BMC Geriatrics

RESEARCH

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Application of the information-motivation-behavioral skills model to improve medication adherence among older adults with type 2 diabetes: findings from a quasi-experimental study in Kermanshah, Iran

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Abstract

Introduction Medication adherence is crucial for effective blood sugar control in diabetes patients. However, older adults face a higher risk of non-adherence. This study aims to evaluate the effectiveness of a theory-based program designed to enhance medication adherence among older adults with type 2 diabetes.

Methods This quasi-experimental study involved 100 elderly individuals with type 2 diabetes in Kermanshah, Iran, in 2024. Participants were randomly assigned to an intervention (50) or control group (50). The intervention group attended six 40-minute sessions over six weeks, based on the Information-Motivation-Behavioral Skills (IMB) model. Data were collected via a questionnaire assessing demographics, IMB model components, and medication adherence. Data were analyzed using SPSS version 16, employing chi-square tests and t-tests for comparisons, moreover, effect sizes were determined using Cohen's d.

Results The intervention group showed significant improvements, especially in "Information," with a very large effect size of 1.3 and an average change of 3.84 ($p < 0.001$). In contrast, the control group had minimal changes. Other components like "Attitude" and "Self-efficacy" also had large effect sizes (0.65 and 0.67). However, "Subjective Norms" showed a small effect size (0.11) with no significant changes. Additionally, the intervention group showed a significant improvement in medication adherence (effect size 1.15), increasing scores from 16.92 to 19.76, ($p < 0.001$) while the control group had minimal changes.

Conclusion The program based on the IMB model significantly improved medication adherence among elderly individuals with type 2 diabetes. We also identified the key theoretical methods of behavior change for each determinant of the IMB model and recommend utilizing them in the development of similar future interventions.

Keywords Medication adherence, Aged, Diabetes mellitus, Health education, Motivation

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Introduction

Diabetes has emerged as a significant public health challenge globally, exerting considerable pressure on healthcare systems [1]. The prevalence of this disease has surged in the 21st century, with reports indicating that in 2021; approximately 537 million adults worldwide were living with diabetes, a figure projected to escalate to 783 million by 2045, reflecting a 46% increase [2]. This rise correlates with increasing life expectancy and an aging population; the World Health Organization (WHO) estimates that by 2030, one in six individuals will be over 60 years old, with this ratio expected to approach one in four by 2050 [3]. In Iran, the Statistical Center reports that 6.3% of the population is currently over 60, projected to rise to 16.2% by 2036, highlighting a significant demographic shift [4].

Diabetes accounts for approximately 1.6 million deaths each year and places a heavy financial strain on healthcare systems worldwide, with global spending hitting an astonishing USD 966 billion in 2021; in Iran, the economic impact is particularly significant, with diabetes-related health expenditures per individual estimated at USD 1,354.8 in 2021, projected to rise to USD 1,839.2 by 2045 [5].

Older adults with diabetes face significant risks of complications, including hypoglycemia, kidney failure, and cardiovascular diseases [6]. The International Diabetes Federation reported that in 2019, one in five older adults worldwide had diabetes [7]. In Iran, research indicates that approximately one in three individuals over 60 is affected, highlighting the urgent need for attention to elderly diabetic patients in this context [4]. Effective self-management of type 2 diabetes involves challenges such as dietary adherence, regular exercise, medication compliance, foot care, glucose monitoring, and psychological support [8].

Long-term management of chronic diseases requires strict adherence to medication regimens to control symptoms and slow disease progression [9]. Medication adherence is vital for glycemic control in diabetic patients, but older adults often struggle with non-adherence due to multiple chronic conditions, polypharmacy, and cognitive decline [7]. Adherence, defined as following prescribed medication regimens [10], significantly impacts physiological outcomes and quality of life [11]. Actual adherence rates for type 2 diabetes vary widely, typically between 36 and 93% [12], with recent studies showing only 54% of adults adhering to therapies [13]. In Iran, about half of diabetic patients do not comply with treatment [14], leading to worse health outcomes and increased healthcare costs [15]. Poor adherence can worsen symptoms and complications, heightening the risk of both macrovascular and microvascular diseases [16, 17]. This global challenge not only accelerates disease progression but also inflates treatment costs [10, 18].

Current intervention strategies—ranging from patient education and counseling to simplifying medication regimens—have not sufficiently addressed the issue of non-adherence [19]. The complexities of medication adherence are influenced by various factors, some immutable (such as age), while others, particularly patient-related factors, can be modified through increased knowledge and altered beliefs about medications [20]. Current interventions aimed at improving medication adherence in diabetic patients are often insufficient due to several factors; many patients face barriers such as complex medication regimens, lack of understanding of their condition, and insufficient support systems; additionally, traditional approaches, may not address the underlying psychological and social determinants of health that influence adherence; thus, a more holistic approach is necessary to enhance adherence rates among diabetic patients [19–21].

Healthcare providers play a pivotal role in enhancing adherence by understanding the typical pathways influencing medication compliance among diabetic patients [22]. Evidence suggests that effective behavior change interventions must meet three criteria: they should target predictive factors of behavior, allow for modifications of those factors, and be practically applicable within the relevant cultural and contextual framework [23]. Various theoretical models have been proposed to elucidate health behavior changes. One such model is the information-motivation-behavioral skills (IMB) model, which facilitates the development and evaluation of diverse intervention strategies [24]. This model comprises three component: Information, which encompasses knowledge about the disease and its management; Motivation, reflecting an individual's desire to engage in healthy behaviors and the social support received; and Behavioral Skills, which pertain to a person's confidence and ability to perform health-related actions [25]. The IMB model is crucial in studies aimed at improving self-management among diabetic patients as it provides a comprehensive framework for understanding the factors that influence health behaviors; by ensuring that patients receive accurate information about diabetes management, fostering motivation through emotional and social support, and enhancing behavioral skills through practical training, healthcare providers can empower patients to take control of their condition; this holistic approach not only helps in improving adherence to treatment regimens but also encourages lifestyle changes that are essential for effective diabetes management, ultimately leading to better health outcomes and enhanced quality of life for patients [26–32]. The identified research gap is the lack of sufficient evidence regarding the application of the IMB model in promoting medication adherence among patients with type 2 diabetes in Iran, particularly elderly

individuals. Despite the existence of various interventions aimed at improving adherence, many of these approaches fail to address the psychological, social, and cultural factors that influence adherence behavior. While the IMB model has shown potential in improving self-management and treatment adherence, its implementation and efficacy remain underexplored in the Iranian context. This study seeks to fill this gap by evaluating the effectiveness of an IMB model-based program tailored for elderly diabetic patients in Kermanshah, Iran, thus contributing to the development of more holistic and culturally relevant interventions.

Methods

Participants

This quasi-experimental study was carried out in 2024, involving 100 elderly individuals diagnosed with type 2 diabetes in Kermanshah city, located in western Iran. Kermanshah is recognized as one of the provinces with a high prevalence of diabetes in the Iran [33]. Participants were identified through health center records in the city and invited to join the study by a healthcare professional. They were then randomly divided into two groups: an intervention group (50 participants) and a control group (50 participants). Those in the intervention group were drawn from three health centers, where they received the educational intervention. Conversely, participants in the control group were selected from two separate health centers. Taking into account a confidence level of 95% and a power of 80%, and based on the findings of the previous study [34] which reported the mean treatment adherence scores among patients with type 2 diabetes in Iran as 61.22 for the intervention group and 58.91 for the control group, with standard deviations of 3.04 and 4.37 respectively, the minimum sample size required for the study is at least 42 individuals in each group. To account for potential sample rejection rate, 50 participants from each group were included in the study.

Inclusion and Exclusion Criteria

Inclusion criteria for the study encompassed individuals aged 60 years and above, without any mental disorders, possessing the physical and cognitive ability to answer questions, and providing consent to participate. All patients had a medical record at a health center located near their residence. They were evaluated by a physician and a healthcare specialist, who reviewed their medical records. Patients diagnosed with a mental or cognitive disorder by a physician and noted in their records were excluded from the study. Additionally, patients with comorbidities such as kidney failure or severe heart disease were also excluded. Moreover, exclusion criteria included a lack of willingness to participate, incomplete responses to the questionnaire, or missing attendance at two training sessions.

Content and educational intervention

The control group participants were provided with standard education and routine guidance on managing diabetes at healthcare facilities. In contrast, those in the intervention group attended six educational sessions designed around the IMB model. This IMB-focused intervention was tailored to promote medication adherence and was formulated using an intervention mapping strategy (Table 1) [23]. A session was conducted with the participation of a patient's family member acting as a supporter. For each component of the information-motivation-behavioral skills model, a pamphlet and an educational video were developed, taking into account the results of a needs assessment that considered both desires and preferences, as well as input from the researchers. Two posters were also prepared for information purposes and placed in health centers under intervention.

Weekly sessions were conducted from 9 to 10 AM, each lasting roughly 40 min, over a six-week period. These sessions were facilitated and managed by a master's student specializing in health education and promotion, who was also a research team member and an expert in healthcare. Around 20 min in each session were dedicated to open discussions, giving participants the opportunity to ask questions or share their experiences. To reinforce the material covered, participants received both a pamphlet and an educational video at the conclusion of each training session.

The initial two sessions emphasized the informational aspect. During these sessions, patients were instructed on the proper method and timing for taking their medication, the potential side effects of inconsistent use, and the appropriate dosage. The theoretical method used for this component was discussion [23]. At that time, the trainer engaged with the participants to review the topics covered. They were encouraged to seek clarification on anything they found unclear, and comprehensive explanations were provided.

Two sessions were dedicated to the motivation component as well. These sessions primarily aimed to foster motivation by emphasizing the development of positive attitudes, enhancing feelings of social support, and strengthening perceptions of subjective norms [35]. The needs assessment carried out in this study highlighted participants' beliefs regarding the potential advantages of medication adherence. The key messages aimed at addressing these beliefs emphasized trust in recovery, confidence in preventing side effects, and assurance of an undisturbed lifestyle with medication adherence. Consequently, the design and approach for fostering theoretical change, particularly in relation

Table 1 Outlines the determinants, goals of change, message, theoretical method of change, and parameters

Determinants/goals of change	Message	Theoretical method of change	Parameters
Information			
The patient must clearly understand the appropriate timing for taking their medication. They should also be aware that irregular use can lead to various side effects. Additionally, knowing the precise dosage is essential for proper treatment.	1. Understanding the specific timing for taking the medicine 2. Being aware of the potential side effects of inconsistent use 3. Knowing the precise dosage required	Discussion	Paying attention to patients to ensure the effective implementation of positive schemas
Motivation (attitude towards medication adherence)			
The patient believes that medication adherence can aid in recovery, help prevent diabetes-related side effects, and maintain the flow of daily life without disruption.	1. Recognizing the beneficial impact of consistent medication use on overall bodily functions 2. Understanding the role of regular medication in managing and preventing diabetes-related complications 3. Acknowledging that consistent medication use does not interfere significantly with personal life	Self-reevaluation	Encourage a thoughtful assessment of both cognitive and emotional states, comparing experiences with and without the influence of medication adherence.
Motivation (subjective norms towards medication adherence)			
The patient reports that the majority of individuals significant to him/his, including family, friends, and those in his close circle, are supportive of his efforts to follow the prescribed medication adherence. Additionally, he mentions receiving support from his doctor and healthcare provider in maintaining adherence to his treatment regimen.	1. Taking medication more responsibly with encouragement from those around you 2. Using medication more responsibly with guidance from doctors and healthcare professionals	Information about others approval	Fostering a sense of positive expectations within an environment. By creating a space where people feel supported and capable of succeeding, individuals are more likely to embrace challenges, develop confidence, and achieve their goals. This atmosphere not only enhances personal fulfillment but also strengthens collective outcomes.
Behavioral skills (Self-efficacy and individual's objective skills)			
- The patient expresses confidence in maintaining a consistent routine for taking his medication. - He feels assured that he can seek assistance from his doctor whenever necessary. - He believes he can adhere to his medication schedule even during times of illness or a hectic schedule. - He mentions being able to access all the necessary information regarding the proper use of diabetes medications. - He has implemented a reminder system, such as using a phone alarm, to ensure timely medication intake. - He states that he continues taking his medication consistently, even during emotionally challenging periods such as sadness, anger, or depression. - He confirms his ability to follow his medication regimen without interruption, even while traveling.	1. Building self-confidence to maintain a consistent medication routine 2. Trusting your ability to seek medical assistance when necessary 3. Staying confident in adhering to medication schedules, even during inconvenient times 4. Gaining access to reliable information about prescribed medications 5. Establishing reminders to ensure regular medication intake 6. Maintaining consistency in taking medication, even during emotionally challenging periods 7. Adhering to medication routines while traveling	Self-monitoring of behavior Planning coping responses	Control over medication use behavior (identifying reasons for not taking and using regularly), identifying high-risk situations and practicing coping responses (examining problem solutions).

to attitudes and self-appraisal reassessment [23], were carefully incorporated. In the motivation component, sessions progressed by applying the theoretical method of replacing "information about others approval" to enhance patients' social motivation. Patients engaged in discussions about the consistency of medication use among individuals with type 2 diabetes, sharing insights and recognizing one another's positive habits under the trainer's guidance. Furthermore, to promote mental norms that support medication adherence, a dedicated

session was organized, involving a family member as a supporter and caregiver to further encourage and reinforce this behavior. The final two sessions were designed to enhance patients' behavioral skills. Research indicates that interventions targeting self-efficacy and teaching practical strategies, such as setting reminders like phone alert colors for medication adherence, can be effective [35]. In this context, we concentrated on boosting patients' perceived self-efficacy by employing theoretical methods of change, including self-monitoring of behavior and planning coping responses [23].

The process of providing follow-up education on medication adherence has been reported to take up to a month [36]. According to American guidelines, a minimum period of six weeks is recommended for evaluating the response to treatment, while the American Diabetes Association suggests extending this period to two to three months [37, 38]. In the present study, we considered two months and data were collected before and two months after the implementation of the intervention. Creating educational materials such as videos, pamphlets, and posters focused on the practical application of IMB components. The approach also emphasized interpersonal engagement across all IMB components. Table 1 outlines the determinants, goals of change, message, theoretical method of change, and parameters, utilized in the current program, following the intervention mapping approach.

Questionnaire

In this study, we collected data from participants through interviews and a written questionnaire, which was divided into three sections.

The first section captured the demographic characteristics of participants, including age, duration since diabetes diagnosis, gender, education level, marital status, occupation, economic status, household size, smoking habits, type of treatment, family history of diabetes, health insurance coverage, and use of blood pressure-lowering medications.

The second section evaluated components of the IMB model. This part was developed based on prior research that utilized the IMB model to assess medication adherence among individuals with diabetes [26–32]. It included five items (e.g., "I know the right time to take my medication") for information. The motivation component comprised two constructs: personal motivation and social motivation. The personal motivation segment included four items regarding attitudes towards medication adherence (e.g., "Thinking about taking diabetes medication every day for the rest of my life frustrates me"), while the social motivation segment contained two items reflecting subjective norms (e.g., "Most people important to me support my adherence to diabetes medication").

Behavioral skills were assessed through two constructs: perceived self-efficacy and individual's objective skills. Perceived self-efficacy included three items (e.g., "I am confident that I will continue taking my medication even when I feel unwell"), while individual's objective skills comprised nine items (e.g., "I have set reminders for myself to take my diabetes medication"). A higher score in each construct indicated a more favorable situation. To facilitate participant responses, all items were rated on a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). This study also evaluated the face validity, content validity, and reliability of the IMB model questionnaire components, with detailed explanations provided in subsequent sections.

Face validity evaluation

Face validity refers to the degree to which the measured elements appear suitable for assessing the intended concept. In simpler terms, it evaluates how well the items align with the subject in terms of appearance, logical coherence, proportionality, appeal, logical sequencing, practical usefulness, and overall significance. This evaluation particularly emphasizes the perspective of the target audience [39, 40]. The face validity of the questionnaire was assessed using qualitative methods. Individual face-to-face interviews were conducted with 12 experts, whose feedback was analyzed, leading to necessary modifications. The group of experts included professionals from various fields, such as general practitioners, health experts caring for diabetic patients, endocrinologists, health education specialists, and health policymakers.

Content validity evaluation

Content validity assesses the extent to which the selected items effectively represent the characteristics of the construct being measured. It ensures that the items included are appropriate and sufficient for capturing the essence of the concept [39, 40]. The content validity of the IMB model questionnaire was evaluated using both quantitative and qualitative approaches. Similar to the face validity evaluation, feedback was gathered from 12 experts regarding the difficulty, relevance, and clarity of the items. Their suggestions were carefully reviewed, and modifications were made accordingly. For the quantitative evaluation, a separate group of 12 experts classified each item as "essential," "useful but not essential," or "not essential." The feedback collected was used to calculate the Content Validity Ratio (CVR) and Content Validity Index (CVI). The CVR ensured that the most critical content was retained, while the CVI assessed whether the questionnaire items were appropriately designed to measure the intended content. According to the Lawshe table, the minimum acceptable values for CVR and CVI were established at 0.62 and 0.79, respectively [39,

40]. All items were approved based on the CVA and CVR evaluations.

Reliability evaluation

Reliability refers to the consistency and stability of a measurement instrument. An instrument is considered reliable if it yields similar results under comparable conditions and with similar methods [41]. In our study, reliability was assessed using Cronbach's alpha coefficient, with a value above 0.65 generally deemed acceptable [41]. A pilot study involving 30 participants from the target group was conducted prior to the main project. The Cronbach's alpha coefficients for the constructs of information, attitude, subjective norms, self-efficacy, and objective skills were 0.85, 0.81, 0.75, 0.73, and 0.74, respectively.

The third section focused on evaluating patients' medication adherence, using a standardized 5-item questionnaire that included statements such as "I sometimes forget to take one of my medications" [42]. In this study, the questionnaire demonstrated a Cronbach's alpha of 0.79, indicating good reliability.

Data analysis

The data collected were analyzed using SPSS version 16 statistical software, employing appropriate statistical tests. The background and demographic variables of the intervention and control groups were compared through chi-square ($\chi 2$) tests and independent two-sample t-tests. To assess and compare the means of the studied variables, independent two-sample t-tests and paired t-tests were conducted. Additionally, mean changes before and after the intervention were reported. The effect size, calculated using Cohen's d, was determined for the studied variables. This was done by subtracting the mean score of the control group from that of the intervention group and dividing the result by their pooled standard deviation. An effect size score ranging from 0 to 0.2 was categorized as small, 0.2 to 0.5 as medium, 0.5 to 0.8 as large, and above 0.8 as very large [43]. It is worth mentioning that the normality of the IMB components and medication adherence was assessed and confirmed using the Kolmogorov-Smirnov test.

Results

All participants remained actively engaged throughout the program, including the intervention phases, follow-up, and data collection, both before the program implementation and two months after the intervention.

The analysis shows that there are no statistically significant differences between the two groups across various demographic and health-related factors. For instance, the mean age of participants in the intervention group was 71.48 years, compared to 69.30 years in the control group, with a p-value of 0.102, indicating no significant age difference. In addition, the mean of diabetes duration participants in the intervention group was 9.68 years (SD: 6.71), compared to 8.64 years (SD: 5.78) in the control group, with a p-value of 0.409, indicating no significant diabetes duration difference. Table 2 presents a comparison of background variables between the intervention and control groups in the study. Variables such as sex, marital status, job status, education level, economic status, family size, health insurance coverage, type of treatment, family history of diabetes, smoking status, and use of blood pressure-lowering medications all yielded p-values greater than 0.05, suggesting comparable characteristics between the groups. These findings reinforce the validity of the study by ensuring that the intervention and control groups are similar in their baseline characteristics, which minimizes potential confounding variables. This homogeneity is crucial for attributing any observed effects on medication adherence specifically to the intervention implemented, rather than to pre-existing differences between the groups.

Table 3 presents a comparison of the IMB components' scores among participants in both intervention and control groups before and after the implementation of the intervention. The intervention group exhibited significant improvements across several components, particularly in "Information," where the effect size was very large (1.3) with a substantial average rate of change (3.84) and a paired sample t-test result of <0.001. This indicates that the intervention had a profound impact on the participants' information. In contrast, the control group showed minimal changes, with no significant improvements in the same component. Other components such as "Attitude" and "Self-efficacy" also demonstrated large effect sizes (0.65 and 0.67, respectively) in the intervention group, further underscoring the program's effectiveness. However, "Subjective Norms" displayed a small effect size (0.11) with no significant changes in either group. Additionally, the intervention group for medication adherence demonstrated a very large effect size of 1.15, with an average rate of change of 2.84 and a paired sample t-test result of <0.001, indicating a significant improvement in medication adherence from an average score of 16.92 (SD = 2.80) before the intervention to 19.76 (SD = 3.10) afterward. In contrast, the control group showed minimal change, with a slight increase in scores from 16.12 (SD = 2.47) to 16.50 (SD = 2.54) and a non-significant p-value of 0.252. This data highlights the efficacy of the intervention in enhancing medication adherence among intervention group participants compared to the control group, which remained relatively stable.

Table 2 Comparison of background variables between intervention and control groups

Variables		Intervention *n*(%)	Control *n*(%)	*P*
Sex	Women	22 (48.9%)	23 (51.1%)	0.841
	Men	28 (50.9%)	27 (49.1%)	
Marital status	Married	34 (48.6%)	36 (51.4%)	0.663
	Single	16 (53.3%)	14 (46.7%)	
Job	Empolyed	14 (41.2%)	20 (58.8%)	0.525
	Retired	15 (53.6%)	13 (46.4%)	
	Housewife	15 (51.7%)	14 (48.3%)	
	Unemployed	6 (66.7%)	3 (33.3%)	
Education level	Primary school	11 (52.4%)	10 (47.6%)	0.983
	Scendoray school	15 (51.7%)	14 (48.3%)	
	High School	15 (48.4%)	16 (51.6%)	
	Academic	9 (47.4%)	10 (52.6%)	
Economic ststus	Weak	11 (55%)	9 (45%)	0.714
	Average	20 (45.5%)	24 (54.5%)	
	Good	19 (52.8%)	17 (47.2%)	
Family size	1 and 2 people	23 (52.3%)	21 (47.7%)	0.754
	3 and 4 people	20 (52.6%)	18 (47.4%)	
	5 and 6 people	5 (41.7%)	7 (58.3%)	
	More than 6 people	2 (33.3%)	4 (66.7%)	
Health insurance	No	10 (52.6%)	9 (47.4%)	0.799
	Yes	40 (49.4%)	41 (50.6%)	
Type of treatment	Medications	30 (46.9%)	34 (53.1%)	0.660
	Insulin injections	10 (52.6%)	9 (47.4%)	
	Both (medication + insulin)	10 (58.8%)	7 (41.2%)	
Family history of diabetes	No	33 (52.4%)	30 (47.6%)	0.534
	Yes	17 (45.9%)	20 (54.1%)	
Smoking	No	31 (46.3%)	36 (53.7%)	0.288
	Yes	19 (57.6 5)	14 (42.4%)	
Blood pressure-lowering medications use	No	17 (45.9%)	20 (54.1%)	0.534
	Yes	3 (52.4%)	30 (47.6%)	

Discussion

The results of our study demonstrated that implementing the intervention substantially improved the information scores in the intervention group. The calculated effect size for this improvement was 1.3, reflecting a very large impact. Supporting this observation, Nouri et al. similarly reported a very large effect size of 3.2 for knowledge construct among type 2 diabetes patients in Isfahan, Iran [44]. Moreover, Ahmed et al., in their study involving 100 patients with type 2 diabetes in Port Said, Egypt, found that the average knowledge score significantly increased from 2.69 before the intervention to 5.30 afterward [45]. The current study employed the theoretical approach of discussion-based change to address information construct. Similar to our findings, previous research has highlighted the efficacy of this method of change in enhancing information management among individuals with chronic illnesses [46, 47]. Based on the findings of our study, it is crucial for patients with type 2 diabetes to engage in educational programs that utilize discussion-based approaches to enhance their understanding of diabetes management. The substantial improvements in knowledge scores observed in our research, highlight the efficacy of interactive learning environments. Therefore, healthcare providers should prioritize the implementation of group discussions and peer-led sessions within educational frameworks, as these methods not only foster a deeper understanding of diabetes but also encourage patient engagement and motivation. Additionally, incorporating regular assessments of knowledge and self-management practices can help tailor educational interventions to meet individual needs. By actively involving patients in their learning process and promoting continuous dialogue about their experiences, healthcare professionals can empower individuals with type 2 diabetes to take control of their health, ultimately leading to improved clinical outcomes.

The mean attitude score among patients in the intervention group improved from 14.24 to 15.38 following the intervention, with the increase being statistically significant. The calculated effect size was 0.65, reflecting a large effect on the attitude construct. These results align

Table 3 Comparison of scores of components of the IMB among participants in the intervention and control groups before and after the implementation of the program

	Before Intervention	After Intervention	Paired Sample t-Test	Average rate of change	Effect Size
Information					
Intervention Group	15.54 (3.15)	19.38 (3.06)	< 0.001	3.84	1.3 (Very large)
Control Group	14.86 (3.23)	15.06 (3.37)	0.713	0.2	
Independent t-test	0.289	< 0.001			
Attitude					
Intervention Group	14.24 (2.92)	15.38 (2.27)	0.014	1.14	0.65 (Large)
Control Group	13.28 (3.64)	13.76 (2.72)	0.143	0.48	
Independent t-test	0.149	0.002			
Subjective Norms					
Intervention Group	8.44 (1.32)	8.20 (1.55)	0.379	-0.24	0.11 (Small)
Control Group	7.98 (1.22)	7.84 (1.62)	0.516	-0.11	
Independent t-test	0.074	0.259			
Self-efficacy					
Intervention Group	10.76 (1.87)	11.26 (1.66)	0.088	0.5	0.67 (Large)
Control Group	10.22 (2.18)	10.06 (1.87)	0.545	-0.16	
Independent t-test	0.189	0.001			
Individual's objective skills					
Intervention Group	31.66 (4.07)	33.66 (4.45)	0.008	2	0.72 (Large)
Control Group	30.14 (5.49)	30.08 (5.53)	0.957	-0.06	
Independent t-test	0.121	0.001			
Medication adherence					
Intervention Group	16.92 (2.80)	19.76 (3.10)	< 0.001	2.84	1.15 (Very large)
Control Group	16.12 (2.47)	16.50 (2.54)	0.252	0.38	
Independent t-test	0.133	< 0.001			

with findings from multiple studies, which have reported significant improvements in attitude scores post-intervention. For instance, Ahmed et al. conducted a study with type 2 diabetes patients in Egypt and observed a notable rise in their mean attitude scores after the intervention was implemented [45]. A study conducted by Malathy et al. in India also demonstrated the beneficial impact of an educational intervention on enhancing the attitudes of patients with type 2 diabetes [48]. In this study, we adopted self-reevaluation as a theoretical framework for understanding attitude change. This method involves encouraging patients to evaluate themselves both cognitively and emotionally regarding their actions or inactions related to healthy behaviors—specifically in our study, medication adherence [23]. Our findings highlighted the effectiveness of this approach in fostering behavior change among individuals with type 2 diabetes. Based on the significant improvements in attitude scores observed following the intervention, it is essential for healthcare providers to implement structured educational programs that utilize self-reevaluation techniques for patients with type 2 diabetes. These programs should encourage patients to critically assess their own behaviors and beliefs regarding medication adherence and lifestyle choices. By facilitating a reflective process, patients can develop a deeper understanding of the consequences of their actions, ultimately leading to more positive attitudes towards their treatment plans. Regular follow-ups and assessments of patient attitudes should also be conducted to ensure that the educational interventions remain effective and responsive to individual needs, thereby optimizing adherence and improving overall health outcomes.

Our analysis revealed a notable difference in self-efficacy scores between the intervention and control groups following program implementation. While the change in the intervention group's mean self-efficacy score before and after the program was not statistically significant, there was a 0.5-point increase in their mean score. The intervention's estimated effect size for this construct was 0.67, reflecting a large effect size. Similarly, Nouri et al., in their clinical trial aimed at improving treatment adherence among patients with type 2 diabetes in Isfahan, reported an estimated effect size of 0.63 (also large) for the construct of perceived self-efficacy [44]. A study by Mirzaei-Alavijeh et al. [34] in Tehran found a large effect size of 0.78 for the intervention's impact on self-efficacy related to treatment adherence behaviors among patients with type 2 diabetes. Similarly, research by Jalilian et al. reported a significant enhancement in self-efficacy for self-management behaviors in the same patient population [49]. Lee et al.'s study conducted in South Korea also observed a meaningful rise in perceived self-efficacy scores among intervention group participants with

type 2 diabetes [50]. Additionally, Toygar et al. identified an effect size of 1.233 for self-care self-efficacy in their research on patients with type 2 diabetes [51]. Furthermore, a systematic review by Alharbi et al. concluded that diabetes self-management education interventions substantially improve self-efficacy, empowering individuals with type 2 diabetes to better manage their blood glucose levels [52]. Self-efficacy encompasses an individual's cognitive, social, and skill-based capabilities essential for carrying out a specific action. It refers to one's assessment of their ability to plan and execute tasks that demand particular types of performance [53]. As the findings showed, following the implementation of the intervention, the mean individual's objective skills score among patients in the intervention group showed a significant improvement. Consistent with this result, a study by Bakır et al. in Turkey demonstrated that an educational program significantly enhanced the behavioral skills of patients with type 1 diabetes [30]. In contrast to the current findings, Jeon and Park, in their single-group intervention study based on the information-motivation model and behavioral skills framework for patients with diabetes, reported that the intervention had no significant impact on enhancing the patients' self-care behavioral skills scores [31]. The current study incorporated two theoretical approaches to facilitate change: self-monitoring of behavior and planning coping responses, both utilized as part of the behavioral skills component. In a related study, Choi et al. emphasized the importance of hands-on skills training paired with numerical benchmarks for enhancing behavioral skills among patients with type 2 diabetes [29]. The findings of a systematic review highlight the effectiveness of various methods in promoting behavioral self-management skills for chronic diseases. These methods include role-playing, psychoeducational techniques such as targeted instruction provided by healthcare professionals or peer mentors, and the use of customized modules or kits designed for specific diseases [35]. Based on the findings regarding self-efficacy and behavioral skills in patients with type 2 diabetes, it is crucial for healthcare practitioners to develop and implement comprehensive educational interventions that focus on enhancing self-efficacy and practical self-management skills. These programs should incorporate hands-on training methods, such as role-playing and scenario-based exercises, to allow patients to practice skills in real-life contexts. For instance, teaching patients how to set medication reminders or develop strategies for managing their health while traveling can significantly improve their confidence in adhering to treatment plans. Future research could explore and compare the impact of theory of change approaches on enhancing behavioral skills or other components of the IMB model. In general, it seems intervention content designed to help patients discover strategies for maintaining adherence in various situations, such as setting reminder alerts or managing medications while traveling, can enhance their behavioral skills for consistent medication adherence.

The results of this study revealed that the implemented intervention did not significantly enhance subjective norms associated with consistent medication adherence in patients with type 2 diabetes. Contrary to these findings, Burner et al. identified mHealth as a feasible, well-accepted, and potentially effective approach to strengthening social support among individuals with diabetes [54]. In alignment with this finding, Mirzaei-Alavijeh et al. noted in their study that the intervention carried out showed no significant impact on enhancing the social support scores among patients with type 2 diabetes [34]. Social support involves receiving technical guidance and help with health-related behaviors from friends, family members, colleagues, and healthcare professionals [55]. This study included not only an intervention for patients but also a session for the families of individuals with type 2 diabetes. The session emphasized the importance of ensuring elderly patients adhere to regular medication schedules. However, it did not lead to a noticeable improvement in the patients' subjective norms scores. Future research is recommended to determine the primary sources of support for patients with type 2 diabetes in Iran and to develop targeted interventions aimed at enhancing subjective norms and social support for these individuals.

Our findings revealed a notable enhancement in medication adherence among patients in the intervention group. The estimated effect size for this improvement was 1.15, indicating a very large impact. This aligns with prior research demonstrating that self-care behaviors tend to improve following diabetes education programs. For instance, Mirzaei-Alavijeh et al. reported an estimated effect size of 0.62 (large) for adherence behaviors in their study involving patients with type 2 diabetes [34]. Similarly, Lee et al. highlighted the effectiveness of educational interventions in fostering self-care practices in their research on patients with type 2 diabetes in South Korea [50]. The findings of a systematic review by Nieuwlaat et al., indicated that only a few implemented interventions have led to improved medication adherence and more favorable clinical outcomes for patients. They stated that current methods for enhancing adherence to medication for chronic health issues are primarily complex and not very effective. The lack of improvement in treatment adherence following the implementation of programs can often be attributed to the absence of individualized strategies tailored to the specific needs of patients. This evidence highlights the complexity of behavior change and emphasizes the need to adopt comprehensive approaches that consider the

psychological, social, and contextual factors influencing treatment adherence [56]. Given the findings that indicate a significant improvement in medication adherence among patients in the intervention group, it is essential for healthcare providers to refine and enhance diabetes education programs. To address the contradictory results reported in various studies, interventions should focus on personalized strategies that cater to the unique needs and circumstances of each patient. This could involve conducting thorough assessments to identify individual barriers to adherence and employing tailored educational materials that resonate with patients' specific experiences and preferences. Moreover, incorporating behavioral change techniques such as motivational interviewing, goal-setting, and self-monitoring can further strengthen the effectiveness of these interventions. Engaging patients in their care by fostering a collaborative environment where they feel empowered to take ownership of their health can lead to more sustainable behavior changes. Additionally, integrating support systems, such as peer mentoring or follow-up consultations, may help reinforce learning and provide ongoing encouragement. By adopting a more holistic and individualized approach, healthcare professionals can improve the efficacy of interventions aimed at enhancing medication adherence in patients with type 2 diabetes.

This study was designed to address the research gap in the use of the IMB model to increase medication adherence in elderly diabetic patients in Iran. The use of a valid theoretical framework, the IMB model, increased the scientific validity of the study, and the comprehensive intervention design, including education, motivation, and behavioral skills improvement, provided a multifaceted approach for better effectiveness. Involvement of family members, use of diverse educational tools, interactive and structured sessions, and two-month follow-up assessment are other strengths that enhance the efficacy of the intervention. However, this study is not without its limitations. Reliance on self-reported measures may have led to recall bias and social desirability bias. Nonetheless, the use of questionnaires offers a practical and cost-effective approach to gathering valuable insights into individuals' reasons for non-adherence [57]. It is worth noting, however, that objective methods for measuring adherence to regular medication were not employed, nor were patients' clinical indicators assessed.

Conclusion

We developed a program to enhance medication adherence among older adults with type 2 diabetes, based on the IMB model, achieving a very large increase in adherence. Our findings highlight the effectiveness of specific theoretical approaches to behavior change, offering valuable insights for future interventions. Researchers and healthcare providers should prioritize clear guidance on medication routines through lectures, educational videos, pamphlets, and interactive discussions. To boost motivation, health educators can foster positive attitudes and emphasize social support and shared norms. Additionally, employing change theory techniques like self-monitoring and coping strategies can enhance patients' self-efficacy, further improving treatment adherence. Future studies should explore the long-term effects of these interventions and investigate the impact of personalized strategies tailored to individual patient needs.

Acknowledgements
We want to express our gratitude to the elderly individuals who participated in the study. We also want to thank the Research Vice-Chancellor at Kermanshah University of Medical Sciences for their support in this project. Additionally, we are thankful for the collaboration of the Clinical Research Development Center at Motazedi Hospital in Kermanshah.

Author contributions
"M.M.A. and F.J. contributed to the idea of study interpretation. F.J. contributed to the data analysis. M.M.A. and F.J. contributed to the set-out of the first draft of the manuscript. S.Y. was involved in data collection and providing training. S.KH. contributed to the edit of the manuscript. All authors participate in the final approval of the revised manuscript for publication."

Funding
This research was carried out as part of a Master's thesis (Code: 4020855) in the field of health education and promotion. It received support from Kermanshah University of Medical Sciences.

Data availability
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical approval
The study protocol (IR.KUMS.REC.1402.530) was approved by the research ethics committee at Kermanshah University of Medical Sciences. All procedures followed the ethical standards of the institution, national research committee, and the 1964 Helsinki Declaration along with its amendments. Participants were provided with detailed information about the study, including procedures, confidentiality of their information, and purpose before they agreed to participate. Informed consent for participation in the study was obtained from all participants. The participants were given the participant information statement and signed the consent form.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Clinical trial number
Not applicable.

Received: 29 January 2025 / Accepted: 29 April 2025
Published online: 13 May 2025

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