.

Diabetes self-management (DSM) is a key strategy of glycemic control that enables the maintenance of a controlled glycemic target through comprehensive self-monitoring of blood glucose, medication adherence, and exercise [7]. The DSM is crucial for cultivating and maintaining healthy lifestyle behaviors, which can prevent and minimize acute and chronic complications through improved metabolic control [8]. However, it is challenging for individuals with T2DM to maintain self-management, especially the balance between physical activity and diet, a well-established underlying principle of DSM [9]. The individual and family self-management (IFSM) education program is a novel theory with various benefits and comprehensive and integrative approaches to increasing DSM [10,11]. In Indonesia, family members play a crucial role in assisting other family members with illnesses such as T2DM, and family-focused healthcare programs, particularly diabetes management, are extremely important [12]. Focusing on individuals and dyads within the family, the IFSM education program integrates and expands prior research on individual and family self-management, covering self-management, self-efficacy, self-regulation, and family support [10]. However, most interventions focus on the individual patient and do not integrate family members [11,13,14]. Consequently, they may not be sustainable in family-centered Indonesian culture.

A previous study has demonstrated that DSM significantly correlates with glycated hemoglobin (HbA1c) [15] and fasting blood glucose [9]. Insulin resistance (IR) and HbA1c are the gold standard and essential pathogenetic mechanisms of T2DM development, but their high cost and complexity render them unsuitable for clinical investigations [16]. As detecting the triglyceride-glucose (TyG) index is inexpensive, reproducible, and easy to perform [17], researchers have concluded that the index has potential as an IR alternative and HbA1c [18]. Meanwhile, biobehavioral approaches present a significant challenge, necessitating the integration of biological markers with psychological and behavioral modifications in health-related outcomes [19]. To address this challenge, the TyG index and behavior-related health outcomes can be examined in individuals with uncontrolled T2DM.

Diabetes distress represents a multitude of fears, anxieties, and worries encountered by individuals with T2DM as they navigate a predominantly self-managed condition and its significant complications [20]. A meta-analysis revealed that the estimated prevalence of diabetes distress among individuals with T2DM is approximately 36 %, indicating that this psychosocial issue is prevalent within the population [21]. Diabetes distress frequently stems from concerns regarding dietary and potential complications [22] and correlates with inadequate self-care, elevated HbA1c levels, IR, and fasting blood glucose [20,21].

This study aimd to compare the TyG index, self-management behaviors, and diabetes distress among adults with uncontrolled T2DM who receive IFSM education versus those with only standard routine care.

2. Methods

2.1. Study design

This study used a two-arm, single-blind, randomized controlled trial (RCT) with 8-week interventions and was reported by the Consolidated Standards of Reporting Trials (CONSORT) [23] and the Template for Intervention Description and Replication (TIDieR) checklist [24]. The trial was registered in the Thai Clinical Trials Registry (TCTR20240321003).

2.2. Study participants

From March to September 2024, participants with uncontrolled T2DM and their family members were recruited from four health community clinics using stratified multistage cluster sampling in East Java, Indonesia. In the first stage, we selected the east, middle, and west regions. In the second stage, we randomly selected seven health community clinics for data collection, three of which declined to participate in the study. Eligible participants were recruited according to the following inclusion criteria: 1) adults with uncontrolled T2DM with HbA1c $\geq$ 7 % [25]; 2) aged 30–60 years; 3) diagnosed with T2DM at least six months prior; 4) able to communicate verbally and written in Indonesian; 5) willing to participate; 6) having a smartphone with Internet access and 7) having family members living with them. Meanwhile, the exclusion criteria included: 1) being pregnant; 2) having previous cancer or thrombotic autoimmune diseases; 3) having a disability, auditory deficiencies, or dementia; and 4) having previous self-management intervention programs.

The inclusion criteria for the family members were as follows: 1) living in the same residence and having regular contact with the patient, with the duration of care at least one year; 2) aged 21–60 years; 3) being a spouse, child, sibling, or other close relatives (the family members were chosen by patients); 4) having a smartphone with internet access and 5) willingness to provide informed consent. The exclusion criteria were: 1) previously receiving self-management interventions; 2) having a chronic disease (e.g., T2DM, stroke, and cardiovascular disease); and 3) having a disability, auditory deficiencies, or dementia.

2.3. Sample size

The sample size calculation G*power 3.1 software was estimated with a power of $(1\text{-}\beta) = 0.90$, a significance level $\alpha = 0.01$, and an effect size $(f) = 0.35$ [26], which was calculated from the primary outcome of the DSM intervention, yielding a required sample of 56 dyads (adults with uncontrolled T2DM and one family member). An attrition rate of 20 % was added, resulting in a prescribed sample of 34 dyads per group (68 dyads in total). A total of 198 participants with T2DM were recruited from four community health clinics, including 119 individuals in urban areas (two community health clinics in Kediri City) and 79 individuals in rural areas (one community health clinic in Kediri Regency and one community health clinic in Jombang Regency), who were identified based on their medical records.

2.4. Randomization and blinding

A research randomizer with stratified block randomization www.randomizer.org was created for the arms assignment sequence (ratio of 1:1), carried out by a research assistant uninvolved in data collection. A clinical nurse recruited potential subjects. Once an individual with uncontrolled T2DM agreed to participate in the study, research information and consent forms were provided. Using an opaque and sealed envelope, the clinical nurse allocated the participants to one of the groups based on the sequence in which they entered the intervention and control. The nature of the interventions allowed no participant concealment.

2.5. Interventions

2.5.1. The intervention group

The IFSM education program was designed based on the IFSM middle-range theory (Appendix A). This theory contributes to the self-management literature by emphasizing individuals, familial dyads, or the family unit collectively, clarifying the process components of self-management, and advocating for the consideration of proximal self-management behaviors and distal objectives with quality of life [10]. The program was undertaken for eight weeks and provided four core components, including the education of knowledge and belief, training of self-efficacy improvement, self-regulation skill improvement, and social facilitation improvement via small group discussions involving approximately 8–9 dyads, family telephone calls, the delivery of diabetes infographics (detailed in Appendix B), and motivational card messages by WhatsApp (detailed in Appendix C).

Participants also received diabetes work modules developed based on *"Pedoman Pengelolaan dan Pencegahan Diabetes Mellitus Type 2 di Indonesia 2021,"* a guideline by the Indonesian Society of Endocrinology [27]. Intervention materials were derived from multiple references, such as the IFSM theory [10] and the National Standards for Diabetes Self-Management Education and Support [28]. A panel of four experts in Indonesia verified the content and cultural validity of the work modules following their review by a panel of two diabetes self-management experts. Ten patient-carer dyads evaluated the work modules for comprehensibility and readability, reporting that the resources enhanced their knowledge and self-management abilities.

The first module consisted of two parts. The first part addresses key information on diabetes, including its definition, different types, diagnostic methods, recognition of signs and symptoms, and awareness of potential complications. The second part discusses DSM behaviors, including walking exercise, diabetic diet, medication, blood sugar monitoring, positive affirmations, and the role of family support.

Furthermore, the second module provided self-regulation skills and capabilities related to DSM. The module contained the following elements: a worksheet that listed DSM goals for personal and family and a physical activity planning section that specified activity goals. The diabetes meal objective and plan could be written in a spreadsheet for planning weekly meals and a guide for adhering to a nutritious diet while self-monitoring blood glucose strategies could be written down in a diary for documenting blood sugar levels and a self-monitoring timetable. In addition, regarding physical activity planning, we provided a weekly planner for diabetic medication consumption to facilitate planning and management. It also provides a weekly monitoring report to facilitate progress reviews, particularly emphasizing self-reminders of self-management behaviors.

Intervention call scripts were also provided by WhatsApp. WhatsApp is the most popular and accessible social communication media platform in Indonesia. A previous study indicated that WhatsApp was useful for medical education [29]. WhatsApp is a complimentary social networking platform available through smartphones. It provides instant messaging, phone and video conversations, group chats, and file sharing, which can be utilized in delivering DSM education to individuals with T2DM, especially in areas with limited access to in-person DSM education programs [29]. Telephone calls by WhatsApp as follow-up were intended to enhance patient adherence to DSM practices, such as positive affirmations, routine blood glucose monitoring, medication adherence, and problem-solving. During family telephone conversations, we directed the patients and their family members to describe their recent experiences with their weekly dietary plans, regular physical activity schedules, diabetic medications, problem-solving, and blood glucose monitoring. They were also asked to describe their challenges when combining their weekly nutrition plans with exercise schedules, diabetes medications, and blood glucose monitoring. At the end of the conversation, we expressed our admiration for their adherence to weekly planning and accomplishments through gratitude and compliments.

The participants in the intervention group also received routine care. The researcher, clinical nurse, research assistant, and physician held meetings to review procedures, confirm competency assessments, and equalize perceptions of the investigation protocol and process, thereby establishing research fidelity.

2.5.2. The control group

The control group received standard routine care from nursing educators, encompassing blood glucose monitoring, blood pressure, nursing assessments, and medication adherence. The control group participants were instructed to maintain their usual diet and physical activity, and the research assistant monitored their daily activities and dietary intake. The research assistant also encouraged the participants to adhere to their usual diet and routines for safety management.

2.6. Measures

2.6.1. Demographic data

The research assistant collected data using a questionnaire containing questions concerning participants' demographic characteristics collected at baseline and covered participants' age, gender, diabetes duration, duration of caring, body mass index (BMI), income, marital status, educational level, Javanese and Muslim ethnicity, diabetes complications, and diabetes medication [30,31].

2.6.2. Triglyceride-glucose index

Participants were invited to a clinical measurement session following a 12 h fasting period. The venipunctures were conducted by certified phlebotomists. Biochemical analysts and qualified phlebotomists were blinded to the assignment of the intervention group. Biochemical parameters included the fasting blood glucose (FBG) and triglyceride (TG) levels. The TyG index was calculated as ln [fasting triglyceride (mg/dL) × fasting glucose (mg/dL)/2]. FBG and TG levels were analyzed using an automated hematology cell counter (XP-100).

2.6.3. Diabetes self-management

The Diabetes Self-Management Questionnaire (DSMQ) measures self-management in patients with T2DM [32]. It accurately measured self-behaviors related to glycemic management with 16 items classified into four domains: dietary control (four items), healthcare use (three items), physical activity (three items), and glucose management (five items). One separate question (item

number 16) is included in the sum scale. Each question was scored on a four-point Likert scale (0–3), with a score ranging from 0 (does not relate to me) to 3 (applies to me very much). The total possible scores range from 0 to 48, with higher scores indicating better diabetes self-management. The Indonesian version of the DSMQ for T2DM has a Cronbach's α coefficient of 0.84 [4]. This study's total Cronbach's α coefficient was 0.92, which assumes high internal consistency.

2.6.4. Diabetes distress

Diabetes distress were determined using the Diabetes Distress Scale (DDS), a 17-item self-report instrument that measures the experience of diabetes distress over the preceding month across four distinct domains. Each domain represented a different source of the negative emotional construct: emotional burden (five items), health professional-related distress (four items), regimen-related distress (five items), and interpersonal distress (three items). Responses were evaluated on a Likert scale from 1 (not a problem) to 6 (a very serious problem). The total possible scores range from 17 to 102, with higher scores reflecting greater diabetes distress [33]. We calculated the total DDS mean score and the mean score of each domain-specific subscale by dividing the total score of the items by the number of items (ranging from 1 to 6). This study's total Cronbach's α coefficient was 0.82, indicating high internal consistency.

2.7. Data collection

Data were collected by the research assistants, blinded to the participants of two groups, at baseline and after the 8-week intervention. Both groups were assessed at baseline for sociodemographic characteristics, self-management, and diabetes distress. The questionnaire was distributed to patients in paper form and took approximately 15 min to complete. Research assistants assisted respondents and monitored completion to ensure accuracy. T2DM patients scheduled for routine medical check-ups at four participating community health clinics were recruited by a clinical nurse. The physicians at these clinics introduced the recruiter, who then extended the invitation to eligible patients. After the 8-week intervention, research assistants were blinded to the study hypotheses and patient classification, and they evaluated the patients' TyG Index, self-management, and diabetes distress.

2.8. Data analysis

Statistical analyses were conducted using SPSS (version 25.0, Chicago, IL, USA), with a $P < 0.05$, indicating a statistically significant state. Continuous and categorical data were presented using descriptive statistics of the mean (standard deviation) and n (%), respectively. We performed a chi-squared test, an independent sample t-test, and a one-way analysis of variance (ANOVA) to compare the sociodemographic and baseline results among the two groups. Generalized estimating equation (GEE) models employing suitable link functions and distribution assumptions were utilized to compare outcome variations over time and among the two groups. Data loss due to follow-up attrition was considered randomly missing, and the analysis was conducted using an intention-to-treat strategy.

2.9. Ethical consideration

The study protocol was approved by the Universitas Strada Indonesia, Kediri (001050/EC/KEPK/I/03/2024). Each participant provided written or verbal consent after receiving information about the research. The Ethical Review Board followed the Declaration of Helsinki.

3. Results

3.1. Characteristics of the participants

We excluded 130 individuals from the study; of these, 118 did not meet the inclusion criteria, and 12 did not provide informed consent. In total, 68 dyads with uncontrolled T2DM were randomly assigned to the IFSM education program intervention group ($n = 34$) and the control group ($n = 34$). One participant in the control group was lost to follow-up (due to the move to live) at week 8 (Appendix D). Comparisons of the sociodemographic and clinical variables of participants with T2DM and the baseline outcomes between the two groups are summarized in Table 1. Moreover, all enrolled respondents were of Javanese and Muslim ethnicity.

3.2. Effectiveness of the intervention

Table 2 shows there were no significant differences ($P > 0.05$) in all outcomes at baseline, but significant differences ($P < 0.05$) of TyG index, DSM, and diabetes distress scores between the two groups after intervention. The GEE analysis revealed that there were significant within-time-induced differences in DSM (dietary control, physical activity, glucose management, and total diabetes self-management) and diabetes distress (emotional burden, regimen-related distress, interpersonal distress, and total diabetes distress) before and after the 8-week intervention. However, no significant within-group-induced differences in all outcomes before and after the 8-week intervention.

Finally, the significance of the interaction group and time analysis for all outcomes revealed that participants in the intervention group exhibited significant reductions in TyG index and diabetes distress and increased DSM. Individuals in the IFSM education program had a lower TyG index than the control group, and the program decreased the TyG index score by 1.97. Additionally, the GEE revealed that participants in the intervention group had higher dietary control scores, health-care use, physical activity, glucose management, and total DSM after the 8-week intervention than those in the control group. Furthermore, compared to the control group, participants in the IFSM education arm also had significant declines in emotional burden, health professional-related distress, regimen-related distress, interpersonal distress, and total diabetes distress after the 8-week intervention (Table 2).

4. Discussion

We found that the IFSM education program effectively decreased the TyG index. In line with a previous study reported that diabetes education programs significantly decreased HbA1c, fasting blood glucose, and triglyceride [34]. The TyG index serves as a significant marker of IR, reflecting the complex relationship between lipid and glucose metabolism and elements such as inflammation and oxidative stress [35]. Elevated triglyceride levels may elevate pro-inflammatory cytokines and exacerbate the inflammatory process within the body [36]. Inflammation can disrupt the insulin pathway and elevate insulin resistance and HbA1c [18]. An educational program might advise patients to improve their self-regulation skills by selecting healthier foods [37]. The high level of TyG index was significantly correlated with unhealthy dietary patterns [38]. Thus, the relationship between diet and the TyG index may be explained by diet-induced changes

Table 1
Comparisons of participants' and family members' sociodemographic and clinical data among the two groups ($n = 68$ dyads).

Characteristics	Participants with type 2 diabetes mellitus				Family members			
	Intervention group ($n = 34$)	Control group ($n = 34$)	χ^2/t	P	Intervention group ($n = 34$)	Control group ($n = 34$)	χ^2/t	P
Age (years)	53.82 ± 3.92	54.59 ± 3.97	0.705[a]	0.427	47.06 ± 6.35	47.59 ± 5.35	1.632[a]	0.713
BMI (kg/m^2)	25.41 ± 3.89	26.05 ± 3.81	0.350[a]	0.492	24.54 ± 2.22	24.43 ± 1.27	0.227[a]	0.806
Diabetes duration (years)	4.47 ± 1.76	4.09 ± 1.55	0.639[a]	0.345				
Duration of caring (years)					4.44 ± 1.24	4.47 ± 0.99	2.147[a]	0.914
Gender								
Female	20 (58.8)	22 (64.7)	0.618[b]	0.249	19 (55.9)	20 (58.8)	0.060[b]	0.806
Male	14 (41.2)	12 (35.3)			15 (44.1)	14 (41.2)		
Marital status								
Non-married	17 (50.0)	18 (52.9)	0.808[b]	0.059	19 (55.9)	17 (50.0)	0.236[b]	0.627
Married	17 (50.0)	16 (47.1)			15 (44.1)	17 (50.0)		
Income (IDR)								
Low income	15 (44.1)	17 (50.0)	0.627[b]	0.236	15 (44.1)	18 (52.9)	0.530[b]	0.467
High income	19 (55.9)	17 (50.0)			19 (55.9)	16 (47.1)		
Education								
ISCED <3	14 (41.2)	16 (47.1)	0.625[b]	0.239	13 (38.2)	18 (52.9)	1.482[b]	0.223
ISCED ≥3	20 (58.8)	18 (52.9)			21 (61.8)	16 (47.1)		
Medication takes for diabetes								
Oral medications	10 (29.4)	8 (23.5)	0.620[b]	0.956				
Insulin injection	13 (38.2)	17 (50.0)						
Oral medications and insulin injection	11 (32.4)	9 (26.5)						
Diabetes complication								
Yes	22 (64.7)	20 (58.8)	0.803[b]	0.249				
No	12 (35.3)	14 (41.2)						

Note: [a] independent sample *t*-test. [b] chi-squared test. Data are *n* (%) or *Mean* ± *SD*. IDR = Indonesian rupiah rate. Low income was defined as being below the regional minimum salary. ISCED = International Standard Classification of Education. Duration of caring: minimum of 2 years and a maximum of 6 years. Diabetes duration: minimum of 2 years and a maximum of 9 years.

in insulin levels, which, in turn, largely drive IR [39]. Previous studies have demonstrated that regular walking (150 min/week) significantly reduced the TyG index [35], oxidative stress, and inflammation markers, such as malondialdehyde, white blood cells, neutrophil-lymphocyte ratio, and fasting blood glucose [19,31]. Therefore, IFSM education might reduce the TyG index for several reasons, particularly because it enabled patients to regulate their dietary consumption and physical activity more effectively, which directly influenced their TyG index. Additionally, this finding confirms the potential of biological mechanisms, such as lipid metabolism, glucose metabolism, inflammation, and oxidative stress. These mechanisms provided convincing insights into the pathways influencing TyG in adults with uncontrolled T2DM.

This study revealed that individuals with T2DM who participated in an IFSM educational program demonstrated a statistically significant improvement in DSM scores, which aligns with a previous study [34]. Previous studies indicate familial participation in DSM interventions enhances familial support and improves diabetes self-regulation [39,40]. Moreover, individuals with T2DM who received family-based self-management support interventions showed significant changes (group-by-time interaction) in dietary control, physical activity, and overall self-management. However, they exhibited significantly decreased healthcare use (foot care and medication management) and glucose management, which became insignificant over time [13]. Another study indicated that participants receiving education-related medication adherence, medical nutrition therapy, and regular physical activity information to enhance glucose regulation and reduce diabetic complication risk exhibited significantly higher DSM scores than those receiving regular care [7]. In the interventions, patient-family dyads received motivation card messages from the health coaching session containing dyadic information to strengthen positive affirmations. They heard success stories told by those with successful diabetes management. The health coaching session focused on family-centered interventions integrated with familial values in coping mechanisms, problem-solving strategies, and perceptions of DSM. Problem-solving skills to manage uncontrolled T2DM and responsiveness to encourage patient compliance could improve and empower individuals with T2DM in DSM practices [41]. In this way, family members will be prepared to tackle and understand difficulties, acquire the ability to make decisions in problem-solving, and effectively address any issues that may arise, thereby enhancing the overall functioning of the family [42]. Inadequate DSM has been linked to inadequate social support from family members, including dyads. In fact, family members provide emotional support in problem-solving and assist patients in accommodating, reminding, motivating, and collaborating on behavior changes and declining quality of life [43]. Therefore, the nurses need to implement the IFSM education program through counseling services for individuals with T2DM, and caregivers can increase DSM scores by providing problem-solving and motivation.

In the present study, we found that with the IFSM education program, there was a significant decrease in diabetes distress among adults with uncontrolled diabetes. Regarding diabetes distress, we should remember that diabetic patients have to deal with numerous roles and responsibilities, bringing about competing priorities, stress, and life-disease conflicts [44,45]. Thus, individuals experiencing distress are more prone to significant T2DM symptom burden, occupational incapacity, and increased medical costs [46,47]. High levels of distress were significantly correlated with poor DSM, such as lower levels of physical activity, glucose management, and diet [48]. Participation in DSM education contributed to a 0.25 % decrease in HbA1c with a change in diabetes distress [49]. A systematic review demonstrated that a self-management education program involving US Latino adult patients with T2DM and their families significantly decreased patients' diabetes distress scores [50]. Support from family members significantly decreases diabetes distress and glycemic control in individuals. Accordingly, individuals with T2DM require additional exposure to integration-based interventions with family support to reduce their diabetes distress

Table 2
Comparison of triglyceride-glucose index, diabetes self-management, and diabetes distress between two groups ($n = 68$).

Variables	Pre-intervention	Post-intervention	Time		Group		Interaction (Group×Time)	
			β (95 %*CI*)	*P*	β (95 %*CI*)	*P*	β (95 %*CI*)	*P*
Triglyceride-glucose index								
Intervention group	8.25 ± 0.91	6.00 ± 0.65	-0.27 (-0.56, 0.02)	0.071	-0.15 (-0.59, 0.30)	0.515	-1.97 (-2.41, -1.53)	<0.001
Control group	8.39 ± 0.98	8.13 ± 0.85						
t	-0.64	-11.52						
P	0.523	<0.001						
Diabetes self-management								
Dietary control								
Intervention group	3.47 ± 1.26	9.36 ± 1.81	1.12 (0.56, 1.68)	<0.001	0.09 (-0.46, 0.64)	0.752	4.77 (3.85, 5.62)	<0.001
Control group	3.38 ± 1.07	4.50 ± 1.14						
t	0.31	13.26						
P	0.757	<0.001						
Physical activity								
Intervention group	3.12 ± 0.77	7.00 ± 1.21	0.79 (0.27, 1.32)	0.003	-0.12 (-0.55, 0.31)	0.592	3.09 (2.34, 3.84)	<0.001
Control group	3.24 ± 1.05	4.03 ± 0.94						
t	-0.53	11.20						
P	0.599	<0.001						
Glucose management								
Intervention group	9.68 ± 1.21	16.03 ± 1.24	1.53 (0.85, 2.21)	<0.001	0.12 (-0.35, 0.59)	0.622	4.82 (3.98, 5.67)	<0.001
Control group	9.56 ± 0.86	11.09 ± 2.19						
t	0.49	11.43						
P	0.629	<0.001						
Health-care use								
Intervention group	3.38 ± 0.82	7.71 ± 0.76	0.32 (-0.02, 0.67)	0.065	-0.29 (-0.70, 0.11)	0.155	4.00 (3.52, 4.49)	<0.001
Control group	3.68 ± 0.91	4.00 ± 0.49						
t	-1.40	23.86						
P	0.166	<0.001						
Total diabetes self-management								
Intervention group	19.65 ± 2.28	40.09 ± 2.21	3.77 (2.67, 4.86)	<0.001	-0.21 (-1.17, 0.76)	0.676	16.68 (15.23, 18.09)	<0.001
Control group	19.85 ± 1.81	23.62 ± 2.74						
t	-0.41	27.29						
P	0.682	<0.001						
Diabetes distress								
Emotional burden								
Intervention group	20.55 ± 2.49	11.09 ± 1.93	-1.47 (-1.97, -0.97)	<0.001	-0.09 (-1.13, 0.95)	0.868	-8.00 (-9.04, -6.96)	<0.001
Control group	20.65 ± 1.92	19.18 ± 1.92						
t	-0.16	-16.26						
P	0.871	<0.001						
Health professional-related distress								
Intervention group	19.44 ± 1.89	8.94 ± 1.56	-0.89 (-0.81, 0.63)	0.809	0.53 (-0.28, 1.34)	0.200	-10.41 (-11.50, -9.33)	<0.001
Control group	18.97 ± 1.51	18.82 ± 2.63						
t	1.26	-18.84						
P	0.261	<0.001						
Regimen-related distress								
Intervention group	20.85 ± 2.19	11.15 ± 1.31	-2.27 (-2.73, -1.80)	<0.001	0.38 (-0.53, 1.30)	0.412	-7.44 (-8.35, 6.54)	<0.001
Control group	20.47 ± 1.67	18.21 ± 1.39						
t	0.81	-21.60						
P	0.422	<0.001						
Interpersonal distress								
Intervention group	12.07 ± 1.61	6.59 ± 1.33	-0.62 (-1.12, -0.12)	0.016	0.43 (-0.27, 1.12)	0.228	-4.87 (-5.62, -4.12)	<0.001
Control group	11.65 ± 1.35	11.03 ± 1.68						
t	1.19	-12.10						
P	0.240	<0.001						
Total diabetes distress								
Intervention group	72.94 ± 3.16	37.76 ± 3.20	-4.44 (-5.64, -3.25)	<0.001	1.27 (-0.23, 2.76)	0.097	-30.74 (-32.57, 28.90)	<0.001
Control group	71.68 ± 3.22	67.24 ± 4.51						
t	1.64	-31.18						
P	0.107	<0.001						

Note: Data are *Mean* ± *SD*. *t:* independent sample *t*-test. β: regression coefficient. β values and 95 %*CI*s were estimated using generalized estimating equations.

[51]. In an investigation in China, empowerment self-management interventions significantly reduced diabetes distress and emotional and regimen distress [52]. The dyadic health providers, such as physicians or nurses, helped adults with uncontrolled T2DM understand their strengths and weaknesses as they moved along the self-management path. Specifically, dyadic patient-family interactions would create a supportive and empowering environment, causing the distress score to decline [52]. However, two previous investigations demonstrated that DSM education programs were not associated with diabetes distress [53,54]. This inconsistency might have arisen because the education program neglected to incorporate psychological lessons with the psychological effects of diabetes by transforming negative perspectives into positive ones. Furthermore, we noted that it was necessary to have reflection sessions where patients could talk about their views, correct negative perceptions, and hear success stories from those who had successfully managed their blood sugar levels [10,52]. Thus, these findings suggest that interventions should combine patient and family to reduce diabetes distress, which could potentially decline HbA1c among individuals with T2DM.

Overall, the intervention's unique aspect was its alignment with the valued concept of familial involvement. By engaging

family members as care partners rather than passive observers, the intervention helped to create a shared sense of responsibility and solidarity, which has been shown to improve long-term adherence to diabetes self-care behaviors. The findings underscore the importance of the IFSM education program, particularly relevant in Indonesia's collectivist cultures, where family influence strongly shapes individual health behaviors, such as improving diabetes self-management and alleviating TyG index and diabetes distress.

5. Limitations

The present study has several limitations. First, although it was necessary to evaluate the immediate impact after the 8-week intervention, an investigation of long-term follow-up is still required. In addition, the current study was unable to measure HbA1c due to a longer detection time of more than three months and increased cost. Additionally, all enrolled respondents were of Javanese and Muslim ethnicity, which may have limited the assessment of occupational status, potentially reducing the generalizability of our findings. Future studies should include home visits as a critical component of therapeutic success.

6. Conclusions

The IFSM (patient-family dyads) education program successfully reduced TyG and diabetes distress in individuals with uncontrolled T2DM while also improving DSM scores, attesting to the program's feasibility in advanced T2DM. To facilitate the care of individuals with diabetes, nurses can implement a protocol that enables them and their families to manage their disease. In clinical care, nurses can acquire and implement IFSM strategies to improve self-management, TyG, and diabetes. Nurses should efficiently implement the IFSM education initiative to alleviate the long-term burden on primary care services potentially. Family support for individuals with T2DM may lessen the burden on diabetes educators and healthcare services by offering supplementary assistance and potentially mitigating complications. Moreover, the setting implemented in community health clinics provided a model hospitals could adopt through an integrated discharge planning procedure.

CRediT authorship contribution statement

Yohanes Andy Rias: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Data curation, Funding acquisition, Writing - original draft, Writing - review & editing, Project administration. **Ratsiri Thato:** Conceptualization, Methodology, Validation, Data curation, Funding acquisition, Writing - review & editing, Supervision. **Margareta Teli:** Conceptualization, Methodology, Data curation, Writing - review & editing. **Ferry Efendi:** Methodology, Validation, Writing - review & editing.

Data availability statement

The datasets generated during and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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Declaration of competing interest

The authors have declared no conflict of interest.

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Appendices. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijnss.2025.06.001.

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