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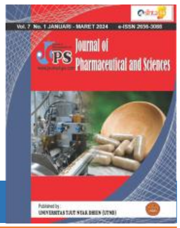

REVIEW ARTICLE JPS. 2026, 9(1), 472-485

The Effect of Medication Adherence on HbA1c Control in Type 2 Diabetes Patients: A Systematic Review Based on Adherence Measurement Methods

Pengaruh Kepatuhan Minum Obat terhadap Pengendalian HbA1c pada Pasien Diabetes Melitus Tipe 2: Tinjauan Sistematis Berdasarkan Metode Pengukuran Kepatuhan

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Abstract

Type 2 diabetes mellitus (T2DM) is a major public health concern in Asia, where rapid urbanization and lifestyle changes have contributed to a marked increase in disease prevalence. Poor medication adherence remains a major barrier to achieving optimal glycemic control, leading to an increased risk of complications and greater healthcare burden. This systematic review aimed to examine the relationship between medication adherence and glycated hemoglobin (HbA1c) levels among patients with T2DM, compare the strength of this association across different adherence measurement methods, and identify key factors influencing adherence and glycemic control in Asian populations. A literature search was conducted in PubMed, Europe PMC, Scopus, and ScienceDirect for cross-sectional studies published between January 2015 and April 2025. Eligible studies included adult patients with T2DM who reported medication adherence (e.g., MMAS-8, pill counts) and HbA1c outcomes. Data were synthesized narratively, and study quality was assessed using standardized appraisal tools. Of the 584 records screened, 14 studies met the inclusion criteria. Most studies demonstrated a significant inverse association between medication adherence and HbA1c levels, with stronger associations observed when objective or multidimensional adherence measures were used. Reported adherence levels varied substantially across studies, with the proportion of high adherence ranging from 3.7% to over 58%, depending on the measurement method. Mean HbA1c values ranged from 6.4% to 9.2%. Higher educational level, greater self-efficacy, and supportive healthcare environments were associated with better adherence. In contrast, psychological distress, regimen complexity, and comorbidities were linked to lower adherence and poorer glycemic control. Medication adherence is a critical determinant of glycemic control among patients with T2DM in Asia. The choice of adherence measurement method influences the observed association with HbA1c. Interventions should address psychosocial and clinical barriers and incorporate culturally adapted, multidimensional adherence assessment approaches.

***Keywords:** Adherence; Glycemic control; HbA1c; Medication adherence; Type 2 diabetes mellitus.*

Abstrak

Diabetes melitus tipe 2 (DMT2) merupakan masalah kesehatan masyarakat utama di Asia, seiring dengan pesatnya urbanisasi dan perubahan gaya hidup yang menyebabkan peningkatan prevalensi penyakit. Kepatuhan minum obat yang rendah masih menjadi hambatan utama dalam mencapai kontrol glikemik yang optimal, sehingga meningkatkan risiko komplikasi dan beban pelayanan kesehatan.Tinjauan sistematis ini bertujuan untuk mengkaji hubungan antara kepatuhan minum obat dan kadar hemoglobin terglikasi (HbA1c) pada pasien DMT2, membandingkan kekuatan hubungan tersebut berdasarkan metode pengukuran kepatuhan, serta mengidentifikasi faktor-faktor utama yang memengaruhi kepatuhan dan kontrol glikemik di Asia. Pencarian literatur dilakukan pada basis data PubMed, Europe PMC, Scopus, dan ScienceDirect untuk studi potong lintang yang dipublikasikan antara Januari 2015 hingga April 2025. Studi yang memenuhi kriteria melibatkan pasien DMT2 dewasa dengan pelaporan kepatuhan minum obat (misalnya MMAS-8, penghitungan pil) serta luaran HbA1c. Data disintesis secara naratif, dan kualitas studi dinilai menggunakan instrumen penilaian terstandar. Dari 584 artikel yang disaring, sebanyak 14 studi memenuhi kriteria inklusi. Sebagian besar studi menunjukkan hubungan terbalik yang signifikan antara kepatuhan minum obat dan kadar HbA1c, dengan hubungan yang lebih kuat pada penggunaan metode pengukuran kepatuhan yang objektif atau multidimensional. Tingkat kepatuhan berkisar antara 12% hingga 42%, sedangkan rerata HbA1c berkisar antara 6,4% hingga 9,2%. Tingkat pendidikan yang lebih tinggi, efikasi diri yang baik, serta lingkungan pelayanan kesehatan yang suportif berhubungan dengan kepatuhan yang lebih baik. Sebaliknya, distres psikologis, kompleksitas regimen, dan komorbiditas berhubungan dengan kepatuhan yang rendah dan kontrol glikemik yang buruk. Kepatuhan minum obat merupakan determinan penting dalam pengendalian glikemik pada pasien DMT2 di Asia. Pemilihan metode pengukuran kepatuhan memengaruhi kekuatan hubungan dengan HbA1c. Intervensi perlu menargetkan hambatan psikososial dan klinis serta menggunakan pendekatan penilaian kepatuhan yang multidimensional dan sesuai budaya.

Kata Kunci: Kepatuhan; Kontrol glikemik; HbA1c; Kepatuhan pengobatan; Diabetes melitus tipe 2.

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Introduction

Type 2 diabetes mellitus (T2DM) is a chronic, progressive disease characterized by insulin resistance and pancreatic beta-cell dysfunction, resulting in persistent hyperglycemia and a heightened risk of microvascular and macrovascular complications [1]. The global prevalence of T2DM continues to rise sharply, with the International Diabetes Federation estimating 537 million adults living with diabetes in 2021 and projecting this number to reach 783 million by 2045, with the most significant increases occurring in Asia. In Asian countries such as China, India, and Indonesia, the diabetes epidemic is fueled by rapid urbanization, lifestyle changes, and population aging, making Asia the epicenter of the global diabetes [2]. (Primary health care (PHC) plays a central role in the management of T2DM in Asia, as the majority of diabetes care and follow-up are delivered at this level[3]. However, despite advances in pharmacological therapy and diabetes management guidelines, a large proportion of patients in Asian PHC settings still fail to achieve optimal glycemic control, as assessed by glycated hemoglobin (HbA1c), which increases the risk of complications and health system burden [1,4]. Poor medication adherence is a key modifiable factor contributing to suboptimal HbA1c outcomes and is widely recognized as a persistent challenge in both urban and rural PHC contexts across Asia [5,6].

Medication adherence in T2DM is influenced by a complex interplay of demographic, psychosocial, clinical, and health system factors, which may differ across Asian populations and PHC settings[4]. Socioeconomic status, education, health literacy, psychological well-being, regimen complexity, comorbidities, and access to care all contribute to adherence variations [8]. Cultural beliefs, family support, and traditional health practices are especially important in Asia, where family involvement in care and community-based interventions can significantly influence medication-taking behavior [4,8]. Psychosocial factors such as self-efficacy, depression, diabetes-related distress, and trust in healthcare providers further impact adherence, while diabetes education and community engagement have been shown to improve outcomes in Asian PHC settings [6,9,10].

Assessment of medication adherence remains a methodological challenge. Commonly used approaches include subjective self-report questionnaires such as the Morisky Medication Adherence Scale (MMAS-8) and Medication Adherence Report Scale (MARS), as well as objective measures like pill counts and pharmacy refill data [11,12]. Self-report tools are widely used in cross-sectional studies due to their practicality in PHC, but may overestimate adherence because of recall and social desirability bias [10,13]. Objective measures, while more accurate, are often less feasible in resource-limited settings. The heterogeneity in adherence measurement complicates comparisons and may influence the observed relationship between adherence and HbA1c[14,15].

Previous studies have emphasized the importance of multifaceted interventions to improve medication adherence in type 2 diabetes, but most have focused on global populations and rarely examined how different adherence measurement methods influence clinical outcomes such as HbA1c, particularly within Asian contexts [16]. To date, systematic reviews that specifically focus on adherence measurement approaches within Asian primary healthcare settings remain limited, and methodological heterogeneity in adherence assessment has not been comprehensively synthesized.

Therefore, this systematic review synthesizes evidence from cross-sectional studies in Asia on the relationship between medication adherence and HbA1c control in T2DM patients, evaluates the influence of different adherence measurement methods, and identifies key factors affecting adherence and glycemic outcomes. By addressing this gap, the review aims to inform optimized assessment strategies, tailored interventions, and evidence-based policy development to improve glycemic control in Asian primary healthcare systems.

Methods

Study design

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure methodological rigor and transparency[17,18]. It aimed to synthesize evidence from cross-sectional studies investigating the relationship between medication adherence and HbA1c levels among adult patients with type 2 diabetes mellitus (T2DM) in primary health care (PHC) settings across Asian countries. All methodological steps—from study selection to data extraction, analysis, and synthesis—were performed systematically to minimize bias and enhance reproducibility. In addition to evaluating the association between adherence and glycemic control, this review compared the strength of this relationship across the adherence measurement methods (e.g., self-report scales, objective measures) used in the included studies. The cross-sectional design enabled focused analysis of adherence patterns and their immediate association with HbA1c outcomes across diverse Asian PHC contexts.

Search strategy

A systematic literature search was performed across four major databases: PubMed, Scopus, ScienceDirect, and Europe PMC (Table 1). These databases were selected for their comprehensive coverage of medical and pharmaceutical research relevant to type 2 diabetes and medication adherence. The search strategy utilized a combination of Medical Subject Headings (MeSH) and keywords, including terms such as "Type 2 Diabetes Mellitus," "Medication Adherence," "HbA1c," "Glycemic Control," and specific adherence measurement methods like "Morisky Medication Adherence Scale," "Medication Possession Ratio," and "Pharmacy Refill." Boolean operators (AND/OR/NOT) were applied to construct search queries tailored to each database. The search was restricted to English-language articles published between January 2015 and April 2025. Although this restriction ensured consistency in data interpretation, it may have excluded relevant studies published in local Asian languages, thereby introducing potential language bias. The search strategy was designed to identify studies examining the association between medication adherence and HbA1c levels among adult patients with type 2 diabetes, with particular attention to the adherence assessment methods employed.

Eligibility criteria

The eligibility criteria were established to prioritize studies investigating the relationship between medication adherence and HbA1c control in adults with type 2 diabetes mellitus (T2DM) within primary health care (PHC) settings across Asia. Studies were included if they utilized a cross-sectional design, were

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conducted in Asian PHC facilities, involved adult patients (≥18 years), explicitly assessed the association between medication adherence and HbA1c levels, specified the adherence measurement method employed (e.g., self-report scales, objective tools), and reported factors influencing adherence. Only articles published in English between 2015 and 2025 were considered. Studies were excluded if they failed to report HbA1c as an outcome, were conducted outside Asia or lacked separate Asian data, did not explicitly evaluate medication adherence, or were non-empirical publications such as reviews, editorials, or commentaries.

Table 1. Search terms in the database

Database	Search terms	Search date	Number of articles	Filter
PubMed	("Diabetes Mellitus, Type 2" [Mesh] OR "Type 2 Diabetes" OR "Type 2 Diabetes Mellitus" OR T2DM) AND ("Medication Adherence" [Mesh] OR "Patient Compliance" [Mesh] OR "Medication Adherence" OR "Treatment Adherence" OR "Therapeutic Adherence") AND ("Hemoglobin A, Glycosylated" [Mesh] OR "HbA1c" OR "Glycated Hemoglobin" OR "Glycosylated Hemoglobin") AND ("Blood Glucose" [Mesh] OR "Glycemic Control" OR "Glycemic Regulation") AND ("Surveys and Questionnaires" [Mesh] OR "Self Report" [Mesh] OR "Electronic Monitoring" [Mesh] OR "Morisky Medication Adherence Scale" OR "Medication Possession Ratio" OR "Adherence Scale" OR "Adherence Measurement" OR "Adherence Assessment" OR "Pill Count" OR "Pharmacy Refill")	April, 07 th 2025	93	Best match 2015-2025 English Language
Scopus	(TITLE-ABS-KEY ("Type 2 Diabetes" OR "T2DM") AND ALL ("Medication Adherence" OR "Therapeutic Adherence") AND ALL ("HbA1c" OR "Glycated Hemoglobin") AND ALL ("Glycemic Control") AND ALL ("Adherence Measurement" OR "Adherence Scale" OR "Adherence Method")) AND PUBYEAR > 2014 AND PUBYEAR < 2026 AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (OA, "all"))	April, 07 th 2025	110	English Language All Open Access 2015-2025 Sorted by relevance
Science direct	("Type 2 Diabetes" OR "T2DM") AND ("Medication Adherence") AND ("HbA1c" OR "Glycated Hemoglobin") AND ("Glycemic Control") AND ("Adherence Measurement" OR "Adherence Scale" OR "Adherence Method")	April, 07 th 2025	44	English Language Open Access and Open Archive 2015-2025 Sorted by relevance
Europe PMC	("Type 2 Diabetes" OR "Type 2 Diabetes Mellitus" OR T2DM) AND ("Medication Adherence" OR "Treatment Adherence" OR "Therapeutic Adherence") AND ("HbA1c" OR "Glycated Hemoglobin" OR "Glycosylated Hemoglobin") AND ("Glycemic Control") AND ("Adherence Measurement" OR "Adherence Scale" OR "Adherence Assessment") AND (FIRST_PDATE:[2015 TO 2025])	April, 07 th 2025	337	English Language 2015-2025 Sorted by relevance

Data Extraction

Data extraction was conducted after duplicate articles were removed using Zotero and Microsoft Excel to enhance the efficiency of the initial selection process. After duplicates were removed, the remaining articles' titles and abstracts were screened to assess their relevance and consistency with the review's objectives. Only studies with complete full-texts and coherent content were included in the eligibility assessment, based on predetermined inclusion and exclusion criteria. The eligible articles were then subjected to a detailed data extraction process, carried out independently by the researchers using a standardized form. Key information extracted included the study title, author names, year of publication, journal source, research objectives, sample characteristics (such as age and sample size), study setting, data collection and analysis methods, main findings, authors' recommendations, notable comments, and the strengths and limitations of each study. Any

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discrepancies or disagreements during the extraction process were resolved through collaborative discussion among the researchers until consensus was reached. This structured and multi-step approach ensured that the final dataset was comprehensive, reliable, and unbiased.

Article selection

The article selection process in this systematic review adhered to the PRISMA 2020 guidelines to ensure transparency and methodological rigor. A total of 584 records were initially identified from four electronic databases: PubMed (n = 93), Europe PMC (n = 337), Scopus (n = 110), and ScienceDirect (n = 44). After removing 109 duplicate records, 475 unique articles remained for title and abstract screening. During the screening phase, 475 records were assessed, and 420 were excluded for the following reasons: not relevant based on title and abstract (n = 326), review articles (n = 88), book chapter or practice guideline (n = 1), and not original research (conference abstracts, n = 2, paper, n = 5). This resulted in 53 articles sought for retrieval. Of the 53 articles, 3 could not be retrieved due to limited access, broken links, or administrative issues. Thus, 50 full-text articles were assessed for eligibility. After full-text review, 32 articles were excluded for the following reasons: not relevant to study design (n = 3), no relevant outcomes (n = 3), not relevant medication adherence tool (n =1), not conducted at Primary Healthcare settings in Asia (n = 29), and full text not available (n = 0). Ultimately, 14 studies met all inclusion criteria and were included in the final systematic review. The entire selection process is summarized in the PRISMA flow diagram (Figure 1), which details the number of records identified, screened, and excluded, and the reasons for exclusion at each stage.

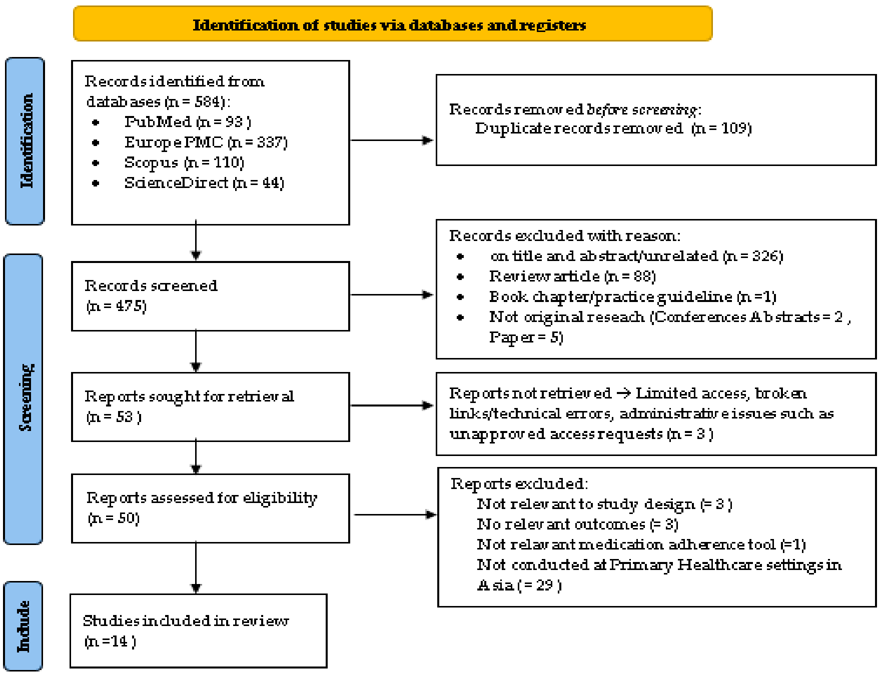

Figure 1. PRISMA flow diagram

Data Analysis

Data analysis used a narrative synthesis to summarize the characteristics of the included studies comprehensively, the adherence measurement methods employed, and the relationship between medication adherence and HbA1c levels. Statistical findings were organized into tables and synthesized by adherence measurement tool type and regional variation. Where reported, effect size estimates (e.g., correlation coefficients, odds ratios, regression coefficients) and corresponding p-values and confidence intervals were extracted and presented to facilitate comparison of association strength across studies. The methodological quality of each included study was evaluated using the JBI Critical Appraisal Checklist for Analytical Cross-Sectional Studies, and the appraisal results were integrated into the interpretation of the findings to provide context on the robustness and reliability of the evidence. Based on the JBI critical appraisal, a total of 14 articles were included, with 12 (86%) achieving the highest methodological quality score of 8 out of 8 and 2 (14%) scoring 7 out of 8. Variations in study populations, adherence definitions, and measurement approaches were further explored through subgroup analyses and stratification by region and adherence assessment method.

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Table 2. The quality assessment of studies

Author (Year)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Total 8/8 (100%)
Mirahmadizadeh et al. (2020)[5]	Y	Y	Y	Y	Y	Y	Y	Y	8/8 (100%)
Jafarian-Amirkhizi et al. (2018)[14]	Y	Y	Y	Y	Y	Y	Y	Y	8/8 (100%)
Lee et al. (2017)[19]	Y	Y	Y	Y	Y	Y	Y	Y	8/8 (100%)
Yahya et al. (2023)[20]	Y	Y	Y	Y	Y	Y	Y	Y	8/8 (100%)
Chew et al. (2015)[4]	Y	Y	Y	Y	Y	Y	Y	Y	8/8 (100%)
AlShayban et al. (2020)[9]	Y	Y	Y	Y	Y	Y	Y	Y	8/8 (100%)
Sayed Ahmed et al. (2023)[6]	Y	Y	Y	Y	Y	Y	Y	Y	8/8 (100%)
Khdour et al. (2020)[21]	Y	Y	Y	Y	Y	Y	Y	Y	8/8 (100%)
Muliyil et al. (2017)[12]	Y	Y	Y	Y	Y	Y	Y	Y	8/8 (100%)
Al-Oerem et al. (2022)[13]	Y	Y	Y	Y	Y	Y	Y	Y	8/8 (100%)
Radwan et al. (2017)[10]	Y	Y	Y	Y	Y	Y	Y	Y	8/8 (100%)
Al-Chawishli et al. (2024)[15]	Y	Y	Y	Y	Y	Y	Y	Y	8/8 (100%)
Arafat et al. (2020)[22]	Y	Y	Y	Y	Y	CT	Y	Y	7/8 (87,5%)
Durai et al. (2021)[23]	Y	Y	Y	Y	Y	CT	Y	Y	7/8 (87,5%)

Y, Yes; CT, Can not tell

Results And Discussion

Characteristics of Included Studies

This systematic review included 14 cross-sectional studies conducted across countries in the Middle East, South Asia, and Southeast Asia, representing heterogeneous populations of patients with type 2 diabetes mellitus (T2DM) (Table 3) [13,23]. Sample sizes varied substantially, ranging from 100 participants in a community-based study in India.[12] to 700 in a multi-clinic study in Malaysia[4] The mean age of participants ranged from 44.0 years in Saudi Arabia. [9] to 62.0 years in Singapore[19], encompassing both middle-aged and older adults. Most studies included patients with a minimum diabetes duration of one year, with some focusing exclusively on insulin users[20] and others on oral hypoglycemic agents only [12]. Medication adherence was assessed using various instruments, including the Morisky Medication Adherence Scale (MMAS-8, MMAS-4), Medication Adherence Report Scale (MARS-5), General Medication Adherence Scale (GMAS), Morisky-Green Levine Scale (MGLS), pill counts, and other locally developed adherence scales. Adherence levels were highly variable, with high adherence reported in only 13.6% of patients in one Iranian study[5],while several studies reported moderate-to-high adherence exceeding 50% (e.g., Khdour et al., 2020; Arafat et al., 2020). In contrast, poor adherence was predominant among insulin-treated patients in Malaysia (60%) [20]. This variability may be partly attributed to differences in adherence measurement instruments and reporting formats (continuous mean scores versus categorical classifications), which limited direct comparability across studies. Glycemic control, measured by mean or median HbA1c, also showed substantial variation. Well-controlled levels were observed in high-adherence groups, such as 6.4% in Iraq [15], whereas poorly controlled levels exceeding 9% were reported among insulin-dependent populations [20] and in Palestinian primary care settings [10]. Several studies noted that self-reported adherence did not always align with glycemic outcomes, as seen in Malaysia [4] and India [12].

Statistical Association Between Medication Adherence and HbA1c

Most of the 14 reviewed studies demonstrated a significant inverse relationship between medication adherence and HbA1c levels, indicating that higher adherence is associated with improved glycemic control [5,15] (Table 4). For example, Mirahmadizadeh et al. (2020) reported a moderate negative correlation between adherence and HbA1c ($r = -0.30$, $p < 0.001$), suggesting that patients with better adherence tend to have lower HbA1c values. Similarly, Al-Chawishli et al. (2024) found that patients with high medication adherence had significantly lower odds of poor glycemic control (adjusted odds ratio [aOR] = 0.21, $p < 0.001$). Other studies reinforce this association, including Al-Shayban et al. (2020), who reported a strong negative correlation between General Medication Adherence Scale (GMAS) scores and HbA1c ($r = -0.423$, $p < 0.01$). Ahmed et al. (2023) identified medication adherence as a significant predictor of lower HbA1c ($\beta = -0.198$, $p = 0.001$). Radwan et al. (2017) demonstrated that patients with high adherence were more likely to achieve good glycemic control (odds ratio [OR] = 2.757, 95% confidence interval [CI]: 1.308–4.693). Dhillon et al. (2019) found

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similar results, showing that adherence was significantly associated with better quality of life, including glycemic outcomes (aOR = 3.35, p = 0.012). Moreover, Al-Qerem et al. (2022) reported that patients with low or moderate adherence had higher odds of poor glycemic control than those with high adherence (OR = 0.28 and 0.36, respectively; $p < 0.05$). Muliyil et al. (2017) and Durai et al. (2021) also demonstrated significant inverse associations between adherence and HbA1c (β = –0.236, p = 0.02; β =- 0.016, p = 0.016, respectively). Additional factors influencing glycemic outcomes were identified. Older age, overweight status, smoking, and longer diabetes duration were associated with poorer glycemic control[5,14]. Conversely, higher levels of education and health literacy were associated with better medication adherence and glycemic outcomes [10,20]. Female sex and stronger beliefs about medication necessity also positively correlated with glycemic control[13]. Nevertheless, some studies did not find significant associations. For instance, Jafarian-Amirkhizi et al. (2018) reported no significant relationship between adherence and HbA1c (p = 0.19), likely due to limited variability within their sample. Similarly, Arafat et al. (2020) found no meaningful correlation (r = –0.002, p > 0.05), suggesting that self-reported adherence alone may be insufficient to predict glycemic control without accounting for other lifestyle factors, such as diet and physical activity. Overall, the findings consistently demonstrate that medication adherence is a crucial determinant of glycemic control in patients with type 2 diabetes mellitus. Regular medication intake ensures therapeutic plasma drug levels that help maintain glucose homeostasis and prevent complications[5,15]. However, discrepancies in findings across studies highlight that adherence interacts with other behavioral and clinical variables that influence HbA1c, underscoring the importance of comprehensive diabetes management strategies that integrate pharmacological adherence with lifestyle modification and patient education [10,20].

Factors Influencing Medication Adherence or HbA1c

Several demographic, clinical, and psychosocial factors were found to significantly influence medication adherence and glycemic control (HbA1c) in the 14 reviewed studies (Table 4). Older age was associated with poorer glycemic control, with odds ratios ranging from 0.48 to 1.032 and significant p-values (OR = 0.48, 95% CI: 0.26–0.88; AOR = 1.032, p = 0.007) [5,9]. Conversely, younger age correlated with better adherence (OR = 0.97, p = 0.01)[19]. Longer diabetes duration was consistently linked to worse HbA1c and adherence challenges (β = 0.77, p = 0.016) [14], while a shorter duration was associated with better control (OR = 2.255) [10]. Higher education and health literacy significantly improved adherence and glycemic outcomes, with p-values ranging from 0.001 to 0.02 [10,20,21]. Patients with higher income and access to insurance coverage showed significantly better management outcomes (AORs 2.79–5.40, $p < 0.05$) [9]. Female sex and stronger beliefs in medication necessity were significantly correlated with better adherence and HbA1c control (OR = 2.28 for sex; OR = 2.75 for necessity; $p < 0.05$) [13]. Clinical comorbidities such as overweight (OR = 0.53, CI: 0.34–0.84) and smoking (OR = 0.24, CI: 0.13–0.42) were linked to poorer glycemic control [5]. Dyslipidemia and absence of home glucose monitoring showed strong associations with poor control (OR = 70.1 and OR = 0.20, respectively) [15]. These findings suggest that medication adherence is a multidimensional construct shaped by psychological and social determinants as much as by clinical ones. Patients with stronger self-efficacy, social support, and trust in healthcare providers are more likely to follow prescribed regimens and achieve optimal HbA1c levels [6,13]. Meanwhile, regimen complexity and treatment fatigue, common in long-standing diabetes, can undermine adherence. Importantly, non-adherence is often intertwined with emotional distress and low motivation, emphasizing the need for psychosocial interventions alongside pharmacotherapy. Studies further noted that active self-management behaviors, such as dietary modification and glucose self-monitoring, complemented adherence to medication in improving glycemic control [15,23]. Hence, interventions targeting both behavioral and systemic barriers are essential for sustainable diabetes management.

Regional Variations and Cultural Context

Cultural, socioeconomic, and healthcare system factors across Asia exert significant influence on medication adherence and glycemic control (Table 3 and Table 5) [9,15]. In Middle Eastern countries such as Iraq and Saudi Arabia, family support and religious motivation often encourage better adherence behaviors, while political instability or healthcare disruptions, as seen in Gaza, can hinder consistent treatment access [10]. In Southeast Asia, Malaysia faces unique challenges: insulin stigma among patients contributes to poor adherence despite relatively good healthcare infrastructure [20]. Socioeconomic disparities are also evident; patients in rural India and Palestine often experience financial barriers and limited access to medications, resulting in suboptimal adherence despite reported motivation[12]. Conversely, urban patients generally show

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higher adherence due to improved education and healthcare accessibility [5,23]. These findings underscore the importance of culturally contextualized interventions. Locally validated tools such as the Kurdish MMAS-8, Arabic GMAS, and Malaysian MALMAS improved the reliability of adherence assessments and supported the development of region-specific adherence strategies [9,15]. Integrating these cultural insights into diabetes management may enhance patient engagement and long-term outcomes. Family-based counseling, community pharmacist interventions, and religious or peer-group support systems have demonstrated promise in improving adherence rates. Taken together, regional differences emphasize that successful diabetes management requires not only pharmacological optimization but also social, economic, and cultural responsiveness in healthcare delivery.

Comparison of Medication Adherence Instruments

Among the reviewed studies, the Morisky Medication Adherence Scale-8 (MMAS-8) was the most frequently employed adherence assessment tool (Table 6). It demonstrated moderate to high internal consistency (Cronbach's $\alpha = 0.657–0.83$) and has been validated in several languages. However, its reliance on self-report makes it vulnerable to recall and social desirability bias, potentially leading to overestimated adherence. [10,14]. This limitation may partly explain the weaker statistical relationships observed in some MMAS-based studies. The shorter Morisky Medication Adherence Scale-4 (MMAS-4) offered greater efficiency and ease of use but lacked the detailed granularity provided by longer instruments and was susceptible to similar self-report biases[10]. Other tools, such as the Medication Adherence Report Scale (MARS-5) and the General Medication Adherence Scale (GMAS), provided good psychometric reliability ($\alpha = 0.77–0.90$ and 0.82–0.88, respectively) and broader coverage of contextual factors like medication cost and pill burden[9,19]. The GMAS, particularly useful in populations with multiple comorbidities, showed a stronger correlation with HbA1c, possibly because of its multidimensional construct, which captures behavioral, economic, and regimen-related factors. Similarly, the Adherence to Diabetes Self-Management Questionnaire (A-DSMQ) integrated behavioral aspects, yielding strong negative correlations with HbA1c ($r = –0.48$)[6]. Objective measures, though less frequently applied, offered more robust clinical insights. Pill counts and pharmacy refill data correlated well with HbA1c, but cannot confirm the actual ingestion of medication[10, 12]. Taken together, these findings suggest that no single adherence instrument is universally optimal; rather, measurement selection should be guided by psychometric robustness, intended clinical or research purpose, and feasibility within the healthcare setting. Studies also emphasized the importance of culturally adapted instruments to enhance accuracy and interpretability across diverse Asian populations. For rapid screening in busy primary care clinics with limited resources, culturally validated brief self-report tools such as the MMAS-4 or MMAS-8 are appropriate due to their simplicity, low cost, and ease of administration. In contrast, for research purposes or for monitoring patients with complex regimens or persistently uncontrolled HbA1c, multidimensional instruments such as the GMAS or A-DSMQ are preferable, particularly when combined with objective measures (e.g., pharmacy refill records or pill counts) to enhance measurement accuracy. This differentiation allows clinicians and researchers to align instrument selection with the purpose of assessment, available resources, and the complexity of patient needs. In high-risk patients or those with discordant clinical outcomes, integrating self-reported adherence assessment with objective refill data may provide a more comprehensive evaluation of medication-taking behavior, thereby improving the identification of true non-adherence and informing targeted interventions.

Limitations

This review has several limitations. First, the literature search was restricted to English-language publications, potentially excluding relevant studies published in local Asian languages. Given the regional focus of this review, this restriction may have introduced language bias and limited the comprehensiveness of the findings. Second, all included studies employed cross-sectional designs, as longitudinal and interventional studies were excluded based on the eligibility criteria. Although this design is appropriate for examining associations, it does not allow causal inferences between medication adherence and HbA1c levels. The observed inverse relationship should therefore be interpreted as an association rather than a cause-and-effect relationship. Longitudinal and interventional studies are needed to establish temporal relationships and causality. Third, substantial heterogeneity was observed in the definitions and measurement of medication adherence, including the use of different self-reported and objective instruments and varying adherence cut-off points. This variability may limit comparability across studies and preclude quantitative synthesis of effect estimates. Finally, although most studies demonstrated moderate to high methodological quality according to standardized appraisal tools, variations in sample size, statistical adjustment for confounders, and reporting transparency may have introduced residual bias and weakened the reported associations.

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Table 3. Characteristics of Included Studies

Author (Year)	Country	Setting	Population	Mean Age (years)	Study Design	Sample Size	Medication Adherence Instrument	Adherence Score (Mean ± SD)	Adherence Category Score (%)	Mean/Median HbA1c (%)
Mirahmadizadeh et al. (2020) [5]	Iran	10 diabetes clinics, Shiraz	T2DM, ≥30 years old, diabetes ≥2 years	56.9	Cross-sectional	500	MMAS-8	Not Reported	27.2 Low, 59.2 Moderate, 13.6 High	7.48
Jafarian-Amirkhizi et al. (2018) [14]	Iran	Community pharmacies, Tehran	T2DM, on meds ≥6 months, urban Iran	55.8	Cross-sectional	348	MMAS-8	Not Reported	57.5 Low, 42.5 Moderate/High	8.39
Lee et al. (2017) [19]	Singapore	Public primary care clinic, SengKang	T2DM, 35–84 years, on ≥1 OHA, ≥2 visits/6 mo	62.0	Cross-sectional	382	MARS-5	Not Reported	57.1 Low, 42.9 High	7.2 (median, IQR 6.6–7.9)
Yahya et al. (2023) [20]	Malaysia	Sungai Buloh Health Clinic, Selangor	T2DM, ≥18 years, insulin users ≥1 year	58.8	Cross-sectional	300	MIAS (Insulin-specific)		60 Poor, 36.3 Moderate, 3.7 Good	9.65 (pre), 9.19 (6 mo)
Chew et al. (2015) [4]	Malaysia	3 public health clinics	T2DM, ≥30 years, diabetes >1 year, regular follow-up	56.9	Cross-sectional	700	MMAS-8	Mean 5.6 ± 1.42	Not Reported	8.5 ± 2.1
AlShayban et al. (2020) [9]	Saudi Arabia	3 community pharmacies, Khobar	T2DM, adults, diagnosed ≥3 months, outpatients	44.0 ± 15.5	Cross-sectional	318	GMAS	Not Reported	33 High, 25.5 Good, 33 Partial, 6.6 Low, 1.9 Poor	8.1
Sayed Ahmed et al. (2023) [6]	Egypt	5 PHC centers, Port Said	T2DM, ≥40 years, diabetes ≥1 year, PHC patients	59.7 ± 7.9	Cross-sectional	319	MMAS-8	Mean 6.58 ± 1.48	79.9% moderate/excellent	7.75 ± 1.07
Khdour et al. (2020) [21]	Palestine	Primary Healthcare Unit, Ramallah	T2DM, >18 years, on meds >3 months	52.9 ± 13.9	Cross-sectional	380	MGLS (Morisky Green Levine)	Not Reported	57.9 High, 42.1 Low	45.8% <7%, 54.2% ≥7%
Muliyil et al. (2017) [12]	India	Peripheral mobile clinics, Vellore	T2DM, >30 years, on OHA ≥1 year, not on insulin	60.3 ± 10.2	Cross-sectional	100	Pill count (home visit)	Not Reported	52 compliant (≥80% pills taken)	7.3 ± 1.4

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Al-Oerem et al. (2022) [13]	Jordan	NCDEG, Amman	T2DM, ≥18 years, diabetes ≥1 year, on ≥1 antidiabetic	56.0 ± 14	Cross-sectional	287	4-item Adherence Scale (Arabic)	Not Reported	12.2 Low, 46.7 Moderate, 41.1 High	7.7 ± 1.8
Radwan et al. (2017) [10]	Palestine	4 MoH PHCs, Gaza Strip	T2DM, ≥26 years, on antidiabetic ≥6 months	56.4	Cross-sectional	369	MMAS-4 (Arabic)	Not Reported	58.0 High, 39.6 Medium, 2.4 Low	8.97 ± 2.02
Al-Chawishli et al. (2024) [15]	Iraq	Public/private clinics, Erbil	T2DM, ≥25 years, on antidiabetic ≥3 months	N/A	Cross-sectional	300	MMAS-8 (Kurdish)	Not Reported	27 High, 32.6 Moderate, 40.3 Low	6.4 (High), 9.2 (Low)
Arafat et al. (2020) [22]	Qatar	Mesaimeeraand West Bay Health Centers	T2DM, adults, on oral antidiabetics and/or insulin	54.3 ± 10.2	Cross-sectional	387	MMAS-8	Not Reported	57.8 High, 17.9 Medium, 24.3 Low	Median 7.5 (IQR 2.2)
Durai et al. (2021) [23]	India	Rural health center, Tamil Nadu	T2DM, registered at NCD clinic, on treatment ≥6 mo	56.2	Cross-sectional	390	Modified MMAS/Hill-Bone/ARMS	Not Reported	57.2 good, 42.8 poor	62.8% ≤7%, 37.2% >7%

Note : Abbreviations: MMAS = Morisky Medication Adherence Scale; MARS = Medication Adherence Report Scale; GMAS = General Medication Adherence Scale; MGLS = Morisky Green Levine Scale; OHA = Oral Hypoglycemic Agent; PHC = Primary Health Center; NCDEG = National Center for Diabetes, Endocrinology and Genetics. Adherence data are presented as mean ± standard deviation (SD) when available or as categorical distribution (%) according to the original study classification. "Not Reported" indicates that the original study did not provide data in that format.

Table 4. Association Between Medication Adherence and HbA1c and Influencing Factors

Author (Year)	Association with HbA1c (Direction/Strength)	Key Influencing Factors (Adherence or HbA1c)	Statistical Test and Result
Mirahmadizadeh et al. (2020) [5]	Negative, moderate (r=-0.30, p<0.001)	Older age, overweight, smoking	Ordinal logistic regression; OR=0.48 (age), 0.53 (overweight), 0.24 (smoking); CI: 0.26–0.88, 0.34–0.84, 0.13–0.42
Jafarian-Amirkhizi et al. (2018) [14]	Not significant (p=0.19)	Longer diabetes duration, therapy complexity	Linear regression; β=0.77 (oral+insulin), p=0.016
Lee et al. (2017) [19]	Negative, significant (OR=1.27, p=0.01)	Younger age, Chinese ethnicity, higher HbA1c	Logistic regression; OR=0.97 (age), 2.80 (Chinese), 1.27 (HbA1c)
Yahya et al. (2023) [20]	Negative, significant (p=0.001)	Higher education	Chi-square; p=0.004 , Effect size not reported; only p-value provided.
Chew et al. (2015) [4]	Univariate: Negative, significant (r=-0.136, p<0.001)	Not Reported	Not Reported

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	Multivariate: Negative, non-significant (β=-0.11, p=0.082)		
AlShayban et al. (2020) [9]	Negative, significant (r=-0.423, p<0.01)	Disease knowledge, income, education, comorbidity, insurance	Logistic regression; OR=4.46 Age (AOR=1.032, p=0.007); income (AOR=4.16 to 5.40, p<0.001); education (primary: AOR=0.33, p=0.027; secondary: AOR=0.32, p=0.043); comorbidity (AOR=2.72, p=0.005); medicine obtain from government/company insurance (AOR=2.79–4.03, p=0.009–0.040)
Sayed Ahmed et al. (2023) [6]	Negative, significant (β = –0.198, p = 0.001)	Age, marital status, duration of diabetes	Multiple regression; β= –0.168 p = 0.018 (age), –0.181 p= 0.002 (married), 0.227 p= 0.001 (duration)
Khdour et al. (2020) [21]	Positive, significant (p=0.01)	Higher education, fewer medications, no comorbidities, HbA1c <7%	Chi-square, t-test, Mann-Whitney; p=0.02, 0.01, 0.01, 0.01, Effect size not reported; only p-value provided
Muliyil et al. (2017) [12]	Negative, significant (β=-0.236, p=0.02)	Age, Diabetes duration	Multiple linear regression; (β=–0,223, p=0,036), (β=0.269, p=0.01)
Al-Oerem et al. (2022) [13]	Negative, significant (OR=0.28/0.36, p=0.04/<0.01)	Female sex, necessity score	Binary logistic regression; OR=2.28 (sex), 2.75 (necessity)
Radwan et al. (2017) [10]	Positive, significant (OR=2.757, p<0.05)	Older age, shorter diabetes duration, and health literacy	Multivariate logistic regression; OR=0.96 (age), 2.255 (duration), 2.124 (literacy)
Al-Chawishli et al. (2024) [15]	Negative, strong (aOR=0.21, p<0.001)	Dyslipidemia, home glucose monitoring	Multivariate logistic regression; OR=70.1 (dyslipidemia), 0.20 (monitoring)
Arafat et al. (2020) [22]	Not significant (r=-0.002, p>0.05)	Disease duration, medication count	Spearman correlation; r=0.19 (duration), 0.17 (medications), p<0.001
Durai et al. (2021) [23]	Negative, significant (p=0.016)	Diet modification compliance	Chi-square; p = 0,006, Effect size not reported; only p-value provided.

Note: Abbreviations: OR = Odds Ratio; AOR = Adjusted Odds Ratio; CI = Confidence Interval; β = Regression Coefficient. "Not reported" indicates that the original study did not provide detailed information regarding influencing factors or multivariable statistical analyses relevant to this review. "Effect size not reported" indicates that the study reported only p-values without corresponding effect size estimates (e.g., OR, r, β).

Table 5. Regional Barriers and Facilitators of Medication Adherence in Asian Countries

Region	Countries Included	Key Barriers to Adherence	Key Facilitators of Adherence	Contextual Factors
Middle East	Iran [5,14], Iraq [15], Saudi Arabia [9], Jordan [13], Palestine [10,21], Qatar [22], Egypt [6]	Political instability (Gaza), healthcare disruptions, financial constraints, and comorbidities	Family support, religious motivation, health literacy, and stronger beliefs about medication necessity	Use of culturally adapted tools (Arabic MMAS-4, GMAS, Kurdish MMAS-8); variable healthcare access
Southeast Asia	Malaysia [4,20], Singapore [19]	Insulin stigma, therapy complexity	Higher education, structured primary care systems, and pharmacist involvement	Urban primary care clinics; validated tools (MIAS, MMAS-8); relatively strong infrastructure
South Asia	India [12,23]	Financial barriers, rural access limitations, and limited healthcare resources	Community/mobile clinics, pill-count monitoring, family involvement	Rural healthcare settings; home visits; resource-limited environments

Note: Barriers and facilitators were synthesized from cross-sectional studies conducted in each region. Factors presented reflect those reported or discussed in the included studies and may not have been uniformly measured across all studies.

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Table 6. Medication Adherence Measurement Method

(Author, Year)	Instrument	Validation / Reliability (Cronbach's α, etc.)	Strengths	Weaknesses
Mirahmadizadeh et al. (2020)[5]; Jafarian-Amirkhizi et al. (2018)[14]; Chew et al. (2015)[4]; Sayed Ahmed et al. (2023)[6]; Al-Chawishli et al. (2024)[15]; Arafat et al. (2020)[22]	MMAS-8	α=0.83 (original), α=0.657 (Malay), α=0.795 (Arabic)	Widely validated; easy to administer; moderate correlation with HbA1c; available in multiple languages	Recall/social desirability bias; moderate internal consistency in some translations
Radwan et al. (2017)[10];	MMAS-4	α=0.61–0.70 (various)	Quick, simple, and useful for screening	Overestimates adherence; less granularity
Lee et al. (2017)[19]	MARS-5	α=0.77–0.90 (various)	Validated in chronic diseases; good criterion validity (r=0.71 with objective measure)	May overestimate adherence; self-report
Yahya et al. (2023)[20]	MIAS	α=0.89 (8-item, revised)	Insulin-specific; high reliability and dimensionality (EFA/CFA supported)	Needs further external validation
Khdour et al. (2020)[21]	MGLS	α=0.61		
Muliyil et al. (2017)[12]	Pill count	Objective method	Direct, objective; strong correlation with HbA1c	Cannot confirm ingestion; risk of pill dumping
AlShayban et al. (2020)[9]	GMAS	α=0.82–0.88 (English/Arabic)	Multidimensional (cost, comorbidity, pill burden); validated for chronic illness	Less global validation; more complex
Al-Oerem et al. (2022)[13]	4-item Adherence Scale	Not Reported	Simple, validated Arabic version	Less granularity; recall bias
Durai et al. (2021)[23]	Modified MMAS/Hill-Bone/ARMS	Not Reported	Adapted for local context; comprehensive	Not externally validated

Note: Cronbach's alpha values are reported as presented in the original studies and may vary depending on language adaptation and population. "Not reported" indicates that reliability data were not available in the respective publication.

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Conclusion

Medication adherence remains a key and modifiable determinant of glycemic control among adults with type 2 diabetes mellitus across Asia. The evidence consistently demonstrates an inverse association between adherence and HbA1c levels, although its magnitude varies depending on measurement methods and contextual factors such as education, healthcare access, and cultural support. While self-reported instruments are practical and widely used, combining them with objective measures may enhance assessment reliability. Effective diabetes management, therefore, requires integrated strategies addressing pharmacological, psychosocial, and socioeconomic barriers. Future research should prioritize longitudinal and prospective studies to clarify causal relationships and develop simple, objective, and standardized adherence measurement tools tailored to Asian healthcare settings, thereby strengthening clinical practice and policy development. In clinical practice, routine adherence screening using brief validated tools such as the Morisky Medication Adherence Scale-8 should be incorporated into diabetes care, particularly for patients with suboptimal glycemic control. At the program and policy level, integrating structured adherence assessment and culturally appropriate patient education into national diabetes strategies may improve outcomes. Future research should emphasize standardized and culturally validated measurement approaches to support evidence-based decision-making across diverse Asian settings.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this review.

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