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Understanding factors influencing medication adherence in Type 2 diabetes guided by the COM-B behaviour change model and assessed using the Morisky scale: A systematic review

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ABSTRACT

Background: Type 2 Diabetes Mellitus (T2DM) requires a multifaceted management approach involving lifestyle modifications, education, and pharmacological treatments. Medication adherence is critical for achieving glycaemic control; however, up to 45 % of patients fail to meet HbA1c targets. The Morisky Medication Adherence Scale (MMAS) is a validated tool widely used in clinical practice to assess self-reported medication adherence, offering valuable insights into patient behaviours affecting treatment outcomes.

Aim: This systematic review evaluates medication adherence in adults with T2DM using the MMAS and to identify modifiable factors influencing non-adherence. The COM-B model was used to structure the analysis by mapping barriers and enablers to the Capability, Opportunity, and Motivation components that underpin medication-taking Behaviour.

Method: A systematic review was conducted following the PRISMA framework. MEDLINE, EMBASE, EMCARE, and Ovid Nursing databases were searched for cross-sectional studies published between January 2013 and December 2024 that utilised the MMAS scale to assess adherence in adults with T2DM receiving oral or injectable anti-glycaemic therapies. A narrative synthesis was conducted using the COM-B model to identify key barriers and enablers influencing adherence.

Results: Of 9990 records screened, 30 studies from 17 countries, involving 8405 participants, met the inclusion criteria. Overall, 40.9 % of participants demonstrated high adherence, while 42.6 % had low adherence. Key barriers included poor diabetes knowledge, depression, polypharmacy, side effects, inadequate patient-provider communication, and lack of continuity in care. Enablers encompassed patient education, family support, effective patient-provider communication, and structured diabetes education programmes.

Conclusions: The MMAS remains a reliable tool for assessing self-reported medication adherence in T2DM. However, adherence levels remain suboptimal. Addressing modifiable factors, such as depression, enhancing diabetes education, and improving healthcare communication, may improve adherence, glycaemic control, and overall T2DM management outcomes.

Registration: Registered with PROSPERO (CRD42022359969)

1. Introduction

Type 2 Diabetes Mellitus (T2DM) accounts for 90–95 % of all diabetes cases, predominantly affecting adults and contributing to complications such as neuropathy and cardiovascular disease. Recent multinational data show that people with type 2 diabetes lose

approximately 2.5–12.9 years of life expectancy compared with those without the condition [1]. Furthermore, T2DM is associated with a twofold increase in the risk of depression, which negatively impacts patient engagement with treatment and adherence to medication. Regular monitoring of Haemoglobin A1c (HbA1c) and maintaining optimal glycaemic control are critical for reducing complications and guiding

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treatment decisions. Evidence suggests that improved glycaemic control, combined with adherence to medication, is essential for effective T2DM management [2,3].

Management of T2DM involves a multifaceted approach, incorporating diet, physical activity, patient education, and pharmacological treatments. The “Look AHEAD” study demonstrated that intensive lifestyle interventions resulted in greater weight loss, reduced cardiovascular risk, and a lower HbA1c level (6.6 % vs. 7.2 % in controls) after one year [4]. Lifestyle modification and self-management are fundamental to diabetes care, with exercise interventions leading to a 0.66 % reduction in HbA1c, independent of weight loss. Education and structured support for self-management and improved adherence to medication are vital for individuals living with T2DM, particularly as patient motivation plays a critical role in sustaining lifestyle modifications [5].

A systematic review evaluating the relationship between diabetes and physical activity found a 26 % lower incidence of T2DM in individuals meeting the recommended physical activity levels [6]. However, while lifestyle changes are beneficial, they alone may not be sufficient to maintain glycaemic control or mitigate cardiovascular risk without pharmacological interventions, highlighting the need for a multifactorial intervention approach that integrates lifestyle and pharmacological strategies [7]. However, managing multiple health behaviours, such as glucose monitoring, medication adherence, diet, and exercise, poses significant challenges for individuals with T2DM [8]. Among pharmacological treatments, metformin is the first-line oral anti-glycaemic agent recommended for T2DM management in the UK [7]. A meta-analysis demonstrated that metformin use resulted in a 1.12 % reduction in HbA1c compared to placebo [9]. Therefore, achieving optimal glycaemic control and minimising T2DM-related complications necessitates a holistic approach that integrates medication adherence alongside lifestyle and educational interventions [10].

Medication adherence refers to the extent to which a patient's behaviour aligns with prescribed treatment plans, including medication type, dosing, and frequency [11,12]. High adherence rates are associated with reduced healthcare costs, improved clinical outcomes, and greater treatment optimisation. However, approximately 45 % of individuals with T2DM fail to achieve the recommended HbA1c target of < 7.0 %, which is associated with increased morbidity and mortality [13]. Medication adherence can be assessed using several methods, including the medication possession ratio (MPR), pill counting, and validated self-report scales [14]. Given its significance, adherence remains a key determinant in optimising diabetes management and mitigating complications.

1.1. The Morisky MMAS adherence scale

The Morisky Medication Adherence Scale (MMAS) is a validated scale that captures adherence by allowing patients to evaluate their medication-taking behaviours. Originally developed as a 4-item questionnaire for patients with hypertension, it remains widely applicable for chronic conditions, including diabetes [15]. Morisky et al. highlighted adherence as the most critical factor in managing hypertension, stressing that long-term adherence is essential even after control is achieved [16]. The simplicity of the MMAS makes it easy to implement in practice, improves patient-provider communication, and helps assess patients' understanding of their treatment. [15]. The 8-item MMAS, developed in 2008, expanded on the original 4-item tool and is now widely used to measure adherence in various chronic conditions [17]. A study of 154 patients with T2DM examining the validation and psychometric properties of the 4 and 8-item in MMAS showed that 18.83 % of participants had high adherence, 45.45 % had medium and 35.71 % had low adherence [17]. The key difference between 4- and 8-item scales is the addition of a 5-point Likert scale question on the 8-item MMAS, allowing choices and quantifying opinions. In the 4-item MMAS, adherence scores of 3 or above indicate low adherence, 1 or 2 medium, and 0 high adherence, while in the 8-item MMAS, scores below

6 indicate low adherence, 6–8 medium, and above 8 high adherence [16].

1.2. Prevalence of nonadherence to medication in T2DM

The prevalence of nonadherence to anti-glycaemic medications is high. A systematic review of 27 studies by Krass et al. conducted in 2013 found that adherence, measured using the MPR and MMAS, ranged from 38.5 % to 93.1 %, with only 22.2 % of participants reporting high adherence. The most consistent factors affecting adherence were medication cost and depression [18]. Similar findings were reported in a meta-analysis of 12 studies assessing adherence in patients with T2DM using oral anti-glycaemic medications, with or without insulin [19]. Adherence to medication varied from 44.4 % to 89.9 %, with male gender and older age linked to higher adherence [19]. A cross-sectional study using the MMAS found low adherence in 49.4 %, medium in 29.7 %, and high in 20.9 % of patients with T2DM (N = 91), with high adherence improving quality of life [20]. Another study identified factors affecting adherence, including age, medication cost, health beliefs, literacy, side effects, and depression. The authors recommended health coaching, pharmacy-led interventions, point-of-care testing, and patient education to improve adherence [21].

1.3. Systematic review aim and objectives

The aim of this systematic review was to evaluate medication adherence in adults with T2DM using the Morisky Medication Adherence Scale (MMAS) [16] and to identify modifiable factors influencing non-adherence, guided by the COM-B (Capability, Opportunity, Motivation–Behaviour) model [22].

1.4. Objectives

- To examine how the MMAS has been applied in observational studies to assess self-reported medication adherence in adults with T2DM.
- To identify modifiable barriers and enablers associated with medication adherence, mapped to the COM-B behaviour change model.
- To compare the findings of this review with those of the previous systematic review of medication adherence in T2DM conducted in 2013 [18].

2. Methods

The systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines [23] and registered with PROSPERO (CRD42022359969).

2.1. Data sources

A preliminary search found a similar systematic review conducted by Krass et al. in 2013 [18], therefore, the search was limited to any publications post-January 2013. The initial search was completed on 24th January 2023 using the following databases: MEDLINE, EMBASE, EMCARE, and Ovid Nursing databases. A grey search and a secondary review of the reference lists of key articles was also undertaken to ensure all available evidence was reviewed. A secondary search, using the same strategy, was run covering the period between 24th January 2023 and 30th October 2024; no new studies were identified. Rayyan (<https://www.rayyan.ai/>), a software used to manage and collaborate on systematic reviews, was used to organize the results from each database, to remove duplicates, and to collaborate on blind-screening the review records.

2.2. Search strategies

Search terms were hierarchically structured and combined with the

Boolean operators (“AND”, “OR”) of the following group keywords and their respective synonyms and MeSH terms:

“Diabetes” OR “type 2 diabetes” OR “T2DM” (population) AND “medication” OR “treatment” OR “therapy” (exposure) AND “adherence” OR “nonadherence” OR “compliance” OR “noncompliance” OR “concordance” OR “persistence” OR “discontinuation” (outcome). An example of the search strategy including all keywords, MeSH terms, and Boolean operators, has been provided in the [Supplementary Material](#).

2.3. Study selection and data screening process

Records from the database search were exported onto Rayyan and duplicates were removed. A two-stage screening process was employed. In the initial stage, all titles and abstracts were screened by the first author, and the second author blind-screened 20 % of these records for validation purposes. In the second stage, all retrieved full-text articles were screened in full by both authors to determine eligibility, while the second author additionally blind-reviewed 20 % of the data extraction for coding consistency. Any discrepancies at either stage were discussed and resolved collaboratively.

2.4. Eligibility criteria and participants

2.4.1. Inclusion criteria

- Adults aged 18 years or older with T2DM, on oral and/or injectable anti-glycaemic therapies.
- Quantitative observational cross-sectional studies utilising self-reported MMAS scales to assess medication adherence and associated modifiable factors were included, as the MMAS produces numerical adherence scores that can be quantified and compared across studies.
- Studies published in English in peer-reviewed journals between January 2013 and October 2024, with full text accessible.

2.4.2. Exclusion criteria

- Published before January 2013.
- Included participants aged under 18 years.
- Focused on populations without T2DM.
- Used study designs other than quantitative observational cross-sectional methods (e.g., qualitative studies, randomised controlled trials, reviews).
- Did not use the MMAS to assess medication adherence.

2.5. Quality assessment and critical appraisal

The quality appraisal was undertaken to aid the interpretation of findings and to assist in determining the strength of the conclusions drawn. The Joanna Briggs quality appraisal tool for cross-sectional studies [24] was used to appraise the studies to ensure validity and to examine the reliability with a quantifiable score on each included study. Each question was dichotomised to either YES (1 point) or NO (0 points) producing a scale ranging from x2 ‘NO’s’ (poor quality), x1 ‘NO’s’ (fair quality) or x6 YES’ (good quality). (see [Supplementary material](#)).

2.6. Outcome measures

The primary outcome of this review was to evaluate self-reported medication adherence in adults with T2DM as measured using the Morisky Medication Adherence Scale (MMAS), with adherence levels categorised as low, medium, or high in accordance with established scoring guidance [16]. The secondary outcome was identification of the barriers and enablers associated with adherence to medication underpinned by the COM-B Behaviour Change Model [22].

2.7. Theoretical framework: the COM-Behaviour Change Model

The COM-B Behaviour Change Model underpinned the data extraction and analysis in this systematic review. This model explains how behaviours come about at any particular moment based on an individual’s Capability (C) and Motivation (M), and the situations that provide them with the Opportunity (O) to enact or change Behaviour (B), thereby outlining all potential influences on the targeted behaviour [22]. The COM-B model has been applied previously to synthesise determinants of behaviour in systematic reviews [25], demonstrating its suitability for structuring complex behavioural evidence. Following study selection, all reported factors associated with medication adherence were extracted and categorised as barriers or enablers. These factors were then systematically mapped onto the COM-B components to identify the behavioural domains influencing adherence: 1) Physical and Social Opportunity, 2) Psychological and Physical Capability, and 3) Reflective and Automatic Motivation [22]. This structured approach enabled the synthesis of modifiable determinants of adherence and supported the development of a behaviourally informed interpretation of the findings.

2.8. Data extraction and analysis

A narrative synthesis and descriptive analysis were conducted using data from the included studies to evaluate adherence to medication in patients with T2DM and identify barriers and enablers. Extracted data included study design, sample size, setting, participant demographics, types of medications, glycaemic control, and adherence scores based on the 4-item, 6-item, and 8-item MMAS scales. Factors were reported if they showed a correlation with adherence to medication statistically significant based on a $p < 0.05$. A cut off point of 80 % differentiated between adherent and non-adherent, although some studies employed cut off point of 60 % [26].

3. Results

3.1. Study characteristics

A total of 9990 records were extracted from the initial search, and 3464 duplicate records were removed, resulting in 6526 records. The first stage screening eliminated 5516 records at title-screening and 929 at abstract screening. A total of 81 full-text articles were retrieved for screening against the eligibility criteria, of which 51 were excluded, giving a final number of 30 studies from 17 countries and with a total of 8405 participants across all studies included in analysis. A detailed summary of the screening is presented in the PRISMA Flowchart in [Fig. 1](#).

Two studies included patients taking only Oral Anti-Diabetic medication (OAD) [27,28], twenty three studies used oral, and insulin combined [29–51], one study used insulin alone [52] and four studies did not report the type of anti-diabetic medication used [53–56]. Sample size ranged from 70 [30] to 700 [34] patients with T2DM, with a mean age between 50 and 60 years. Glycaemic control was reported in 17 studies, with HbA1c used as the primary monitoring test in 12 studies. All studies used questionnaires to collect data, which were distributed by post or in-person for self-completion or interviewer-led completion; one study combined online and postal dissemination [47], while another did not report on data collection approach [31]. Duration of diabetes was reported in 27 studies and ranged from 6 months [40] to 19 years [52] ([Table 1](#)).

3.2. Quality of the studies

Eighteen out of 30 studies were of high quality as they provided a clear explanation of their analytical strategies and relevant data to address the study question, as well as identified knowledge and research

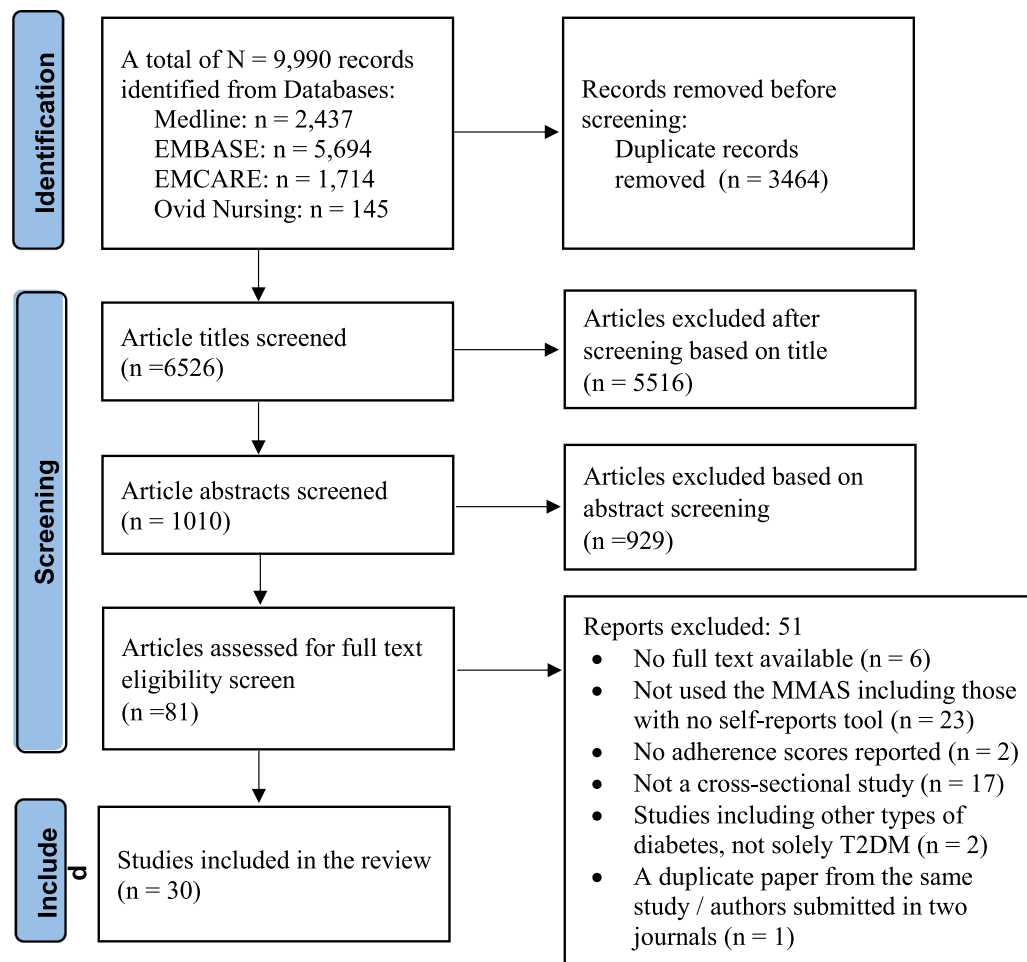


Fig. 1. PRISMA Flowchart of study search, screening and selection.

gaps in adherence to medication in patients with T2DM. None of the studies were excluded based on the results of the quality assessment (see [Supplementary Material](#)).

3.3. Barriers and enablers to medication adherence

Table 2 presents the MMAS adherence scores for all 30 studies. Twenty-four studies used the 8-item MMAS, scoring adherence as high (score of 8), medium/moderate (6–7) and low (<6) [16]. Five studies used the 4-item Morisky scale scoring adherence as low (>3), medium (1–2), and high (0) [15], though three studies classified non-adherence with the 4-item MMAS scores as > 1 [31,35,49], and another study classified good adherence as 0–1 and low adherence as 2–4 [32]. One study used a 6-item modified version of the 6-item MMAS scale where scores of 4–6 indicated good adherence and 0–3 indicated low adherence [48]. Several studies combined medium and high scores into high adherence primarily due to low numbers of patients with high adherence [33,34,38,39,47,50,55].

Adherence levels were also reported as percentages (%) of respondents based on how they scored on the MMAS scale. High/good adherence levels varied from 0 % [54] to 84.5 % [44]. Of the 30 studies included in this review, 14 studies reported high adherence [28,30–34, 39,42,44,46–48,55,56], 3 medium [36,43,50], and 13 low adherence [27,29,35,37,38,40,41,45,49,51–54]. Of the total patient population (N = 8405) across all 30 studies, 40.93 % (N = 3439) of participants reported high adherence scores and 42.64 % (N = 3583) reported low adherence highlighting that most participants reported low adherence to their anti-diabetic medication. Adherence scores were retrieved

directly from each article and deducted from the total number of participants combined from all studies.

3.4. Factors influencing medication adherence: the COM-B Model

For each study we extracted the barriers and enablers to medication in patients with T2DM; factors that were explored but did not show any association with adherence were also extracted (Table 2). Non-modifiable factors affecting adherence includes gender, age, ethnicity, duration of diabetes and treatment initiation. The modifiable factors (barriers and enablers) that influence adherence to medication in patients with T2DM were mapped against the components of the COM-B Behaviour Change Model [22]: 1) Physical and Social Opportunity, 2) Psychological and Physical Capability, and 3) Reflective and Automatic Motivation. Three studies did not report any barriers to adherence [30, 46,50], while fourteen studies did not report any enablers [27,28,30–32, 34,35,38,39,43,44,46,52,54].

3.4.1. Physical opportunity

Diet, exercise, and lifestyle: Jannoo and Mamode-Khan found that abnormal BMI (Body Mass Index), obesity and restrictive diets were reported as barriers, while a healthy balanced lifestyle was an enablers in a study involving 497 patients with T2DM; 47.7 % of patients in this study reported low adherence, reflecting the highest mean BMI 29.2 ± 6.86 in comparison to patients with medium and high adherence [41]. Specific diets ‘high fat foods’ enabled patients to gain better control over their food intake which they felt compensated for their low medication adherence however, a general diet ‘healthy eating plan’ was followed on

Table 1
Study design and sample characteristics and treatment.

Study citation	Country	Design & data collection approach	Sample size, Mean age (SD), Gender N (%)	HbA1c	Type of anti-glycaemic treatment	GBI score
Huang et al. 2018 [29]	USA in two family medical clinics	(CS) face-to-face questionnaire	N = 174 58.7 (SD=12.8; range 18–92) n = 100 female (57.5 %)	≤ 7 % n = 77 (44.3 %) > 7 % n = 96 (55.2 %) Missing n = 1 (0.6 %)	Oral n = 110 (63.2 %) insulin + oral medication n = 64 (36.8 %)	G
Achappa and Sri Lakshmi 2020 [30]	India in a rural village	(CS)- researchers administered using semi-structured questionnaire	N = 70 (58.49 ± 14.54) n = 42 female (60 %)	(RBS) Values > 200 mg/dl determined uncontrolled diabetes n = 54 (77 %) uncontrolled RBS n = 16 (23 %) controlled RBS (HbA1C) < 7 %	oral n = 67 (96 %) oral and insulin n = 03 (4 %)	G
Gonzalez Heredia et al. 2021 [31]	USA-Mexico in an outpatient clinic	(CS)- Unclear from patients	N = 179 (56 ± 13) n = 123 female (69 %)	Fasting glucose ≤ 7.2 mmol/L defined glycaemic control	47 % received dual therapy	G
Khdour et al. 2021 [32]	Palestine, primary healthcare unit	(CS)- Questionnaires followed by 15–20-minute interviews	N = 380 (52.97 ± 13.95) n = 160 females (42 %)	HbA1C < 7 % = good glycaemic control > 7 % = poor glycaemic control 174 patients (45.8 %): HbA1C < 7 % 206 patients (54.2 %): HbA1C > 7 %	Insulin and oral medication	G
Nazir et al. 2016 [27]	Pakistan hospital	(CS)- Questionnaire	N = 392 (50.77 ± 9.671) n = 170 females (43 %)	Not reported	Oral	F
Gu et al. 2017 [53]	China hospital endocrine department	(CS)-Questionnaire	N = 331 (57.23 ± 11.41) n = 158 females (48 %)	Not reported	Did not specify	F
Eh et al. 2016 [33]	Australia community and hospital	(CS)- Self-completed + researcher-administered	N = 139 (64 ± 12) n = 77 females (54 %)	Not reported	Oral n = 95 (68.3 %) Oral and insulin n = 40 (28.8 %) Insulin alone n = 3 (2.2 %)	G
Chew et al. 2015 [34]	Malaysia three public health clinics	(CS)- Questionnaires	N = 668 questionnaires obtained) (56.9 ± 10.18) n = 359 females (54 %)	Not reported	oral n = 605 (91.3 %) 1 type of insulin n = 183 (27.6 %) ≥ 2 types of insulin n = 76 (11.5 %)	F
Zhang et al. 2021 [35]	Singapore primary care polyclinics	(CS)- interviewer-administered questionnaire	N = 448 61 years n = 203 females (45 %)	7.8 ± 1.4	Insulin n = 75 (16.7 %) non-insulin n = 373 (83.3 %)	G
Kassahun et al. 2016 [36]	Ethiopia university teaching hospital	(CS)- interviewer administered questionnaires	N = 309 < 40 n = 12 (3.9 %) 40–60 n = 188 (60.8 %) > 60 n = 87 (28.2 %) Age not reported by n = 22 (7.1 %) n = 120 females (38 %)	(FBG) > 130 mg/dl = poor glycaemic control:	Oral and Insulin- no comparison	G
Blackmon et al. 2016 [37]	USA- North Carolina two rural counties	(CS): mixed methods, interviewer administered questionnaires	N = 45, Age not reported n = 25 female (56 %)	Male: average (HbA1c) 9.0 (=poor metabolic control) Female: average (HbA1c) (7.2) moderately good metabolic control	Oral n = 23 (55 %) Oral and Insulin n = 18 (40 %) n = 4 (5 %) stopped their medications without medical advice Oral n = 136 (74.3 %) Insulin n = 20 (10.9 %) Oral and Insulin n = 27 (14.7 %)	G
Shams et al. 2016 [38]	Pakistan- Islamabad department of medicine	(CS)- questionnaires	N = 183 (56.6 ± 10.6) n = 140 female (77 %)	(HbA1c) < 7 % = satisfactory glycaemic control. Results were unsatisfactory in n = 149 (81.4 %) of patients	Oral n = 136 (74.3 %) Insulin n = 20 (10.9 %) Oral and Insulin n = 27 (14.7 %)	G
Sontakke et al. 2015 [54]	India diabetic tertiary hospital	(CS)- interviewer administered questionnaires	N = 150 (62.09 ± 10.44) n = 56 female (37 %)	Not reported	Did not specify	F
Thapar et al. 2020 [55]	India in a tertiary hospital	(CS)- Questionnaire	N = 124 (59.8 ± 11.2) n = 65 female (42 %)	(FPG) levels good adherence: ≤ 126 n = 14 (66.7 %); > 126 n = 56 (54.4 %) poor adherence: ≤ 126 n = 7 (33.3 %); < 126 n = 47 (45.6 %)	Not reported	G

(continued on next page)

Table 1 (continued)

Study citation	Country	Design & data collection approach	Sample size, Mean age (SD), Gender N (%)	HbA1c	Type of anti-glycaemic treatment	JB1 score
Ashur et al. 2015 [39]	Libya diabetes and endocrinology centre	(CS)- Questionnaire	N = 523 54.43 (SD= 10.03) Gender not reported	Not reported	Oral n = 199 (38.0 %) Insulin with/without oral medications n = 324 (62.0 %)	F
Thurston et al. 2015 [40]	USA- three clinical sites southeastern US	(CS)- Survey	N = 192 55.4 (SD= 10.3) n = 109 female (57 %)	≥ 7 % 65.6 % patients < 7 % 34.4 % patients Range 4.7–14.9 % Average HbA1c level 8.1 ± (1.9 %)	Injectables 57.3 % Oral 42.7 %	G
Bermeo-Cabrera et al. 2018 [52]	Mexico tertiary diabetes clinic	(CS)- self-administered questionnaire	N = 200 (61.5 ± 12.0) n = 170 female (65 %)	Nonadherent HbA1c 8.9 % (range 7.9–10.4) Adherent HbA1c 8.4 % (range 7.5–9.6)	Insulin- at least one type over 3 months	G
Aloudah et al. 2018 [28]	Saudi Arabia university diabetes centre	(CS)- self-administered questionnaire	N = 395 (SD= 57.8 (8.7) n = 159 female (40 %)		Oral for at least 12 months	G
Jannoo and Mamode Khan 2019 [41]	Malaysia hospital and government clinic	(CS)-Questionnaires	N = 497 (55.5 ± 10.9) n = 230 female (46 %)	Adherence: High 7.95 ± 2.43 % Medium 8.17 ± 2.93 % Low 8.57 ± 2.97 %	Oral and Insulin, no comparison	G
Waari et al. 2018 [42]	Kenya Hospital	(CS)-Questionnaires	N = 289 (56.6 ± 11.86) n = 196 female (68 %)	Good glycaemic control (HbA1c) < 7 % n = 107 (36.9 %) Poor glycaemic control (HbA1c) > 7 % n = 183 (63.1 %)	Oral n = 129 (44.5 %) Insulin n = 44 (15.2 %) Combination of oral and insulin N = 117 (40.3 %)	G
Kang and Hur 2020 [43]	Laos diabetes hospital clinics	(CS)- interviewer-administered questionnaire	N = 175 (56.59 ± 11.15) n = 118 female (67 %)	Not reported	Oral n = 137 (78.3 %) Insulin n = 38 (21.7 %)	F
Afaya et al. 2020 [44]	Ghana hospitals	(CS)- Questionnaire	N = 330 (57.5 ± 11.8) n = 225 female (68 %)	(FBG) Good < 7.0 mmol/L n = 139 (42.1 %) Poor ≥ 7.0 mmol/L n = 191 (57.9 %)	Oral n = 247 (74.8 %) Insulin n = 33 (10.0 %) Oral and insulin n = 50 (15.2 %)	G
Asheq et al. 2021 [45]	United Arab Emirates hospital clinics	(CS)- Questionnaire	N = 180 20–29 years n = 38 30–39 n = 36 40–49 n = 30 50–59 n = 39 ≥ 60 n = 37 n = 85 female (47 %)	Not reported	Oral n = 114 (63.3 %) Insulin n = 38 (21.1 %) Oral and insulin n = 28 (15.6 %)	G
Ayele et al. 2019 [56]	Ethiopian general hospital	(CS)- Questionnaire	N = 275 (52.7 ± 9.94) n = 146 female (53 %)	(FBG) Good 70–130 mg/dL (3.9–7.2 mmol/L) n = 118 (42.9 %) Poor > 130 or < 70 mg/dL (>7.2 or < 3.9 mmol/L) n = 157 (57.1 %)	Did not specify	G
Elsous et al. 2017 [46]	Palestine primary care clinics	(CS)- Interviewer obtained questionnaire	N = 369 (56.38 ± 10.36) n = female 206 (56 %)	Good glycaemic control ≤ 6.4 % n = 41 (11.1 %)	Oral n = 241 (65.3 %) Insulin n = 85 (23 %) Oral and insulin n = 43 (11.7 %)	F
Dhippayom and Krass 2015 [47]	Australia diabetes council	(CS)-survey online (n = 448 postal (n = 95)	N = 543 (63.0 ± 10.6) n = 230 female (42 %)	Not reported	Oral (79.6 %) Insulin with or without oral medications (20.4 %)	F
Pirdehghan and Poortalebi 2016 [48]	Iran hospital clinic	(CS)- Interviewer obtained questionnaire	N = 300 (58.22 ± 10.27) n = 111 female (37 %)	Not reported	Oral n = 237 Insulin n = 59	F
Jarab et al. 2014 [49]	Jordan hospital diabetes clinic	(CS)- Questionnaires	N = 171 64 (SD=9.8) n = 74 female (43 %)	Not reported	Oral and insulin	F
Acharya et al. 2019 [50]	India, New Delhi hospital	(CS)- Questionnaires	N = 200 (49.8 ± 10.5) n = 126 female (63 %)	Not reported	Oral n = 200 (100 %) Oral and insulin n = 39 (19.5 %)	F
Shiyanbola et al. 2018 [51]	United States medicine clinics	(CS)- Questionnaires (face-to-face)	N = 174 (58.7 (12.8) n = 100 female (58 %)	Not reported	Oral n = 110 (63.2) Insulin n = 64 (36.8 %)	F

Key to abbreviations:

JBIO: Joanna Briggs Institute; P: Poor Quality as per JBI Assessment of Bias; F: Fair Quality; G: Good Quality; HbA1c: Haemoglobin A1c; CS: Cross-sectional; RBS: Random Blood Sugar; FBG: Fasting Blood Glucose; FPG: Fasting Plasma Glucose; SD: Standard Deviation

Table 2

MMAS Morisky scale scores and barriers and enablers to adherence to medication in patients with T2DM.

Study Citation	Diabetes duration: Mean years (SD)	MMAS version and adherence scores: N (%)	Barriers to adherence to medication	Enablers to adherence to medication
Huang et al. 2018 [29]	9.6 years $\pm$ 7.1	8-item MMAS High > 8 n = 42 (24.1 %) Medium > 6 n = 61 (35.1 %) Low < 6 n = 71 (40.8 %)	Poor medication self-efficacy (p < 0.001) and numeracy skills (p > 0.05)	Improve numeracy skills increases self-efficacy (p < 0.05). Self-efficacy increase adherence.
Achappa and Sri Lakshmi 2020 [30]	6.47 $\pm$ 4.55	8-item MMAS Good > 6 n = 56 (80 %). Poor $\leq$ 6 n = 14 (20 %)	No barriers reported but of n = 14 poor adherent participants: Illiterate n = 8 in comparison to literate n = 6 was poor adherent (no statistical significance)	No enablers reported but of n = 56 adherent participants: Over 50 years n = 38 had good adherence in comparison to 18 participants below age 50 34 females in comparisons to 22 males had good adherence None reported
Gonzalez Heredia et al. 2021 [31]	No	4-item MMAS, non-adherence = <4 questions correctly answered Good n = 114 (63.7 %). Poor n = 65 (36.3 %)	Anxiety and depression contributes to non-adherence (p < 0.001)	None reported
Khdour et al. 2021 [32]	n = 116 diagnosed > 10 years	4-item MMAS 0–1 high adherence n = 220 (57.9 %) 2–4 low adherence n = 160 (42.1 %)	Forgetfulness (45.05 % patients) Side effects (18.7 % patients) (p = 0.47) Health perception (21.6 %) Careless of taking medication (33.4 %)	Satisfaction with treatment effectiveness (p = 0.04)
Nazir et al. 2016 [27]	Mean duration 5.58 $\pm$ 4.09	8-item (MMAS-U Urdu version) High > 8 n = 13 (3.3 %) Medium > 6–7 n = 97 (24.75 %) Low < 6 n = 282 (71.93 %)	Forgetfulness (61.22 %) Carelessness (48 %) Low levels of diabetes-related knowledge (p < 0.05)	None reported
Gu et al. 2017 [53]	< 5 years n = 137 (41.39 %) 6–15 years n = 168 (50.76 %) $\pm$ 16 years n = 26 (7.75 %)	8-item (MMAS-CN Chinese version) High n = 90 (27 %) Low n = 241 (73 %) No defined cut off points for high/low	Lack of social support Employment status (p = 0.079) Marital status (p = 0.649) Not having insurance (p = 0.070) Family income (p = 0.517) BMI (p = 0.094)	Social support improves medication adherence (p = 0.036) Higher education level improves adherence (p = 0.483)
Eh et al. 2016 [33]	Median duration = 14 years	8-item (MMAS-CN) Good 8 n = 62 (46.6 %). Fair > 6 to < 8 n = 49 (35.3 %) Poor < 6 n = 28 (20 %)	Beliefs in traditional Chinese medicine predicted poor adherence p = 0.02	Acculturation correlated with medication adherence (p = .004) Longer duration of diabetes improved adherence (p = .01)
Chew et al. 2015 [34]	< 5 years n = 323 (50.0 %). 5–9.9 years n = 183 (28.3 %). $\geq$ 10 years n = 140 (21.7 %)	8-item MMAS Chinese and Malaysian versions. Low < 6 (43 %). Medium-High > 6–8 (57 %)	Younger adults (p < 0.019) Depressive symptoms (p < 0.0001) Higher income (p = 0.048)	None reported
Zhang et al. 2021 [35]	< 5 years n = 134 (30.2 %). 5–10 years n = 107 (24.2 %). $>$ 10 years n = 202 (45.6 %)	4-item MMAS Non-adherent > 1 n = 268 (59.8 %). Adherent 0 n = 180 (40.2 %)	Younger patients were less adherence (p = 0.001) Diabetes-related distress (p = 0.013) Peripheral neuropathy (p = 0.01) Inadequate self-monitoring (p = <0.001) Higher HbA1c correlated with nonadherence (p = 0.001)	None reported
Kassahun et al. 2016 [36]	< 5 years: n = 73 (52.5 %) 5–10 years: n = 48 (34.5 %) $>$ 10 years: n = 18 (13 %)	8-item MMAS High 0 (37.2 %). Medium 1–2 (37.9 %). Low > 2 (24.9 %)	Occupation (farmers had lower adherence than merchants (AOR = 6.8, 95 %CI: 1.6–28.8) Lower education level	Patients with medium or higher level of diabetes knowledge were 80 % less likely to have poor adherence (AOR = 0.2, 95 % CI: 0.1–0.6)
Blackmon et al. 2016 [37]	Mean 10.5 years	8-item MMAS Low < 6 n = 27 (63 %) Average to moderate 6 to < 8 n = 13 (30 %) High $\geq$ 8 n = 3 (7 %)	Personal perceptions of not needing to take medications Fear of hypoglycaemic events 46 % of patients Forgetting to collect medication, cost of medication, side effects	Health insurance (p = 0.001) Paid employment (p = 0.05)
Shams et al. 2016 [38]	8.4 $\pm$ 6.57	8-item MMAS High 8 n = 5 (2.7 %) Medium 6 and < 8 n = 64 (35 %) Low < 6 n = 114 (62 %)	Poor glycaemic control Illiteracy Polypharmacy Poor diabetes knowledge Alternative methods of therapy (p < 0.05)	None reported
Sontakke et al. 2015 [54]	Not reported	8-item Morisky High 0 % Medium n = 39 (26 %) Low n = 111 (74 %)	Forgetfulness (50.66 % of patients) High cost of medication (43.33 %) Unaware of the need/benefit of each medication (55.66 %) Concurrent illnesses (p = 0.002) Number of prescribed medication (p < 0.0001) Male gender correlated with poor adherence (p = 0.0117)	None reported

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Table 2 (continued)

Study Citation	Diabetes duration: Mean years (SD)	MMAS version and adherence scores: N (%)	Barriers to adherence to medication	Enablers to adherence to medication
Thapar et al. 2020 [55]	< 5 years n = 25 (54.3 %) > 5 years n = 45 (57.7 %)	8-item Morisky Low n = 54 (43.5 %) Moderate n = 36 (29 %) High n = 34 (27.4 %) Moderate-high combined= "good" adherence n = 70 (56.6 %)	Forgetfulness Comorbidities (p = 0.897)	Absence of side effects (p < 0.05) Regular blood glucose monitoring Middle socioeconomic status (p = 0.119) No alcohol consumption (p = 0.289) or smoking (p = 0.171)
Ashur et al. 2015 [39]	9.4 (SD=7.3)	8-item MMAS Low < 6 n = 189 (36.1 %) Moderate > 6 High 8 Moderate-high combined= ≥ 6 n = 334 (63.9 %)	Perception of high treatment control (p = 0.044) Perception of high diabetes illness identity (p = 0.008) Females were 1.5 times more likely to be low adherers (p = 0.026) Unemployed patients were half as likely to be low adherers (p = 0.008)	None reported
Thurston et al. 2015 [40]	All participants were on anti-glycaemic therapy for ≥ 6 months	8-item Morisky Low < 6 (58.9 %) Medium 6 to < 8 (27.1 %) High 8 (14 %)	Higher HbA1c (p < 0.01) Younger age (p < 0.05) TOFHLA correlated positively with MMAS-8 question on "difficulty remembering to take medication" (p = 0.017)	Lower HbA1c and older age correlated with better medication adherence
Bermeo-Cabrera et al. 2018 [52]	19.6 ± 8.7 years	8-item Morisky Poor < 6 n = 117 (58.5 %) Moderately good 6 to < 8 n = 61 (30.5 %) Excellent 8 n = 22 (11 %)	Planning daily life around insulin (46.1 %; p = 0.001) & more insulin doses (p = 0.0001) Lack of economic resources (9.6 % adherent vs 15.4 % nonadherent) p = <0.0001 Fear of hypoglycaemia (41 %) p = 0.001 Higher HbA1c p = 0.024	None reported
Aloudah et al. 2018 [28]	Mean duration 12.9 (SD=8.0) years	8-item MMAS High 8 n = 158 (40 %) Moderate 6 to < 8 n = 145 (37 %) Low < 6 n = 92 (23 %)	Younger age p = <0.001 Higher number of non-OHAs p = 0.032 Higher HbA1c levels p = 0.007	None reported
Jannoo and Mamode Khan 2019 [41]	9.97 ± 7.74 years	8-item MMAS Low < 6 n = 222 (44.7 %) Medium 6 to < 8 n = 187 (37.6 %) High 8 n = 88 (17.7 %)	Specific diet p < 0.05 Higher BMI	Ethnicity (p = 0.031) Controlled HbA1c (p = <0.05) Longer duration of diabetes (p < 0.05) Older age (p < 0.05) Balanced diet
Waari et al. 2018 [42]	8 ± 7.8 years	8-item MMAS High 8 (45.5 %) Medium 6–7 (26.2 %) Low < 6 (28.3 %)	Dissatisfaction with family support (p = 0.029) Diabetes hospitalisations for diabetes (p = <0.0001) 2–10-year history of diabetes (p = 0.047) Challenges of accessing medication (p = 0.046) Dissatisfaction with clinicians (p = 0.01) Complication or comorbidity (p = 0.125) Lack of self-efficacy (p = .009)	Affordability of medications Family support Good healthcare provider-patient communication Good glycaemic control (HbA1c ≤ 7 %) Number of diabetes medications correlated negatively with adherence: 2 (p = 0.631), 3 + (p = 0.125)
Kang and Hur 2020 [43]	82.59 ± 70.73 months	8-item MMAS Low < 6 n = 53 (30.3 %) Medium 6 to < 8 n = 104 (59.4 %) High 8 n = 18 (10.3 %)	Longer duration of diabetes Unemployment	Higher self-efficacy (p.015) Being in employment (p = 0.43) Shorter duration of diabetes (p = .019) Diabetes knowledge (p = .561)
Afaya et al. 2020 [44]	1–3 years n = 126 (38.2 %) 4–6 years n = 99 (30.0 %) 7–9 years n = 45 (13.6 %) 10 + years n = 60 (18.2 %)	8-item MMAS Non-adherent < 6 n = 51 (15.5 %) Adherent 6–8 n = 279 (84.5 %)	Younger age Education: Respondents with high school education were 3.7 times more likely to be nonadherent compared to those with tertiary education (p = 0.049) No family support p = 0.986 Single marital status (p = 0.042) Older age was associated with nonadherence: age 50–59 (p = 0.047), 40–49 (p = 0.030), 30–39 (p = 0.011) Chronic disease (p = 0.432) Number of diabetic medication (p = 0.2470) Frequency of taking anti-glycaemic' s (p = 0.878) Smoking (p = 0.836)	Elderly > 70 years of age were 79 % less likely to be nonadherent compared to those younger than 50 years old (p = 0.016) Good diabetes knowledge p = 0.630
Asheq et al. 2021 [45]	< 1 year n = 44 (24.4 %) 2–5 years n = 55 (30.6 %) > 5 years n = 81 (45 %)	8-item Morisky Low < 6 n = 111 (61.67 %) Medium 6 to < 8 n = 52 (28.89 %) High 8 n = 17 (9.44 %)	Older age was associated with nonadherence: age 50–59 (p = 0.047), 40–49 (p = 0.030), 30–39 (p = 0.011) Chronic disease (p = 0.432) Number of diabetic medication (p = 0.2470) Frequency of taking anti-glycaemic' s (p = 0.878) Smoking (p = 0.836)	Treatment other than insulin (p = 0.029) Self-confidence of taking medications (p = 0.046) Patients of Emirati background had better medication adherence in comparison to non-Emirati patients (p = 0.025) Education level (p = 0.642)
Ayele et al. 2019 [56]	Not reported	8-item MMAS Adherent 8 n = 194 (70.5 %) Non-adherent < 8 n = 81 (29.5 %)	32 % patients with comorbidities had low adherence compared to those without comorbidities (p = 0.012) High to moderate diabetes (MRCI) p = <0.001 Duration: Patients diagnosed less than ten years were twice more adherence than those diagnosed longer than 10 years (p = 0.015) > 10 years post treatment Distance: Patient living > 100 km from the	Patients with low MRCI were six times more likely to be adherent than those with high MRCI (p = <0.001) Low compared to high patient-level Patients with low MRCI were four times less likely to be adherent compared to those with high MRCI (p = 0.0470 and three time less likely compared to those with medium MRCI (p = 0.009)

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Table 2 (continued)

Study Citation	Diabetes duration: Mean years (SD)	MMAS version and adherence scores: N (%)	Barriers to adherence to medication	Enablers to adherence to medication
Elsous et al. 2017 [46]	Mean duration 10.48 (8.12)	4-item MMAS Arabic version Low ≥ 3 n = 9 (2.5 %) Medium 1 + 2 n = 146 (39.5 %) High 0 n = 214 (58 %)	hospital were less adherent than those living < 100 km (p = 0.013) None reported	Female gender, (OR)= 1.657, 95 % (CI): 1.065–2.578) Higher perception of disease severity correlated with higher adherence (OR=1.510, 95 % CI:0.410–5.560)
Dhippayom and Krass 2015 [47]	Median duration= 9 (4–14) years	8-item MMAS Low < 6 (35.4 %) Adherent ≥ 6 (64.6 %)	Diabetes knowledge, concerns about medication, difficulty paying for their medication, insulin use and having more than one pharmacy were potential predictors of adherence to anti-glycaemic medication (p < 0.001)	Age ≥ 65 years (95 % CI, 1.19–2.82) Education level and employment status (p < 0.05)
Pirdehghan and Poortalebi 2016 [48]	Average 8.87 $\pm$ 6.0 years	6-item MMAS Good 4–6 (63.3 %) Poor 0–3 (33.7 %)	Younger age Lower duration of diabetes Poor family support Insufficient accessibility to medications Family disease related advises All significant at p < 0.05	Older age > 75 years Positive beliefs about diabetes Optimised treatment Married patients University education p = 0.490
Jarab et al. 2014 [49]	9.9 (SD=7.5)	4-item MMAS Arabic version High adherent 0 n = 47 (27 %) Non-adherent 1–4 n = 124 (73 %)	One or more comorbidities (p < 0.05) Number (p < 0.01) and frequency of medication (p < 0.05): nonadherence increased nine-fold for patients taking more than one dose daily (p = 0.023) Also anti-hypertensive medication (p < 0.05) Self-monitoring of blood glucose (p < 0.05) Forgetfulness (58.6 %) Two-fold increase in nonadherence when side effects were present (p = 0.006) Two-fold increase in nonadherence for patients on Metformin (p = 0.037) None reported	Age p < 0.05 Having one or more microvascular complications p < 0.05
Acharya et al. 2019 [50]	< 5 years n = 125 (62.5 %) 6–10 years n = 51 (25.5 %) > 10 years n = 24 (12 %)	8-item Morisky Low < 6 (33 %) Medium 6–8 (34.5 %) High > 8 (32.5 %)		Patients spending > Rs.1000 monthly on diabetes (68.7 %) had good adherence in comparison to those spending less or no money (16.7 %) Living > 30 min from the hospital (80.6 %) had good adherence in comparison to those living closer (56 %) Age > 40 years, years (p = 0.013) Duration of diabetes > 5 years (p = 0.002) Having a glucometer (p < 0.001) Higher educational status (p = 0.005) Self-efficacy (p < 0.001)
Shiyanbola et al. 2018 [51]	9.6 (7.1)	8-item MMAS Low < 6 (40.8 %) Medium 6 to < 8 (35.1 %) High 8 (24.1 %)	Illness perceptions (p < 0.001)	

Key to Abbreviations: AOR: Adjusted odds ratio; OHM: Oral hypoglycaemic medication; SASH: Short acculturation scale for Hispanics; MRCI: Medication regimen complexity index; TOFHLA: Test of functional health literacy in adults; OR: Odds ratio; OHA: Oral Hypoglycaemic agent; CI: Confidence interval

average 5/7 days in comparison to 4/7 on specific diets. Opportunities to partake in adequate exercises also improved adherence and reduced BMI [41].

Concurrent illnesses and co-morbidities were barriers significantly correlating with poor adherence [49,54,56]. Patients with comorbidities (42.2 % of n = 275 patients) had a reduction in their level of adherence by 32 % in comparison to patients with no comorbidity (57.8 % (p = 0.012) [56].

Health literacy and education: Illiteracy and poor numeracy skills were barriers to adherence [38,40] [29]. Lower levels of education were also a barrier [36,44]. Patients with senior high school education in the Afaya et al. study (10 % of the sample n = 330) were 3.7 times more likely to be non-adherent in comparison to patients with tertiary education (15.1 %) [44]; better education attainment was found to improve medication adherence through ongoing educational opportunities including access to diabetes-related education.

Income and health insurance: Higher income was reported as a barrier to adherence in younger adults in one study from Malaysia [34]. Income of 1000–2999 Malaysian Ringgit (RM) found that 138 of the 310 (44.5 %) participants had low adherence compared to the remaining

participants with an income of < 1000 (RM); the authors did not provide a rationale findings, but it may be due to younger adults leading a busier lifestyle which may contribute negatively to their adherence. Having health insurance was a significant enabler to adherence (p = .027) as it enabled patients to afford their medications in the rural area of North Carolina; most patients had some type of insurance with only a fraction (12 % of n = 45) self-paying for their medication [37]. However, health insurance did not influence adherence in three other studies [45,53,56].

Complex treatment regimens such as insulin or combination therapies, impacted on patients' abilities to plan daily activities and affected their adherence [52]. High Medication Regimen Complexity Index (MRCI) [56] and more than one daily dose of medications were further barriers to adherence [49]. Complexity included higher frequency of diabetes medication, dosages forms and script directions. Bermeo-Cabrera et al. found that the number of insulin applications (p = 0.0001) and insulin dose/units/kg (p = <0.0001) were significantly higher in the non-adherent group of participants (n = 117/200) [52].

Cost of medication and economic resources were associated with nonadherence [37,42,47,48,52,54]. In one study, the cost of medication

Table 3

Modifiable Barriers and Enablers associated with medication adherence behaviours in patients with T2DM.

COM-B components	Barrier	Enabler
Physical Capability	Inability to exercise [41] Poor diabetes control and abnormal HbA1c [28,35,38,40,52] Presence of peripheral neuropathy [35,42] Frequent diabetes-related hospital admissions [35,42]	Physical ability to engage in activity or exercise [41] Optimal diabetes control and normal HbA1c levels [40–42] Presence of microvascular complications improved adherence, likely due to the fear of worsening condition [49]
Psychological Capability	Forgetfulness & carelessness of taking medication [27,32,37,40,49,54,55] Diabetes-related knowledge [27,38,47,54] Self-monitoring [35,49] Polypharmacy & practicing other modes of therapy [38,49,52,54]	Patient education, pharmacist counselling & individualised care [32,49] Medium level of diabetes-related knowledge [36] Home blood sugar monitoring and presence of a glucometer [50,55] Behavioural regulation and using fewer medications [28] Patient empowerment [41] Greater awareness of barriers by health care professionals [54] Better education attainment [44] Having health insurance [37] Public awareness programmes and education [38,40] Low and medium MRCI and simplified regimen [56] Affordability of diabetes medications [42,50] Regular medication supply and continuity of care by pharmacist [47,50]
Physical Opportunity	Diet, Exercise & lifestyle choices [41] Concurrent illness / co-morbidity [49,54,56] Literacy & Education [29,36,38,40,44] Income & Health insurance [34] Daily impact of medication and complex regimen [49,52,56] Cost, lack of economic resources and pharmacy-related drug accessibility [37,42,47,48,52,54]	Good family support [42,53] Good healthcare provider / patient communication [42] Greater awareness of barriers by health care professionals [54] Addressing patient medication concerns and structured diabetes education programmes [47] Greater identification of patients with diabetes distress [35] Higher self-efficacy, patient education programmes, confidence in taking medication, higher perception of disease severity & positive beliefs about diabetes and treatments [37,43,45,46,48] Perceived benefits of medication, coping with and managing side-effects [49]
Social Opportunity	Social support: Poor family support & Dissatisfaction [42,48] Dissatisfaction with patient / clinician communication [42]	
Automatic Motivation	Mental health factors: depression & diabetes-related disease [31,34,35]	
Reflective Motivation	Health perception & Medication Self-efficacy [32,33,39,51,52] Side effects, concerns about medication and type of medication [27,32,47,49]	

resulted in nonadherence in 43 % (N = 150) of participants [54]. On the contrary, affordability of medication and healthcare insurance cover was associated with improved adherence [42], [50]. Access to medication and having to use more than one pharmacy were also barriers to adherence resulting in patient's collecting medications from various pharmacies [47].

3.4.2. Social opportunity

Social support: One study found that lack of family support and limited access to community services were perceived barriers to medication adherence [48], while another study of 289 patients with T2DM reported that dissatisfaction with family support was significantly associated with nonadherence to treatment ($p = 0.029$) [42].

Dissatisfaction with attending clinicians significantly contributed to nonadherence, with dissatisfied patients being three times more likely to be nonadherent compared to those who were satisfied [42]. Good healthcare provider/patient communication and greater awareness of barriers by health care professionals through listening and understanding patients' concerns and finding ways to resolve them were enablers to good adherence [42,54].

3.4.3. Psychological capability

Forgetting to take the medication: Forgetfulness was identified as a barrier to adherence in six studies [27,32,37,49,54,55]. Some patients opted not to take their medication through their own choice [32,37]. For example, 45 % (n = 380) of patients forgot to take their medications and 33.4 % intentionally stopped taking them [32]. In Nazir et al. study, 61.22 % of (n = 392) participants were forgetful and 48 % had careless medication behaviours [27]. Although no enablers were reported the authors placed emphasis on patient education, pharmacist counselling and individualised care that ensures medication timings are scheduled around patients' daily routine to improve adherence [32,49].

Diabetes-related knowledge: Poor diabetes knowledge was a barrier to adherence [27,38,47,54]. More than half of patients in the Sontakke et al. study (55.66 % of n = 150) were unaware of the need/usefulness of each medication [54]. Having medium level of diabetes-related knowledge was deemed an enabler to adherence and patients with such were 80 % less likely to be non-adherent [36].

Self-monitoring: The absence of at-home glucose self-monitoring behaviour was significantly associated with nonadherence ($p < 0.001$) [35,49]. In a study of 448 patients with T2DM, of the patients who self-monitored, only 36.7 % of patients in the nonadherent group (N = 268) engaged in self-monitoring, compared to 50.5 % in the adherent group (n = 180) [35]. This highlights a pattern where patients who do not adhere to their medication regimen also tend to neglect monitoring their blood glucose levels. Home blood sugar monitoring was also an enabler to adherence [35,50,55].

Polypharmacy was also found to be a barrier to adherence and self-monitoring in five studies [28,38,49,52,54]. Interestingly, in one of these studies 49 % (N = 183) of patients were on multiple medications, and 74 % of those with low adherence used either multiple homeopathic, herbal or alternative therapies to control their diabetes [38]. Behavioural regulation and using fewer oral hypoglycaemic agents were enablers to adherence [28].

3.4.4. Physical capability

Physical ability to engage in exercise and active lifestyle improved adherence to medication, diabetes control, and reduced BMI [41].

Diabetes control in the presence of abnormally high HbA1c levels, was identified as a barrier to adherence [28,35,38,40,52]. Non-adherence itself contributes to poor glycaemic control, as reflected by higher HbA1c levels (8.0 ± 1.4) in the non-adherent group [35]. Similarly, Thurston et al. reported an average HbA1c level of 8.1 ± 1.9 % among 192 participants, with more than half (58.9 %) showing low adherence, indicating poorly controlled diabetes [40]. Conversely, lower HbA1c levels, indicating better disease control, were associated with better adherence and were reported as enablers [40–42].

Diabetes-related complications: Peripheral neuropathy was identified as a barrier to adherence, along with diabetes-related hospital admissions [35,42]. A study of 448 patients with T2DM, patients with peripheral neuropathy (n = 100) were twice as likely to be nonadherent ($p = 0.010$) [35]. However, another study found that having one or more microvascular complications, such as nephropathy, retinopathy,

or neuropathy, was an enabler of adherence, likely due to the fear of worsening conditions [49].

3.4.5. Reflective motivation

Health perceptions and medication self-efficacy: Patients' health perceptions varied and were often a barrier to adherence [32,33,39,51,52]. Beliefs about the benefits of non-traditional medical therapies such as homeopathic and Chinese and negative illness perceptions were associated with nonadherence ($p < .001$) [33,51,52]. Poor self-efficacy is an additional barrier and refers to a set of beliefs an individual holds about their ability to compete task or execute certain behaviours [29,43]. Self-efficacy was identified in two studies as a powerful self-care behaviour which improved participants' confidence in their medication taking behaviours and adherence to their treatment ($N = 174$, $p > 0.05$) [29] and ($N = 175$, $p = 0.15$) [43].

Side effects and beliefs about medication were identified as barriers to adherence in four studies [27,32,47,49]. This included barriers such as weight gain from insulin therapy, gastrointestinal upset with metformin, fear of insulin injections, bruising at injection sites, and embarrassment and stigma from treatment leading to nonadherence [47,52]. Khodour et al. found that 18.7 % ($N = 380$) of patients stopped taking their diabetes medication due to side effects [32]. Patients who reported concerns about side effects were three times less likely to be adherent, and those receiving metformin therapy were twice as likely to demonstrate nonadherence [49]. Patients with no experience of side effects and those not on insulin therapy reported good adherence [45,55]. Concerns about medications and diabetes knowledge were reported by (53.6 % of $n = 543$) of patient's [47]; concerns involved the long-term effects of medications (61 %) and that medicines are addictive (6.1 %) and poisonous (7.2 %) based on the beliefs about medicine questionnaire [47]. A study of 220 patients on insulin therapy found that for 41 % reported fear of hypoglycaemia, which emerged as the most significant barrier to treatment adherence [52].

3.4.6. Automatic motivation

Mental health status: Depression and Diabetes-Related Distress (DRD) were barriers to adherence [31,34,35]. Anxious depressions were significantly associated ($p < 0.001$) with poor medication adherence in a study of $N = 179$ participants [31]. In a study involving 668 patients with T2DM, DRD symptoms were reported by $N = 639$ (95.7 %) participants and were generally mild compared to depressive symptoms. While DRD symptoms were associated with medication adherence in the study's univariable analysis ($p < 0.0001$), it did not remain a significant factor of nonadherence in multivariable analysis. This suggest, depression ($p = < 0.0001$) in comparison to DRD ($p = 0.546$) is more so strongly associated with poor medication adherence [34]. Similarly, another study found no association between DRD and adherence, but authors suggested that better screening for DRD could improve adherence and address patients' psychological needs [35].

4. Discussion

Nonadherence remains a barrier for the effective management of patients with T2DM. A high prevalence of nonadherence was found in this review as measured by the widely used and validated Morisky MMAS scales: the 4-item MMAS [15], the 6-item MMAS [48], and the 8-item MMAS scale [16]. This could be due to varying sample sizes of studies in this review and patient demographic details such as lower levels of literacy and education which were attributed to poorer adherence. This was also identified in a review of 18 studies addressing the impact limited health literacy has on patient's adherence to medication in T2DM [57]. These findings highlight the need for system-level strategies to improve health literacy, such as standardised education resources and structured diabetes education programmes within primary care pathways. In addition, synthesising these findings through the COM-B lens reinforces that adherence is shaped by interconnected

systemic, provider, and patient-level influences, rather than isolated behavioural barriers.

This present review highlights low levels (42.64 %) of adherence were greater in comparison to high levels (40.93 %). Findings have been consistent across a timeline with other reviews evaluating adherence to anti-glycaemic medication in patients with diabetes. A systematic literature review by Cramer including 20 publications assessing the extent of medication adherence of patients with diabetes found non-adherence varied from 36 % to 93 % in those taking oral anti-glycaemic medication [58]. However, the methods of assessment used to measure adherence were prescription refill rates and electronic monitoring as opposed to MMAS [58]. In Krass et al. review of 27 studies, various methods were used to measure adherence, including the Medication Possession Ratio (MPR) and MMAS [18]. Adherence prevalence ranged from 38.5 % to 93.1 % and only 27 % of patients had a high level of adherence [18]. Another review including 98 studies found low adherence rates of 33 % based on MPR of 80 % and over [21]. The current review found that 41 % of patients had high adherence, which is an improvement compared with the findings of the Krass et al. systematic review [18], representing a positive step towards narrowing the gap between low and high adherence. Clinically, these findings reinforce the need for routine assessment of adherence using validated tools such as MMAS, enabling early identification of patients at risk of poor glycaemic control. Taken together, these trends highlight the importance of embedding adherence monitoring into routine care pathways at a system level to support timely intervention.

This review identified several factors (barriers and enablers) that influence adherence to medication which were mapped onto the COM-B Model [22]. Focus on improving diabetes is targeted towards the modifiable barriers to promote behavioural changes. Of these, the most commonly reported factors included depression, poor diabetes knowledge and poor diabetes control. With the rising prevalence of depression and unconcealed depression, it is possible the negative association with adherence is underestimated. A study of 250 of patients with type T2DM reported a 41.1 % prevalence of depression and significant correlations between medication nonadherence and diabetes-related depression [59]. It is therefore paramount, to screen for, monitor and effectively manage depression in patients with diabetes to improve adherence. Furthermore, greater recognition by healthcare professionals of the levels of presenting depression can improve adherence through encouragement, education, frequent follow-up, and pharmacological and non-pharmacological treatments. These findings directly map to the 'Reflective and Automatic Motivation' components of COM-B and indicate clear provider-level responsibilities, including integration of routine mental-health screening and collaborative care models within diabetes reviews. Importantly, depression does not operate in isolation; it interacts with capability and opportunity factors, underscoring the need for multifaceted interventions rather than single-focus strategies.

This review, similar to others, found that poor diabetes knowledge and misconceptions about medication are negatively associated with adherence. While our systematic review emphasised that limited knowledge remains a significant barrier to adherence, it is important to note that 75 % of the included studies focused on patients of South Asian origin. A cross-sectional study assessing diabetes-related knowledge in 149 South Asian caregivers revealed that 35.6 % believed diabetes could be cured [60]. Further research is needed within this population to better address gaps in diabetes-related knowledge. Higher adherence was associated with better glycaemic control measured via HbA1c [21]. A review by Asche et al. evaluated the association between diabetes treatment adherence and economic and clinical outcomes in 37 studies; 56.5 % found significant associations between adherence and HbA1c suggesting that higher adherence improves glycaemic control [61]. Comorbidities can also impact patients' psychological strength and hinder their engagement with treatment; possibly because they often present with complex medication regimes, thus patients are less likely to be adherent [49]. A greater awareness of these barriers by health

clinicians is an enabler to positively improve adherence [54]. Together, these findings align with the 'Psychological Capability' and 'Physical Opportunity' components of COM-B, highlighting practice-level implications such as simplifying treatment regimens, enhancing patient education during consultations, and ensuring culturally tailored communication strategies.

From a patient-level perspective, interventions that build capability, such as personalised education, home blood glucose monitoring support, and skills-based self-management coaching, may significantly improve adherence and glycaemic outcomes. Such patient-level strategies are most effective when supported by provider-level continuity of care and system-level resource availability, emphasising the multilayered nature of adherence behaviour.

4.1. Strengths and limitations of the systematic review

A major strength of this systematic review is the inclusion of cross-sectional studies to capture real-time adherence rates, reflecting current trends in T2DM and the increasing use of pharmacological therapies. This approach provides a realistic snapshot of adherence in today's healthcare context. Another strength is the exclusive focus on the Morisky Medication Adherence Scale (MMAS), which ensures homogeneity and enhances reliability and generalisability. By contrast, the review by Krass et al. [18] included various adherence tools, leading to more variable results. Using a single tool avoids discrepancies, such as those seen with objective measures like prescription refill data, which track medication collection but not consumption.

The MMAS enables the assessment of both adherence levels and associated factors. However, it has limitations, including recall bias and the risk of overestimating adherence due to patients' concerns about disappointing clinicians [62]. These factors should be carefully considered when interpreting results. Most studies in this review used consistent MMAS cut-offs, facilitating comparability across findings. This review also analysed studies published after 2013, allowing for comparisons with earlier findings from Krass et al. [18] and reflecting advancements in patient-centred care. A limitation of this review was the challenge of accurately mapping medium adherence levels. Of the studies categorising MMAS scores into low/medium/high, some (15 of 30) reported medium levels separately without combining them with high adherence, potentially skewing results. This could inflate high adherence scores and diminish medium adherence scores, warranting caution in interpretation.

5. Conclusion

This systematic review highlights the persistently low adherence to anti-glycaemic medication among patients with T2DM, with only 41 % reporting high adherence based on the Morisky Medication Adherence Scale (MMAS). Key barriers to adherence include depression, limited diabetes-related knowledge, and the complexity of treatment regimens, while enablers include family support, structured diabetes education, and effective patient-provider communication. Mapping these factors onto the COM-B behaviour change model emphasised the importance of addressing capability, opportunity, and motivation, and provides a theoretically grounded framework to guide healthcare professionals in designing more effective adherence-support interventions.

Healthcare providers can enhance adherence by prioritising patient-centred interventions, such as tailored diabetes education programmes, regular screening for depression, and simplified treatment regimens. Strengthening patient-provider communication and offering psychosocial support are crucial for addressing modifiable barriers. Additionally, structured follow-up care that integrates individualised support can help patients develop the knowledge and confidence needed to adhere to treatment plans effectively. At a system level, implementing routine adherence screening and ensuring access to culturally appropriate education resources may further strengthen diabetes management

outcomes.

Future research should explore the integration of combined adherence assessment tools to improve the accuracy of adherence measurements. Further investigation into the socio-cultural factors influencing adherence, particularly in diverse populations, is also necessary. Longitudinal studies are needed to assess the long-term impact of targeted interventions and strategies tailored to COM-B domains on adherence and clinical outcomes for individuals with T2DM.

Declarations

The authors of this manuscript declare that it has not been published elsewhere.

Authors' contributions

MA and SL conceived the idea and designed the methodology for this systematic review; MA conducted the search, screened the articles and extracted the data for write up; SL blind-screened abstracts and full text records; SL provided strategic guidance for conducting the review; SL contributed to the data analysis and revised the manuscript; MA and SL approved the final manuscript.

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Declaration of Competing Interest

The authors declare that they have no competing interests.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.pcd.2026.01.002](https://doi.org/10.1016/j.pcd.2026.01.002).

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