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REVIEW

Medication Adherence Interventions Among People Living with Diabetes: A Systematic Review

Meng Wang[1], Khuan Lee[1], Hui Zhu Thew[2], Siti Noorkhairina Sowtali[3], Qiuhuan Jiang[4], Yang Cao[1], Poh Ying Lim[5]

[1]Department of Nursing, Faculty of Medicine & Health Sciences, Universiti Putra Malaysia, Serdang, SGR, Malaysia; [2]Department of Family Medicine, Faculty of Medicine & Health Sciences, Universiti Putra Malaysia, Serdang, SGR, Malaysia; [3]Department of Professional Nursing Studies, International Islamic University, Kuala Lumper, SGR, Malaysia; [4]Business Management Office, Henan Provincial People's Hospital, Zhengzhou, Henan, People's Republic of China; [5]Department of Community Health, Faculty of Medicine & Health Sciences, Universiti Putra Malaysia, Serdang, SGR, Malaysia

Correspondence: Poh Ying Lim, Department of Community Health, Faculty of Medicine & Health Sciences, Universiti Putra Malaysia, UPM, Serdang, Selangor, 43400, Malaysia, Email pohying_my@upm.edu.my

Background: Medication adherence is a key factor in the management of Diabetes Mellitus (DM). Various interventions have been proposed to improve adherence.

Objective: The objective of this systematic review is to evaluate and summarize the effectiveness of different interventions aimed at improving medication adherence among people living with diabetes.

Methods: A comprehensive search was conducted across five databases (PubMed, Scopus, Embase, Cochrane Library, and ProQuest) to identify studies published between January 2015 and 1st April 2025. Studies were included if they focused on people living with diabetes and interventions targeting medication adherence, with an emphasis on randomized controlled trials (RCTs) published in English. Inclusion and exclusion criteria were independently reviewed for quality by three researchers.

Results: A total of 38 studies were included in this review, with 18 studies as low risk of bias, and the remaining studies exhibiting either some concerns risk of bias. Most studies were conducted in developing countries, with face-to-face education being the most commonly used intervention. Multi-component interventions were also frequently employed. The Morisky Medication Adherence Scale (MMAS) was the most widely used tool for measuring medication adherence. Additionally, eight studies incorporated theoretical models into their interventions.

Conclusion: Both traditional and modern interventions have demonstrated potential in improving medication adherence among people living with diabetes, with multi-component strategies showing the most promising results. Future research should focus on integrating appropriate theoretical models into intervention designs and assessing the long-term effectiveness of these interventions across different populations.

Keywords: diabetes mellitus, medication adherence, intervention, systematic review

Introduction

Diabetes mellitus (DM) is a chronic metabolic disease characterized by persistent hyperglycemia and has become a major global public health concern.[1] It is estimated that in 2021, approximately 536.6 million individuals aged 20–79 years worldwide were living with diabetes and this number is projected to rise to 783.2 million by 2045.[2] Without effective management, chronic hyperglycemia can lead to serious complications such as kidney disease,[3] retinopathy[4] and cardiovascular diseases,[5] significantly compromising patients' quality of life and life expectancy. Despite the availability of various effective pharmacological treatments, poor medication adherence remains a major barrier to achieving optimal glycemic control. Studies have reported that the prevalence of poor medication adherence among people living with diabetes ranges from 70% to 80%.[6,7] Suboptimal adherence not only increases the risk of disease progression and the development of complications but also contributes to higher hospitalization rates and healthcare costs.[8–10]

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In recent years, a variety of intervention strategies have been developed to improve medication adherence in people living with diabetes, including health education programs,[11] blood glucose monitoring systems,[12] and digital health technologies.[13] However, existing systematic reviews have primarily focused on identifying influencing factors and evaluating measurement tools for medication adherence,[14,15] rather than providing a comprehensive analysis of interventions themselves. Some reviews have categorized interventions based on behavior change techniques,[16] yet they have not systematically summarized the specific characteristics and implementation methods of each intervention. Other reviews have narrowly focused on particular intervention types, such as pharmacist-led programs or smartphone applications,[17,18] thereby limiting the generalizability of their findings. Additionally, many available reviews are based on studies conducted more than a decade ago,[19,20] which may not adequately reflect recent advancements in medical technologies and healthcare delivery.

In light of these gaps, the present systematic review aims to comprehensively include studies published in the past decade, covering all types of DM patients. By systematically reviewing and synthesizing the latest evidence on medication adherence interventions, this study seeks to provide an updated, detailed and holistic overview of intervention strategies, implementation approaches and their effectiveness. The findings are expected to fill current gaps in the literature and offer practical insights for the development of more targeted and effective interventions in clinical practice, as well as guide future research directions.

Methods

This review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement[21] and was prospectively registered in PROSPERO (International Prospective Register of Systematic Reviews, registration number CRD42024545467). The review includes studies published between 1st January 2015 and 1st April 2025. A total of five electronic databases were searched for relevant studies: PubMed, Scopus, Embase, Cochrane Library, and ProQuest.

Ethical Considerations

Since this study is a systematic review utilizing publicly available, non-identifiable secondary data from published studies, ethical approval was not necessary in accordance with institutional guidelines.

Search Strategy and Selection Criteria

The keywords used were "(diabetes mellitus OR diabetes OR diabetic OR type 1 DM OR type 2 DM OR T1DM OR T2DM OR glucose intolerance OR glucose metabolism disorders) AND (medication adherence OR medication compliance OR drug compliance OR drug adherence OR medication nonadherence OR nonadherence, medication OR noncompliance, medication OR medication non-adherence OR medication persistence) AND (intervention OR impact OR effect OR effectiveness)". The inclusion criteria for studies are as follows: (1) study population must consist of individuals diagnosed with DM, (2) intervention must focus on medication adherence strategies, (3) study must be published in a peer-reviewed journal with an English language version, (4) study design must be a Randomized Controlled Trial (RCT) and (5) published between 2015 and 2025. The exclusion criteria are: (1) journals that are not published in peer-reviewed sources, such as conference proceedings, conference books, government reports, grey literature or short communications, (2) review journals or meta-analyses and (3) studies that are not available in full text.

Selection of Article (Screening and Eligibility)

This review excluded unpublished, duplicate, non-English, and irrelevant articles. To ensure objectivity, two researchers (MW and YC) independently screened titles, abstracts, and full texts based on the inclusion and exclusion criteria, cross-checking the extracted data. Disagreements were resolved by a third researcher (PYL). The screening process consisted of two phases: the first involved title and abstract review, followed by full-text assessment in the second phase to confirm relevance and adherence to the criteria.

Data Extraction

The data were extracted using a pre-designed form encompassing the following: (1) first author, publication date, (2) study population and sample size, (3) country, (4) study design, (5) measurement instrument and interventionist, (6) intervention on duration, delivery mode and time points, (7) intervention effect and statistical significance. Due to the high heterogeneity in study designs, interventions, measurement instruments and outcomes, a meta-analysis was not performed.

Risk of Bias Assessment

The quality of the Randomized Controlled Trials (RCTs) included in this review was assessed using the Cochrane Risk of Bias Tool 2 (RoB 2).[22] This tool evaluated bias across five domains, ensuring that only studies with a low risk of bias contributed to the evidence on medication adherence interventions for people living with diabetes. Two researchers independently assessed the studies and discrepancies were resolved through discussion among all authors.

Results

Literature Search

Out of 11,711 potential articles, 3,923 duplicate records were removed using Endnote 21 software. Of the remaining 7,788 articles, 7,599 were excluded based on their titles, followed by 189 exclusions based on abstracts and keywords. Ultimately, 38 studies met all eligibility criteria for inclusion in this review. The selection process is illustrated in Figure 1.

Quality Assessment

Based on the RoB2 standard, the risk of bias for all 38 included RCTs was assessed. The overall risk of bias results showed that 20 studies as having some concerns and 18 studies as low risk of bias. Supplementary Figure 1 and Supplementary Figure 2 present the detailed evaluation of the included studies, covering aspects such as randomization, interventions, missing outcome data, outcome measurement and reporting of results.

Study Characteristics and Diversity

The 38 studies included in this review originated from various countries, with the highest number of studies coming from India, the United States and Iran. Among the 38 studies, 34 (89%) focused on T2DM (Type 2 Diabetes Mellitus) patients, 32 studies (84%) had participants aged ≥18 years, while 6 studies (16%) did not specify the age range. The largest study had a sample size of 63,012 participants, while the smallest included only 41 participants. The total sample size across all studies was 70,457 (excluding one community-based study that did not provide specific numbers). The duration of the studies varied widely, ranging from two weeks to 15 months. The measurement tools used across the included studies were primarily categorized into two forms: self-reported questionnaires and pill counts. The most commonly used adherence assessment instruments were the Morisky Medication Adherence Scale (MMAS), utilized in 14 studies (37%), and the Medication Adherence Report Scale (MARS), used in four studies (11%). Regarding intervention providers, 15 studies (40%) were pharmacist-led, while 19 studies (50%) did not specify the identity of the interventionist and were conducted by research staff. Additionally, three studies (8%) involved nurse-led interventions, and one study (3%) was led by a medical advisor or therapist. Further details are provided in Table 1.

Intervention Strategies and Theoretical Models for Medication Adherence in People Living with Diabetes

The 38 studies included in this review utilized a variety of interventions to improve medication adherence among people living with diabetes. 14 studies (37%) employed face-to-face interactions, including oral communication, meetings, educational courses and interviews. 11 studies (29%) utilized multiple combinations of methods. Additionally, five studies (13%) used text messages, three studies (8%) utilized internet-based interventions, two studies (5%) employed telephone interventions, two studies (5%) used mobile applications (apps) and one study (3%) involved fliers. Only eight studies (21%) incorporated theoretical models into their design. The most commonly used models were the theory of planned behavior, self-determination theory, information-motivation-behavioral skills model and the health belief model,

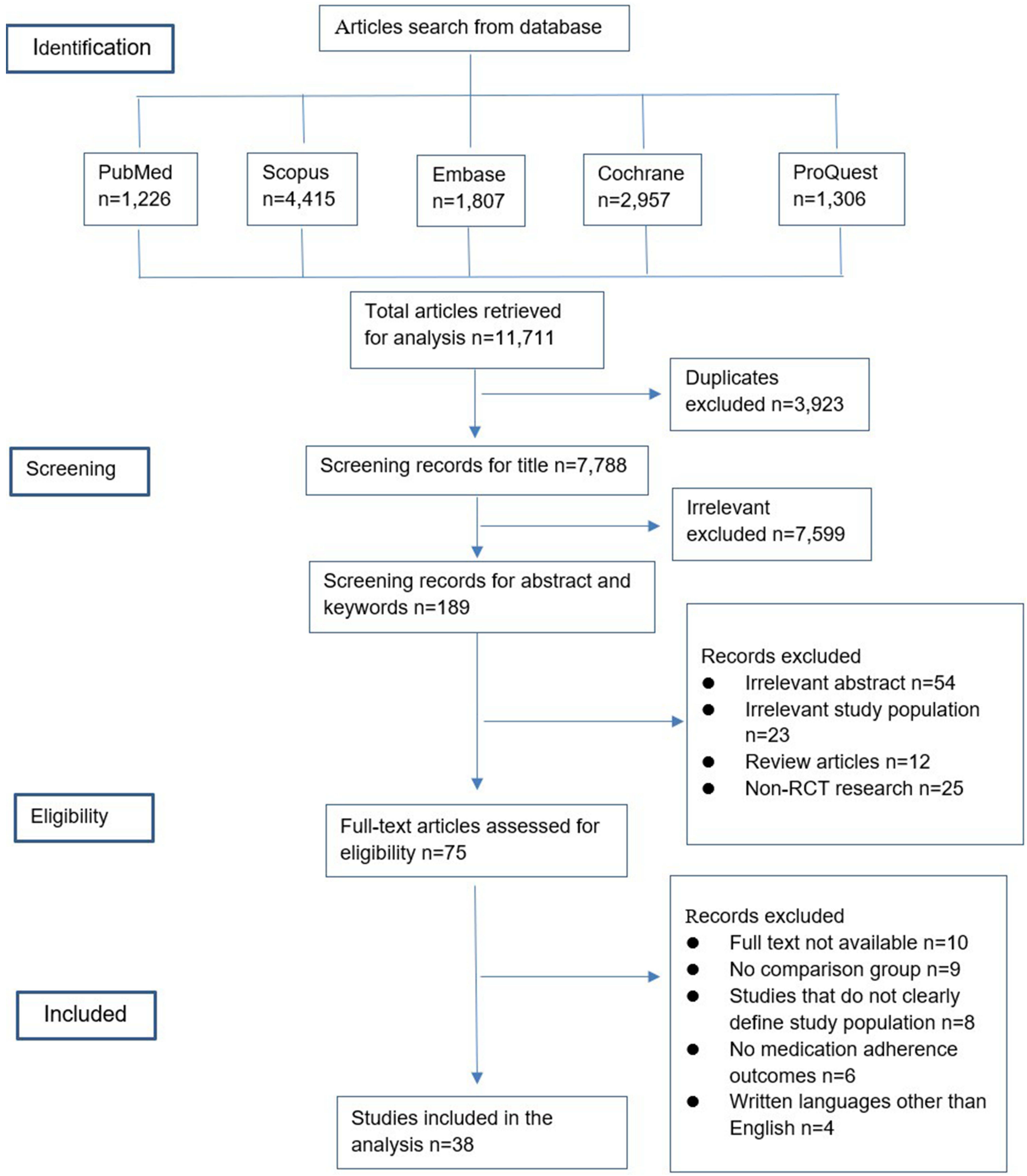

Figure 1 Flowchart of the systematic review selection process.

with some studies combining multiple models. It is noteworthy that five studies (13%) showed no significant improvement in medication adherence ($P > 0.05$). Among these, one study used two different questionnaires to measure medication adherence: one questionnaire indicated a positive effect, while the other showed no effect. The remaining studies demonstrated a positive impact of the interventions on medication adherence among people living with diabetes. The detailed results are presented in Tables 2 and 3.

Table 1 Summary of the Selected Studies (N=38 Articles)

Author & Year	Study Population & Sample Size	Duration of Study	Study Design	Instrument	Interventionist(s)
India (n=5)					
Goruntla et al (2019)[23]	18-75 years, T2DM (n=330)	6 months	Prospective, open-labeled, randomized control trial	Pill count method	Pharmacists
Kleinman et al (2017)[24]	18-65 years T2DM (n=91)	6 months	Two-armed, open-label, randomized clinical trial	Self-reported measures of medication adherence	Nurses
Kandasamy et al (2019)[25]	35-75 years DM (n=50)	9 months	Randomized controlled study	MMAS-8	Pharmacists
Johncy et al (2020)[26]	40-70 years T2DM (n=66)	2 weeks	Parallel-group, prospective, and single-blinded randomized control trial	MMAS-8	Investigators
Simon et al (2021)[27]	T2DM (n=97)	6 months	Prospective, interventional, randomized controlled study	MARS	Pharmacists
USA (n=4)					
Nelson et al (2016)[28]	≥18 years T2DM (n=240)	3 months	Quasi-experimental design	SDSCA-MS	Investigators
Nelson et al (2021)[29]	≥18 years T2DM (n=506)	15 months	Randomized controlled trial	Adherence to Refills and Medications Scale for Diabetes (ARMS-D)	Investigators
Ramachandran et al (2021)[30]	≥18 years T2DM (n=63012)	12 months	Randomized trial design	Proportion of days covered (PDC)	Investigators
Burner et al (2025)[31]	≥18 years DM (n=166)	12 months	Unblinded, parallel, equal-allocation randomized phase-III trial	3-item medication adherence scale	Investigators
Iran (n=3)					
Sarayani et al (2018)[32]	18-80 years, T2DM (n=100)	9 months	Parallel-group randomized controlled trial	MMAS-8	Pharmacists
Ranjbaran et al (2022)[11]	≤65 years T2DM (n=248)	6 months	Cluster randomized controlled trial	MMAS-8	Investigators
Elyasi et al (2024)[33]	T2DM (n=163)	6 months	Randomized controlled trial	MMAS-8	Investigators
Pakistan (n=2)					
Abbas et al (2023)[34]	All ages T2DM (n=90)	16-weeks	Prospective randomized control trial	General Medication Adherence Scale (GMAS)	Medical consultants/ therapist
Abubakar & Atif. (2021)[35]	18-70 years T2DM (n=160)	1 month	Randomized controlled trial	MMAS-8	Pharmacist
Malaysia (n=2)					
Ting et al (2021)[36]	≥18 years T2DM (n=142)	12 months	Two group and parallel randomized controlled trial	Self-Efficacy for Appropriate Medication Use Scale (SEAMS)	Pharmacists
Butt et al (2016)[37]	T2DM (n=73)	6 months	Randomized controlled study	Modified Morisky medication adherence scale (MMMAS)	Pharmacists
Brazil (n=2)					
Trevisan et al (2020)[38]	≥18 years T2DM (n=90)	15 weeks	Single-blinded, randomized controlled trial	Global Evaluation of Medication Adherence (IAGAM)	Investigators
Cani et al (2015)[39]	≥ 45 years T2DM (n=78)	6 months	Randomized controlled trial	1. Morisky-Green questionnaire 2.The Adherence to Medicines Questionnaire (AMQ),	Pharmacists
Netherlands (n=2)					
Vluggen et al (2021)[40]	40-70 years T2DM (n=478)	6 months	Randomized Controlled Trial	Probabilistic Medication Adherence Scale (ProMAS)	Nurse
Du Pon et al (2019)[41]	≥18 years T2DM (n=203)	12 months	Two-arm, parallel group, randomized, open label trial (1:1)	MARS-5	Investigators

(*Continued*)

Table 1 (Continued).

Author & Year	Study Population & Sample Size	Duration of Study	Study Design	Instrument	Interventionist(s)
Thailand (n=2)					
Wungrath et al (2021)[42]	≥18 years T2DM (n=60)	8 weeks	Randomized Controlled Trial	Diabetes Medication Adherence Behavior (DMAB)	Investigators
Poonprapaiet al (2022)[43]	≥65 years T2DM (n=157)	9 months	Two-arm randomized controlled study	Pill count method	Pharmacists
Mainland China (n=2)					
Xin et al (2015)[44]	≥18 years T2DM (n=322)	12 months	Single-center, prospective randomized controlled study	Morisky–Green	Pharmacists
Zhou et al (2022)[45]	≥60 years T2DM (n=94)	3 months	Randomized controlled trial	MMAS-8	Nurses
Singapore (n=2)					
Huang et al (2019)[46]	≥21 years T2DM (n=51)	12 weeks	Randomized two-arm pre-posttest control group design	Adherence Starts with Knowledge-12	Investigators
Tan et al (2023)[47]	26-65 years T2DM (n=330)	6 months	Randomized controlled trial	MARS-5	Investigators
Indonesia (n=1)					
Alfian et al (2021)[48]	≥18 years T2DM (N= 10 Community Health Centers)	3 months	Cluster randomised controlled trial with two parallel arms	MARS-5	Pharmacists
Portugal (n=1)					
Caetano et al (2018)[49]	≥18 years T2DM (n=1170)	6 months	Prospective, randomized, controlled, non-blind and multicenter study	Medication Adherence in Diabetes Therapy (MAT) scale	Investigators
Egypt (n=1)					
Abaza & Marschollek (2017)[50]	DM patients (n=90)	12 weeks	Randomized controlled intervention study	MMAS-4	Investigators
Greece (n=1)					
Doupis et al (2019)[51]	≥18 years T2DM (n=457)	8 months	Cluster randomized, parallel-group study	MMAS-4	Investigators
France (n=1)					
Gautier et al (2021)[52]	≥18 years T2DM (n=249)	8 months	Interventional, real-world, randomized, comparative study	MMAS-8	Pharmacist
Cyprus (n=1)					
Korcegez et al (2017)[53]	T2DM (n=152)	12 months	Prospective, randomized controlled study	Morisky-Green test	Pharmacist
Japan (n=1)					
Sugita et al (2017)[54]	≥18 years T2DM (n=41)	6 months	Single-center, open-label, randomized controlled study	MMAS-8	Investigators
Ethiopia (n=1)					
Erku et al (2017)[55]	≥18 years T2DM (n=127)	6 months	Single-center, prospective randomized controlled study	MMAS-8	Pharmacists
Jordan (n=1)					
Wishah et al (2015)[56]	≥18 years T2DM (n=90)	6 months	Randomized, controlled, prospective trial	Self-reported medication adherence (Morisky Scale)	Investigators
Spanish (n=1)					
Caballero et al (2025)[13]	≥18 years T2DM (n=85)	6 months	Multicenter, randomized, prospective study	The 4-item Morisky, Green, Levine Medication Assessment Questionnaire	Investigators

(*Continued*)

Table 1 (Continued).

Author & Year	Study Population & Sample Size	Duration of Study	Study Design	Instrument	Interventionist(s)
Taiwan (n=1)					
Chang et al (2025)[12]	≥18 years DM (n=120)	3 months	Single-blind randomized controlled trials	The 8-item Chinese Medication Adherence Scale	Investigators
United Arab Emirates (n=1)					
El-Deyarb et al (2024)[57]	30-65 years T2DM (n=281)	12 months	Single-blind randomized controlled trials	Medication possession ratio, self-reported adherence questionnaire	Pharmacist

Abbreviations: MMAS-8, Morisky Medication Adherence Scale; MMAS-4, Morisky Medication Adherence Scale; MARS-5, Medication Adherence Report Scale-5; MARS, Medication Adherence Report Scale.

Discussion

This systematic review shows that over 90% of studies on medication adherence interventions focused on patients diagnosed with T2DM, likely because T2DM accounts for the largest proportion of all DM types, reaching 90–95% of cases.[58,59] The majority of studies were conducted in developing countries, where medication adherence is generally lower, with over 50% of patients exhibiting poor adherence.[60,61] Developing countries frequently encounter substantial constraints in healthcare resources and services, underscoring the importance of implementing cost-effective and efficient strategies, such as enhancing medication adherence. Targeted interventions can enhance adherence, thereby reducing the risks of ineffective treatment and acute complications associated with poor medication adherence.[62,63]

Questionnaires are the most commonly used tool for assessing medication adherence, with the MMAS being the most widely employed. This is supported by a systematic review conducted by Clifford et al (2014), which confirms the prevalence of this method.[14] The widespread use of questionnaires may be attributed to their speed, simplicity, and cost-effectiveness, especially in large-scale studies. Compared to other objective measurement methods, questionnaires do not require expensive equipment or specialized personnel and can capture a range of information related to patients' behaviors, attitudes, and perceptions about medication. They offer insights into patients' cognitive, attitudinal, and emotional dimensions of medication adherence. In contrast, the pill count method and Proportion of Days Covered (PDC) are used less frequently. These methods, while providing more objective data, are often more complex and difficult to implement on a large scale, with challenges in data collection. Additionally, access to comprehensive medication records may be limited, especially in resource-constrained settings. A systematic review by Cramer (2004) highlighted that electronic monitoring systems can effectively improve medication adherence among people living with diabetes.[64] However, since the studies included in this review were published before 2003 and were not limited to RCTs, this method was not incorporated into the current review. Future studies could explore the integration of these objective methods with more accessible tools like questionnaires to balance the accuracy of measurement with practical feasibility.

This systematic review included 14 studies that employed face-to-face interventions, primarily in the form of one-on-one education, health education sessions, lectures and workshops, and group discussions. Through direct interaction, patients and healthcare providers (such as physicians, nurses and pharmacists) were able to communicate more effectively, enabling patients to better understand and adhere to their medication regimens. A systematic review by Williams (2014) demonstrated that face-to-face education can significantly improve medication adherence among people living with diabetes, enhancing disease management and treatment outcomes.[19] Although less commonly used, interventions such as text messaging, telephone calls, and printed materials (fliers) have also shown effectiveness in improving medication adherence. A systematic review by Presley (2019) found that these approaches can significantly enhance adherence, with digital materials and printed fliers demonstrating greater effectiveness than telephone-based interventions.[17] With the advancement of technology, apps and internet-based interventions have emerged as promising tools. These technologies offer personalized medication reminders, health education and medication tracking features, thereby supporting patients in better managing their health. In this review, two studies using mobile apps and three using internet-based interventions reported positive outcomes, suggesting that modern digital approaches hold potential for

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Table 2 Intervention Associated with Medication Adherence Among DM Patients for Selected Studies (n=38)

Author & Year	Intervention Type	Theory Used	Intervention Duration	Delivery Mode	Time Points	Intervention Group (%)/Mean ± SD /Mean Change /β (95% CI)	Control Group (%)/Mean ± SD	Results
Face to face (n=14)								
Cani et al (2015)[39]	Individualized pharmacotherapeutic care plan (PCP)	/	6 months	Face to face	Baseline,6 months	Morisky-Green Baseline: 17.6% 6 months: 70.6% AMQ Baseline: 47.1% 6 months 52.9%	Morisky-Green Baseline: 27.8% 6 months: 25% AMQ Baseline: 30.6% 6 months 25%	The experimental group exhibited a significant improvement in medication adherence after 6 months ($p < 0.001$).
Xin et al (2015)[44]	Health education	/	12 months	Face to face	Baseline,12months	Baseline: 50.8% 12 months: 80.7%	Baseline: 52.2% 12 months: 58.4%	The experimental group exhibited a significant improvement in medication adherence after 12 months ($p < 0.001$).
Butt et al (2016)[37]	Face-to-face health education	/	6 months	Face to face	Baseline 3 months,6 months	Baseline: 5.83± 1.84 Post-intervention: 6.77 ± 1.76	Baseline: 5.95±1.51 Post-intervention: 5.98 ± 1.50	Medication adherence was significantly higher in the intervention group ($p = 0.03$). Additionally, the percentage of patients with poor adherence in the intervention group significantly decreased from baseline to the end of the study ($p = 0.02$).
Korcegez et al (2017)[53]	Health education	/	12 months	Face to face	Baseline, 12 months	Baseline: 46.7% Posttest: 68.0%	Baseline: 57.1% Posttest: 59.7%	Medication adherence significantly improved in the nickel-hydride group ($p = 0.013$), while there was no significant change in the control group ($p = 0.744$).
Erku et al (2017)[55]	Health Education (MTM: Medication Therapy Management)	/	6 months	Face to face	Baseline,3 months, 6 months	Percentage of good adherence: Baseline: 9.2% 3 months: 29.6% 6 months: 61%	Percentage of good adherence: Baseline: 13.2% 3 months: 20.7% 6 months: 30.2%	The experimental group exhibited a significant improvement in medication adherence 6 months ($p < 0.01$).
Du Pon et al (2019)[41]	Proactive Interdisciplinary Self-Management (PRISMA) program	1. Self-regulation theory 2. The dual process theory 3. Self-determination theory 4. The social learning theory	12 months	Face to face	Baseline, 6 months,12 months	0-6 months MARS: 23.98 ±0.91	0-6 months MARS: 24.0 ±1.54	The sum scores of the MARS did not differ between the intervention group and the control group in the 6-month period: (M=23.98, SD=0.91) vs (M=24.00, SD=1.54). There was no significant difference in medication adherence between the intervention and control groups in the 12-month period ($p = 0.080$).
Trevisan et al (2020)[38]	Implementation intention	Theory of planned behavior (TPB)	12weeks	Face to face	Baseline,15weeks	Baseline: 27.3% 15weeks: 88.6%	Baseline: 36.4% 15weeks: 45.4%	The experimental group exhibited a significant improvement in medication adherence after15weeks ($p < 0.001$).
Johncy et al (2020)[26]	Structured Education	/	2 weeks	Face to face	Baseline, 2weeks	High adherence Baseline: 12.5% Follow up: 43.8%	High adherence Baseline: 12.5% Follow up: 18.8%	The experimental group exhibited a significant improvement in medication adherence after 2 weeks ($p = 0.008$).
Alfian et al (2021)[48]	Health education	/	1 month	Face to face	Baseline,1 month, 3 months.	Baseline: 16.3±3.2 1 month: 21.5±4.3 3 months22.3±3.7	Baseline: 16.8±3.0 1 month: 18.8±3.8 3 months18.1±4.7	This intervention improved medication adherence by 4.62 points from baseline to 6 months later ($p = 0.008$)
Abubakar & Atif. (2021)[35]	Health education	/	1 month	Face to face	Baseline, 1 month	Baseline: 1.60 ±0.14 1 month: 7.94±0.03	Baseline: 2.14 ±0.17 1 month: 6.95±0.16	The experimental group exhibited a significant improvement in medication adherence ($p < 0.001$).

Simon et al (2021)[27]	Consulting Sessions	/	6 months	Face to face	Baseline,6 months	MARS score: Baseline: 3.88 ± 0.55 6 months 6.32 ± 0.54	Baseline: 3.92 ± 0.35 6 months: 3.88 ± 0.31	There was a significant improvement in medication adherence after 6 months (p < 0.01)
Ting et al (2021)[36]	Structured group intervention	Theory of Planned Behavior (TPB) Information-Motivation-Behavioral skills model (IMB)	12 months	Face to face	Baseline,1 month,3 months,6 months,12 months.	Baseline: 22.24% Post 1 month: 33.97% Post 3 months: 34.31% Post 6 months: 35.17% Post 12 months: 34.94%	Baseline: 21.99% Post 1 month: 22.36% Post 3 months: 22.44% Post 6 months: 23.23% Post 12 months: 23.65%	Significant improvement in medication adherence in the intervention group at months 1, 3, 6 and 12 follow-up (p < 0.001)
Ranjbaran et al (2022)[11]	Health education	/	3 months	Face to face	Baseline 1 months, 6 months.	Baseline: 34.1±20.6 1month: 80.5±8.4 6 months: 89.1 ± 6.8	Baseline: 37.3 ± 18.5 1month: 42.2 ± 15.8 6 months: 41.5 ± 13.5	The experimental group exhibited a significant improvement in medication adherence after 1,6 months (p < 0.001).
Abbas et al (2023)[34]	Cognitive behavior therapy (CBT)	/	16weeks	Face to face	Baseline, 16 weeks	Baseline: 20.22± 4.73 Post-intervention: 28.19± 3.04	Baseline: 20.77±4.61 Post-intervention: 20.86±3.80	The experimental group exhibited a significant improvement in medication adherence (p < 0.001).
Multiple combinations (n=11)								
Wishah et al (2015)[56]	Implementation intention	/	1 meeting	Face to face +fliers	Baseline, 6 months	Baseline: 12.7±4.3 Follow up: 15.8 ±3.1	Baseline: 13.6±3.1 Follow up: 12.9 ±3.3	Medication adherence was significantly higher in the intervention group compared to the control group after 6 months (p < 0.05).
Huang et al (2019)[46]	Smartphone App	/	12weeks	App+email	Baseline,12weeks	Baseline: 28.6±5.2 Poststudy: 27.2±5.8	Baseline: 25.5±4.4 Poststudy: 28.5±7.0	The experimental group exhibited a significant improvement in medication adherence poststudy (p < 0.001).
Kandasamy et al (2019)[25]	Health education	/	9 months	Face to face +fliers	Baseline,3 months, 6 months, 9 months	Proportion of good adherence Each follow-up 3 months apart Baseline: 0 1st follow-up: 20% 2nd follow-up: 52% 3rd follow-up: 82%	Proportion of good adherence Each follow-up 3 months apart Baseline: 0 1st follow-up: 8% 2nd follow-up: 12% 3rd follow-up: 16%	Medication adherence was significantly higher in the intervention group compared to the control group from baseline to 3rd follow up (p < 0.001).
Nelson et al (2021)[29]	1.REACH 2.FAMS	Information-Motivation-Behavioral skills model	12 months	Telephone +Text message	Baseline 3 months,6 months,12 months,15 months	Baseline ARMS-D: 39.8±3.8 SDSCA: 6.3±1.2 Post intervention:	Baseline ARMS-D: 40.2±3.4 SDSCA: 6.4±1.2 Post intervention:	There was an overall treatment effect on medication adherence (SDSCA-MS omnibus P = 0.003). Improvements in medication adherence as assessed by the ARMS-D were not significant per the omnibus test (P = 0.434).
Wungrath et al (2021)[42]	Line application and telephone-based counseling platform.	/	8weeks	APP +telephone	Baseline, 8weeks	Before: 13.33±0.65 After: 18.03±0.28	Before: 12.27±0.68 After: 12.37±0.62	The experimental group exhibited a significant improvement in medication adherence after 8weeks (p < 0.001).
Tan et al (2023)[47]	Tele-monitoring system	/	6 months	Educational videos, mobile phone, application	Baseline, 6 months	At 6 months for the intervention and control groups: 1.10 (0.68, 1.79)		Did not show a significant difference between the groups (p= 0.691)

(*Continued*)

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Table 2 (Continued).

Author & Year	Intervention Type	Theory Used	Intervention Duration	Delivery Mode	Time Points	Intervention Group (%)/Mean ± SD /Mean Change /β (95% CI)	Control Group (%)/Mean ± SD	Results
El-Deyarb et al (2024)[57]	Medication therapy management	/	12 months	Face-to-face counselling, patient-specific medication booklets, and a mobile application,	3 months, 6 months, 9 months, 12 months	3 months: 0.93±0.09 6 months: 0.94±0.1 9 months: 0.95±0.1 12 months: 0.95±0.09	3 months: 0.92±0.09 6 months: 0.93±0.09 9 months: 0.93±0.09 12 months: 0.92±0.09	Medication possession rates improved in the intervention group at 9 and 12 months post-intervention (p = 0.04, p = 0.02)
Elyasi et al (2024)[33]	Educational program	Self-regulation theory	1 month	Face-to-face education, messaging group	Baseline, 3 months, 6 months	Baseline: 4.06±1.46 3 months: 5.64±1.24 6 months: 5.94±1.12	Baseline: 3.92±1.04 3 months: 3.76±0.95 6 months: 3.59±0.93	The educational intervention significantly affected the mean scores of medication adherence in the intervention group compared to the control group (p < 0.01).
Burner et al (2025)[31]	TExT-MED FANS Curriculum	/	4 months	Text message, paper pamphlet	Baseline, 3 months, 6 months, 9 months, 12 months	Baseline: 28.2% 6 months: 12.39 (31.11, 3.15–21.63) 12 months: −3.22 (22.89; −10.54–4.10)	Baseline: 30.9% 6 months: 15.73 (30.87, 7.13–24.32) 12 months: −1.74 (18.92; −7.36–3.88)	Improvements in medication adherence were not significant (p > 0.05).
Caballero et al (2025)[13]	Digital Educational	/	One intervention	Email, Skype, WhatsApp, phone calls and video conferencing	Baseline, intervention, 6 months	Baseline: 58.6 6 months: 72.4	Baseline: 60 6 months: 50	Medication adherence worsened in the control group after 6 months of follow-up, it significantly improved with the intervention (control: –8% vs intervention:13.8%; p=0.01)
Chang et al (2025)[12]	Continuous glucose monitoring	/	7-day	Continuous glucose monitoring devices, daily structured discussions, self-regulation education	Pre-intervention, post-intervention completion, maintenance phase	Baseline: 35.52±4.94 post-intervention: 35.52±5.77 maintenance phase: 36.67 ±4.65	Baseline: 35.48±6.14 post-intervention: 36.94±11.25 maintenance phase: 36.27 ±5.50	Consistent medication adherence over time for both groups (p > 0.05).
Text message (n=5)								
Nelson et al (2016)[28]	Diabetes Messaging (MED)	/	3 months	Text message	Baseline 1 month, 2 months,3 months	N/A	Baseline: 6.1 ± 1.2 1-month: 6.5 ± 1.4 2-month: 6.8 ± 0.4 3-month: 6.2 ± 1.3	Medication adherence improved at one and two months after baseline but did not persist to three months Compared with baseline, medication adherence improved at one month (adjusted odds ratio [AOR]: 3.88, 95% CI: 1.79, 10.86) and two months (AOR: 3.76, 95% CI: 1.75, 17.44), but not at three months (AOR: 1.49, 95% CI: 0.66, 3.10)
Abaza & Marschollek (2017)[50]	SMS education	/	3months	Text message	Baseline, 3 months	Baseline: 2.74 ±1.19, 3 months: 3.76 ± 0.55	Baseline: 2.74 ± 0.99, 3 months: 2.74 ± 1.07	Medication adherence improved in the intervention group after 3 months of intervention (p<0.001)

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Sugita et al (2017)[54]	SMS	/	6 months	Text message	Baseline,6months	Baseline: 6.15±1.10 6 months: 6.66±1.37	Baseline: 5.86±1.55 6 months: 6.26±1.28	There was no observed improvement in medication adherence in the intervention group after 6 months (p = 0.78)
Goruntla et al (2019)[23]	Pharmacist-directed Counseling and Message Reminder Services	/	6 months	Text message	Baseline,3 months, 6 months.	Baseline: 83.4 ± 7.3 First follow-up (3m): 82.2 ± 8.5 Second follow-up (6m): 96.6 ± 2.25	Baseline: 82.35 ± 6.4 First follow-up (3m): 82.2±8.5 Second follow-up (6m): 81.6 ± 8.1	The mean medication adherence between baseline and the first follow-up and between baseline and the second follow-up was significantly higher in the intervention group compared to the control group (p < 0.001).
Gautier et al (2021)[52]	Text messages	Prochaska's TransTheoretical Model	3 months	Text message	Baseline, 3 months,6 months	From 0 M to 3 M: 0.58 ± 1.29 From 0 M to 6 M: 0.46 ± 1.42	From 0 M to 3 M: 0.12 ± 1.27 From 0 M to 6 M: 0.34 ± 1.05	The mean score change in the SMS group was significantly higher than that in the control group at all time points except at 6 months (3 months after SMS cessation) (0.46 ± 1.42 vs 0.34 ± 1.05, p = 0.38).
Internet (n=3)								
Ramachandran et al (2021)[30]	Mail order pharmacy (MOP)	/	12 months	Internet	Baseline 12 months	Baseline: post-intervention: Metformin: 55.0% Sulfonylureas: 52.7% Statins: 54% Ace inhibitors: 56.7% Beta blockers: 55.9%	Baseline: post-intervention: Metformin: 53.6% Sulfonylureas: 52.8% Statins: 54% Ace inhibitors: 56.2% Beta blockers: 54.5%	Medication adherence was significantly higher in the intervention group than in the control group after 12 months (42.1% versus 39.8%, p < 0.01)
Zhou et al (2022)[45]	Internet+ Intelligent-Based 5A Care Model	/	/	Internet	Post-intervention	95.74%	76.6%	The experimental group exhibited a significant improvement in medication adherence post-intervention (p < 0.001).
Vluggen et al (2021)[40]	A Web-Based Computer-Tailored Program	The theory of planned behavior(TPB), The Health Belief Model(HBM)	6 months	Internet	Baseline 6 months.	Baseline: 13.4±3.4 follow up: 14.3±3.6	Baseline: 13.1±3.8 follow up: 13.4±3.6	The experimental group exhibited a significant improvement in medication adherence after 6 months (p = 0.03).
Telephone (n=2)								
Sarayani et al (2018)[32]	Telephone	/	3 months	Telephone	Baseline,3 months,9 months	Proportion of good adherence Baseline: 16% 3 months: 55.1% 9 months: 63.0%	Proportion of good adherence Baseline: 18% 3 months: 34% 9 months: 22.9%	There was a significant improvement in medication adherence across all intervention groups (p < 0.01)
Doupis et al (2019)[51]	Telephone education	/	8 months	Telephone	Baseline, 4 months,8 months	High adherence Baseline to 4months: 16.8% Baseline to 8 months: 18.8%	High adherence Baseline to 4months: 3.8% Baseline to8 months: 8.5%	The mean scores in the intervention group were significantly higher than those in the control group at both 4 months (p = 0.023) and 8 months (p = 0.043).

(*Continued*)

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Table 2 (Continued).

Author & Year	Intervention Type	Theory Used	Intervention Duration	Delivery Mode	Time Points	Intervention Group (%)/Mean ± SD /Mean Change /β (95% CI)	Control Group (%)/Mean ± SD	Results
Application (n=2)								
Kleinman et al (2017)[24]	A mobile health diabetes management platform (Gather Health)	1.Health belief model. 2.Health action process approach. 3.Theory of planned behavior 4.Bandura's theory of self-efficacy	6 months	APP	Baseline,3 months, 6 months.	Baseline: 61.4% 3 months: 84.2% 6 months: 90.2% Improved from baseline to 6 months: 39.0%	Baseline: 71.7% 3 months: 72.5% 6 months: 79.5% Improved from baseline to 6 months: 12.8%	The experimental group exhibited a significant improvement in medication adherence from baseline to 6 months ($p = 0.03$).
Poonprapai et al (2022)[43]	A mobile application	/	3 months	APP	Baseline,3 months, 6 months	Baseline: 87.17±2.04 3months*: 1.65±1.39 6months: *0.99±1.79 9months: * 1.61 ± 3.40 *Represents the change in relation to the baseline	Baseline: 87.28±2.29 3months*: 0.13±1.43 6months*: 0.13±1.33 9months *: 0.94 ± 1.71 * Represents the change in relation to the baseline	During different periods ranging from 3 months to 9 months, the intervention group exhibited a greater increase in adherence scores compared to the control group ($p < 0.001$).
Flyers (n=1)								
Caetano et al (2018)[49]	Flyers education	/	6 months	Fliers	Baseline,6 months	Baseline: 39.63±2.92 6 months: 40.22±2.47	Baseline: 39.80±2.76 6 months: 40.22±2.63	Medication adherence improved in the intervention group after 6 months of intervention ($p=0.034$)

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Table 3 Type of Theory Models and Delivery Mode Used in the Studies (n = 38 Articles)

Delivery Mode	**Significant Effect**	**Not Significant Effect**
Flyers (n=1)	[49]	/
Telephone (n=2)	[32,51]	/
App (n=2)	[24,43]	/
Internet (n=3)	[30,40,45]	/
Text messages (n=5)	[23,28,50,52]	[54]
Face to face (n=14)	[11,26,27,34–39,44,48,55]	[51,53]
Multiple combinations (n=11)		
Face to face+fliers (n=2)	[25,56]	/
App+email (n=1)	[46]	/
Telephone+text message (n=1)	[29]	[29]
APP+telephone (n=1)	[42]	/
Educational videos+mobile phone+application (n=1)	/	[47]
Face-to-face counselling+medication booklets+mobile application (n=1)	[57]	/
Face to face education+messaging group (n=1)	[33]	/
Text message+paper pamphlet (n=1)	/	[31]
Email+skype+WhatsApp+phone calls+video conferencing (n=1)	[13]	/
Continuous glucose monitoring devices+daily structured discussions+self-regulation education (n=1)	[12]	/
Theory model (n=7) (Multiple models were used in the same study)		
Theory of planned behavior (n=4)	[24,36,38,40]	/
Information-Motivation-Behavioral skills model (IMB) (n=2)	[29,36]	[29]
Health belief model (n=2)	[24,40]	/
Health action process approach (n=1)	[24]	/
Bandura's theory of self-efficacy (n=1)	[24]	/
Self-regulation theory (n=1)	[33]	[41]
The social learning theory (n=1)	/	[41]
The dual process theory (n=1)	/	[41]
Self-determination theory (n=1)	/	[41]
Prochaska's Trans Theoretical Model (n=1)	[52]	/
No theory models used (n=30)	[11–13,23,25–28,30,32,34,35,37,39,42–46,48–51,55–57]	[31,47,53,54]

improving medication adherence among patients with DM. A systematic review by Islam (2022), which examined the impact of smartphone applications on medication adherence in DM, emphasized the importance of rigorous evaluation and selection of such apps.[18] The review noted that nearly half of publicly available, free apps failed to demonstrate moderate to high levels of effectiveness. Therefore, implementing only high-quality, evidence-based applications in clinical settings is essential to achieving meaningful health outcomes. However, a systematic review by Williams (2014) reported no significant improvements in adherence with internet-based interventions. This may be attributed to the fact that most of the included studies were conducted over a decade ago, at a time when internet technology was less developed and digital interventions were still in their early stages of implementation.

This systematic review included 11 studies that employed multi-component interventions to improve medication adherence among patients with DM. These interventions combined various strategies with the aim of enhancing patient engagement and adherence through multiple channels. Examples include face-to-face education combined with printed materials (fliers), mobile applications combined with email, educational videos combined with mobile phones and apps, and continuous glucose monitoring devices integrated with daily structured discussions and self-regulation education. Compared with single-mode interventions, multi-component approaches offer advantages in flexibility, personalization and sustainability. For instance, while traditional face-to-face interventions provide personalized education, they are often limited by fixed time and location, making them less adaptable to patients' evolving needs. In contrast, digital tools such as mobile apps, SMS and emails can deliver support anytime and anywhere, enabling continuous patient engagement and improving adherence outcomes. However, the implementation of multi-component interventions also poses certain challenges. These include patients' acceptance of new technologies, access to necessary devices and the effective integration of various components within a single intervention framework. Future research should further explore the feasibility and effectiveness of such interventions across diverse populations and settings and focus on optimizing their design to ensure maximum impact.

Notably, only a small number of studies incorporated theoretical models into interventions aimed at improving medication adherence among people living with diabetes. The most commonly used frameworks included the Theory of Planned Behavior (4 studies), the Health Belief Model (2 studies) and the Information-Motivation-Behavioral Skills Model (2 studies). With the exception of one study that applied four theoretical models simultaneously but did not yield significant results, all other theory-based interventions demonstrated improvements in adherence. Among the 30 studies that did not apply any theoretical framework, four reported no significant effects, while the rest showed positive outcomes. This suggests that the effectiveness of an intervention is not solely dependent on the presence of a theoretical model, but rather on the appropriateness of the model selected and the rigor of its application in both the design and implementation phases. The use of theoretical models is not about quantity, but fit. A well-matched theoretical framework can offer a structured understanding of health behaviors, clarify mechanisms of behavior change and guide the selection of targeted strategies and techniques. For example, the Theory of Planned Behavior emphasizes the roles of intention and perceived behavioral control, making it suitable for interventions that aim to enhance motivation and perceived ability to adhere to medication regimens.[65] The Health Belief Model, on the other hand, focuses on perceived susceptibility, severity and benefits, and is useful in addressing beliefs about disease risk and treatment effectiveness.[66] Therefore, future studies should prioritize the integration of relevant theoretical frameworks as a foundation for intervention design. Theory-driven approaches not only improve the precision and relevance of interventions, but also facilitate a better understanding of the underlying mechanisms contributing to behavior change. Ultimately, such approaches may lead to higher-quality and more sustainable improvements in medication adherence.

Limitations

Despite conducting an exhaustive search using five databases, this systematic review is not without its limitations. The search was confined to articles published between 1st January 2015 and 1st April 2025, exclusively including English articles, potentially influencing the study outcomes. The encompassed studies employed a diverse range of intervention measures, were carried out in various countries, and utilized a wide array of research tools, thereby rendering the conduction of a meta-analysis impractical.

Conclusion

This systematic review provides a comprehensive analysis of various interventions aimed at improving medication adherence among people living with diabetes. The findings suggest that face-to-face health education remains one of the most commonly used and effective intervention strategies, enhancing patient engagement and adherence. However, modern technological interventions, such as mobile applications and internet-based tools, also show great potential for improving adherence, particularly when used in combination with traditional methods. The integration of multi-component interventions, combining approaches like face-to-face interactions, digital tools and continuous monitoring devices, addresses the limitations of single-mode interventions by offering greater flexibility, personalization, and sustainability.

Despite the promising outcomes, challenges remain in ensuring the effective integration of these interventions and in improving patient acceptance of new technologies. Future studies should prioritize the selection of appropriate theoretical models to guide intervention design, as the effectiveness of these models hinges on their relevance to the specific behaviors and characteristics of the target population. The review emphasizes the importance of rigorously evaluating digital tools, with only high-quality validated applications being recommended for clinical use. While multi-component interventions and theoretical frameworks hold significant potential, further research is needed to assess their long-term effects and feasibility, in order to optimize intervention designs and achieve more sustainable improvements in medication adherence. This study provides valuable evidence and recommendations for improving medication adherence in people living with diabetes. Future intervention designs should focus more on comprehensiveness and personalization, providing stronger theoretical support and empirical data for diabetes medication adherence interventions.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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