

Review

Adherence to diabetes self-care behaviors among patients with diabetes mellitus in Pakistan: a systematic review and meta-analysis

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ABSTRACT

Diabetes mellitus is a major public health challenge in Pakistan. Effective management depends on adherence to self-care behaviors, yet current evidence is fragmented. This systematic review and meta-analysis synthesize evidence on adherence to diabetes self-care behaviors among Pakistani patients. PubMed, Embase, Web of Science, Scopus, Google Scholar, and PakMediNet were systematically searched up to August 2025. Observational studies assessing diabetes self-care were included. Prevalence estimates and standardized mean scores (0–100scale) were pooled. Meta-regression and publication bias analyses were conducted. Sixty-five studies (2003–2025) were included. Overall self-care pooled prevalence was 47% (95% CI: 29%–66%), with a mean standardized score of 53.6% (95% CI: 47.8%–59.4%). Medication adherence was highest (prevalence: 74%, 95% CI: 63%–83%; score: 72.7%). Physical activity showed the poorest adherence (prevalence: 37%, 95% CI: 29%–46%; score: 45.5%). Publication year was significantly associated with physical activity adherence prevalence ($p = 0.02$). Statistical heterogeneity was substantial across most pooled analyses, indicating considerable variability between studies. Diabetes self-care behaviors in Pakistan remain suboptimal, especially for lifestyle-related practices. The substantially higher adherence to medication than to physical activity and other self-care behaviors highlights the need for culturally appropriate interventions that strengthen lifestyle modification alongside pharmacological management.

1. Introduction

Diabetes Mellitus (DM) is one of the major global public health challenges, with its prevalence rapidly increasing, especially in low- and middle-income countries [1]. Pakistan is among the countries with the highest burden of diabetes worldwide. According to the International Diabetes Federation (IDF), approximately 34.5 million adults aged 20–79 years were living with diabetes in Pakistan in 2024, with an age-standardized prevalence of 31.4%, the highest reported globally. The IDF also projects that the number of adults with diabetes in Pakistan may increase to more than 70 million by 2050. This growing burden places substantial pressure on the healthcare system and increases the risk of

diabetes-related complications [2,3].

In addition to pharmacological treatment, effective diabetes management also depends on patients' active participation in self-care behaviors [4]. These behaviors include following a healthy diet, engaging in regular physical activity, maintaining medication adherence, practicing foot care, and performing self-monitoring of blood glucose (SMBG) which are commonly assessed using validated tools such as the Summary of Diabetes Self-Care Activities (SDSCA) measure and the Diabetes Self-Management Questionnaire (DSMQ) [5–7]. Evidence shows that appropriate self-care can lead to improved glycemic control, reduced complications, and enhanced quality of life among individuals with diabetes [4]. Despite the critical importance of self-care, adherence

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0168-8227/© 2026 Elsevier B.V. All rights are reserved, including those for text and data mining, AI training, and similar technologies.

to these behaviors remains suboptimal in many regions, particularly in developing countries such as Pakistan [8].

In one study, only 42% of participants showed good compliance with self-care practices, with physical activity receiving the lowest scores [9]. Another study indicated that blood glucose monitoring and medication adherence were better maintained compared to foot care and physical activity [10]. Furthermore, a qualitative study conducted in Lahore identified financial constraints, physical disabilities, social gatherings and ceremonies, forgetfulness, fear of injections (needles), and work-related pressure as common barriers to practicing self-care [8].

Socio-demographic factors such as age, gender, educational level, income, and marital status also influence adherence levels, suggesting that self-care behaviors in Pakistan are affected by both individual and structural factors [4]. Although several studies have evaluated diabetes self-care practices in Pakistan, the available evidence remains fragmented and inconsistent. Previous reviews have also highlighted the limited evidence on diabetes self-management among Pakistani patients, indicating an important knowledge gap [11]. Therefore, this comprehensive systematic review and meta-analysis aimed to synthesize the available evidence on adherence to diabetes self-care behaviors among individuals with diabetes in Pakistan by estimating pooled adherence prevalence and mean adherence scores. The findings of this study may help identify areas with poor adherence and support the development of targeted interventions, patient education programs, and public health strategies to improve diabetes self-management in Pakistan.

2. Methods

2.1. Protocol and Registration

This systematic review and meta-analysis was prospectively registered in PROSPERO (CRD420251132404) and conducted according to the latest Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [12]. Deviations from the registered protocol and their rationales are summarized in Supplementary Table S1.

2.2. Search strategy and data sources

PubMed, Embase, Web of Science, Scopus, Google Scholar, and the domestic database PakMediNet were systematically searched from inception to August 2025. The search strategy employed three main blocks: Diabetes Mellitus, self-care, and Pakistan. To ensure that no relevant studies were missed, backward and forward citation tracking was performed using a similar systematic review and meta-analysis by Paudel et al. [13]. The detailed search strategies for each database are provided in the Supplementary Material.

2.3. Study selection and Eligibility

After manual deduplication, screening was conducted in two stages: title–abstract screening followed by full-text review. Two reviewers (A. A. and A.P.) independently screened all records, with discrepancies resolved by a third reviewer (R.G.G.). We included observational and cross-sectional studies assessing self-care practices among Pakistani patients with diabetes. Self-care behaviors included five subscales: diet, physical activity, medication adherence, foot care, and SMBG, as well as

overall self-care. Studies reporting outcomes as prevalence or mean scores were included. Exclusion criteria were studies that only reported self-care knowledge, focused on Pakistani immigrants, or were published in languages other than English.

2.4. Data Extraction and synthesis

Two reviewers (A.A. and A.P.) independently extracted data on sociodemographic characteristics, clinical characteristics, and self-care behaviors. Initially, we performed a systematic narrative synthesis using tables to summarize sample sizes, data collection tools (e.g., questionnaires), measure definitions, and practice prevalence or mean scores for each subscale, following the approach by Paudel et al. [13]. Subsequently, A.A., A.P., and R.G.G. reached a consensus to include studies that used standard and comparable measure definitions for quantitative meta-analysis. To minimize selection bias, reviewers performed this selection independently and resolved disagreements through discussion.

2.5. Quality assessment

A.A. and A.P. assessed the quality of included studies using the Joanna Briggs Institute (JBI) critical appraisal tool for prevalence studies [14]. Discrepancies were resolved by R.G.G. The tool evaluates nine domains with responses of “yes”, “no”, or “unclear”. Studies with five or fewer “yes” responses were classified as low quality, six to seven as moderate quality, and more than seven as high quality.

2.6. Statistical analysis

Analyses were performed using R version 4.2.2 (R Foundation for Statistical Computing, Vienna, Austria) using “meta” [15] and “metafor” [16] packages. Two outcomes were synthesized: adherence prevalence, defined as the proportion of participants meeting study-specific adherence criteria, and adherence level, defined as mean self-care scores standardized to a 0–100 scale. Prevalence data were pooled as percentages. Mean scores were transformed to a 0–100 scale to ensure comparability across studies using the following formula:

$$\text{Transformedscore} = ((\text{Actualrawscore} - \text{Lowestpossiblerawscore}) / \text{Possiblerawscoringrange}) \times 100$$

The transformed mean scores were then pooled in the meta-analysis. For studies reporting median and interquartile range (IQR), mean and standard deviation (SD) were estimated using the Box-Cox method from “estmeansd” package as described by McGrath et al. [17]. Meta-analysis was performed using the inverse-variance method and between-study variance was estimated using restricted maximum likelihood (REML) [18]. Statistical heterogeneity was evaluated with the Cochran Q test and the I^2 statistic. Because heterogeneity exceeded 75%, random-effects models were applied. Sensitivity analysis was conducted using the leave-one-out (LOO) approach to evaluate the robustness of pooled estimates. To explore the potential influence of diabetes type on self-care adherence, subgroup analyses were conducted among studies restricted to patients with type 2 diabetes mellitus (T2DM). Separate analyses for type 1 diabetes mellitus (T1DM) were not feasible because of limited data. We used univariate meta-regression with a mixed-effects model to explore potential sources of heterogeneity. Candidate moderators were selected a priori based on their clinical relevance to diabetes self-care behaviors and the availability of sufficient data across the included studies. Consistent with recommendations for meta-regression, only variables reported in at least 10 studies contributing to a

given *meta-analysis* were considered eligible for analysis to ensure reliable estimates and reduce the risk of spurious findings [19]. To assess publication bias, we used Egger's test [20] when ten or more studies were available, while Begg's test [21] was used when fewer than ten studies were included, alongside visual inspection of funnel plots. Statistical significance was set at $p < 0.05$ with 95% confidence intervals (CI).

3. Results

3.1. Study characteristics

The systematic search and screening process identified 65 studies published between 2003 and 2025 that met the inclusion criteria (Fig. S1). Based on quality assessment, 4 studies (6.2%) were rated as low quality, 43 (66.2%) as moderate quality, and 18 (27.7%) as high quality. Detailed quality appraisal results are provided in Table S5.

Most studies were conducted in large cities. Lahore accounted for 21 studies, followed by Karachi with 11. Islamabad and Rawalpindi were the next most frequently represented cities. Regarding diabetes type, 46 studies exclusively included individuals with type 2 diabetes. Eleven studies included participants with both type 1 and type 2 diabetes, while one study included only individuals with type 1 diabetes. Seven studies did not specify the type of diabetes. The most commonly assessed self-care domain was physical activity (35 studies), followed by dietary practices (33 studies), SMBG (30 studies), medication adherence (28 studies), and foot care (24 studies). Twelve studies reported an overall self-care measure (Table S3). Studies reported self-care adherence as either prevalence estimates (proportion adherent) or adherence scores (level of adherence).

Sociodemographic and clinical characteristics of study participants—such as age, antidiabetic therapy, marital status, and duration of diabetes—are summarized in Supplementary Table S4.

3.2. Diet

Thirty-three studies reported dietary practices. We included 16 studies in the prevalence *meta-analysis* and 9 studies in the score *meta-analysis* (Table S6). Among 4,414 patients with diabetes, the pooled prevalence of adherence to dietary practices was 56% (95% CI: 43%–67%; $I^2 = 95.9\%$). For the score analysis, the pooled mean standard score for dietary practices among 2,301 patients was 61.3% (95% CI: 48%–74.5%; $I^2 = 99.6\%$) (Fig. 1). LOO sensitivity analysis showed no significant change after excluding any single study (Fig. S2–S3). Egger's test showed no publication bias for prevalence ($p = 0.58$), and Begg's

test showed no publication bias for the standard score ($p = 0.53$) (Fig. S4 – S5).

3.3. Physical activity

Thirty-five studies reported physical activity practices. We included 16 studies in the prevalence *meta-analysis* and 11 studies in the score *meta-analysis* (Table S7). Among 4,256 patients, 37% (95% CI: 29%–46%; $I^2 = 95.1\%$) adhered to recommended physical activity practices. The pooled mean standard score among 2,760 patients was 45.5% (95% CI: 38%–53%; $I^2 = 99.1\%$) (Fig. 2). LOO sensitivity analysis showed no significant change after removing any study (Fig. S6 – S7). Egger's test showed no publication bias for prevalence ($p = 0.20$) or for the standard score ($p = 0.87$) (Fig. S8 – S9).

3.4. Medication adherence

Twenty-eight studies reported medication adherence. We included 22 studies in the prevalence *meta-analysis* and 8 studies in the score *meta-analysis* (Table S8). Among 5,668 patients, the pooled prevalence of medication adherence was 74% (95% CI: 63%–83%; $I^2 = 97.5\%$). The pooled mean standard score among 1,966 patients was 72.7% (95% CI: 62.7%–82.7%; $I^2 = 99.4\%$) (Fig. 3). LOO sensitivity analysis showed no significant change for either prevalence or score (Fig. S10 – S11). Egger's test showed no publication bias for prevalence ($p = 0.21$), and Begg's test showed no publication bias for the standard score ($p = 0.32$) (Fig. S12 – S13).

3.5. Foot care

Twenty-four studies reported foot-care practices. We included 12 studies in the prevalence *meta-analysis* and 8 studies in the score *meta-analysis* (Table S9). Among 2,930 patients, 55% (95% CI: 39%–70%; $I^2 = 97.5\%$) adhered to recommended foot-care practices. The pooled mean standard score among 1,942 patients was 67% (95% CI: 56.4%–77.6%; $I^2 = 99.6\%$) (Fig. 4). LOO sensitivity analysis showed no significant change for prevalence or score (Fig. S14 – S15). Egger's test showed no publication bias for prevalence ($p = 0.18$), and Begg's test showed no publication bias for the standard score ($p = 0.53$) (Fig. S16 – S17).

3.6. SMBG

Thirty studies reported SMBG. We included 14 studies in the prevalence *meta-analysis* and 6 studies in the score *meta-analysis* (Table S10).

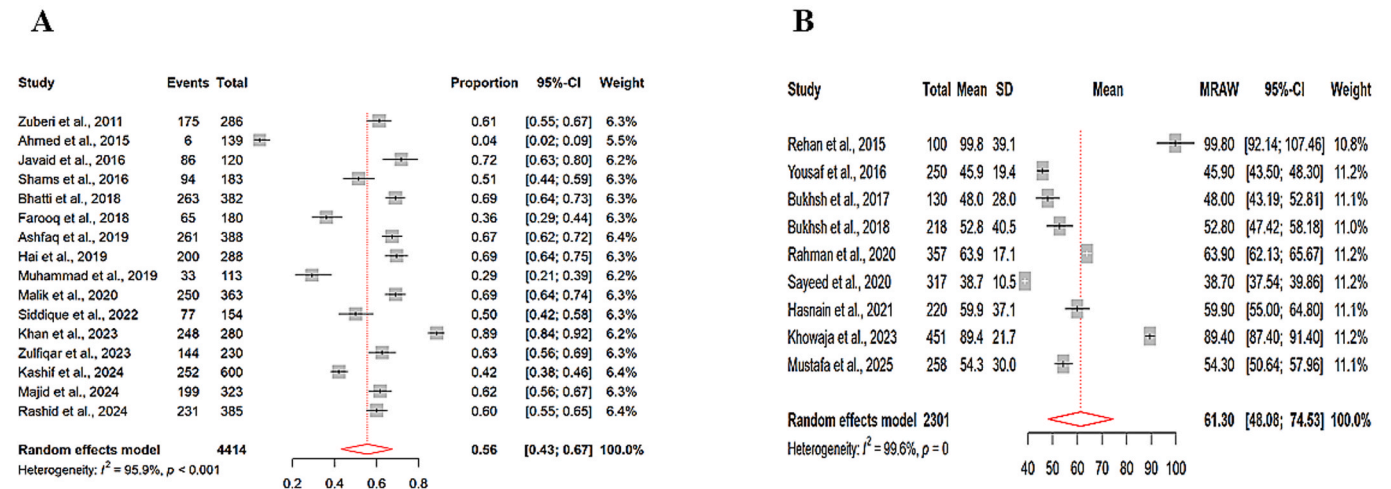


Fig. 1. A: Pooled dietary adherence prevalence; B: Pooled dietary mean adherence score.

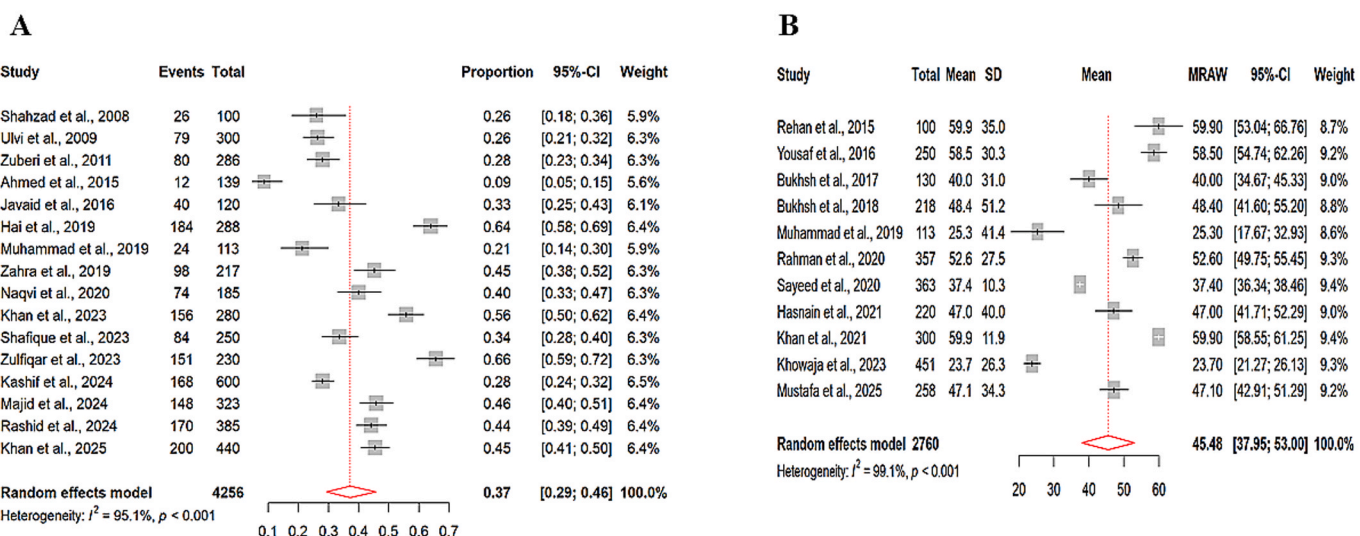


Fig. 2. A: Pooled physical activity adherence prevalence; B: Pooled physical activity mean adherence score.

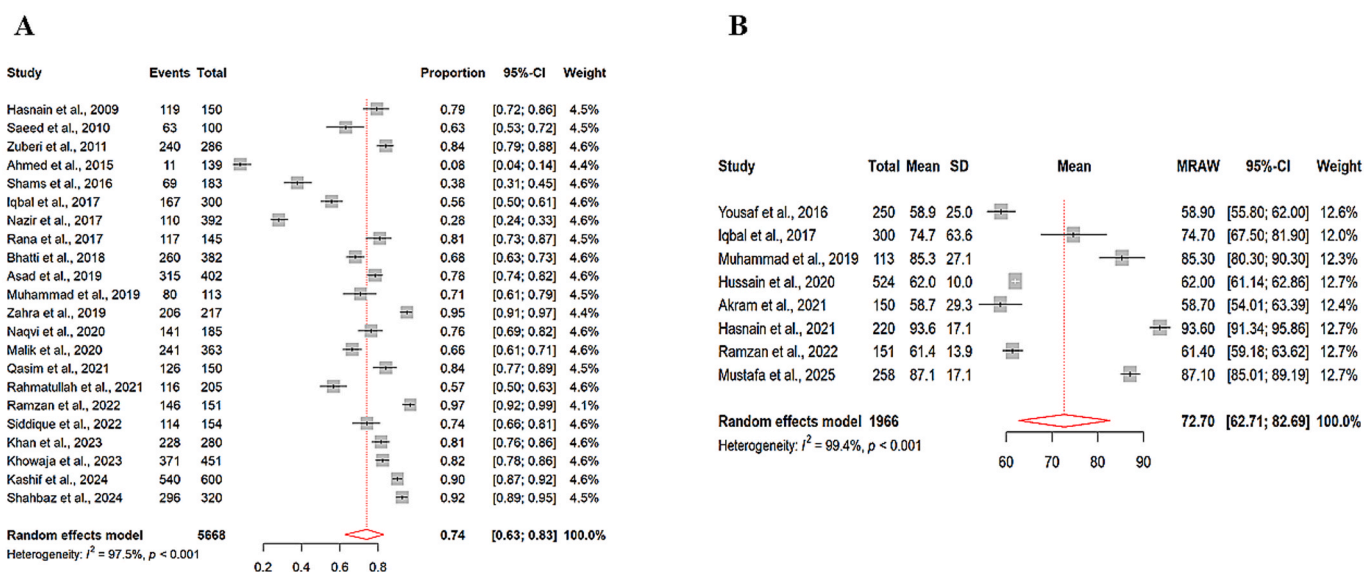


Fig. 3. A: Pooled medication adherence prevalence; B: Pooled medication adherence mean score.

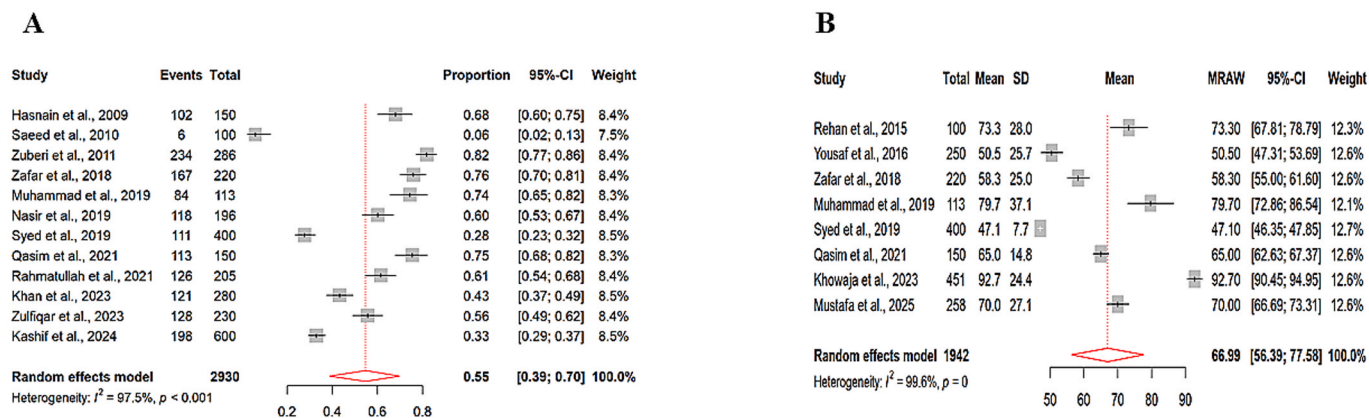


Fig. 4. A: Pooled foot care adherence prevalence; B: Pooled foot care mean adherence score.

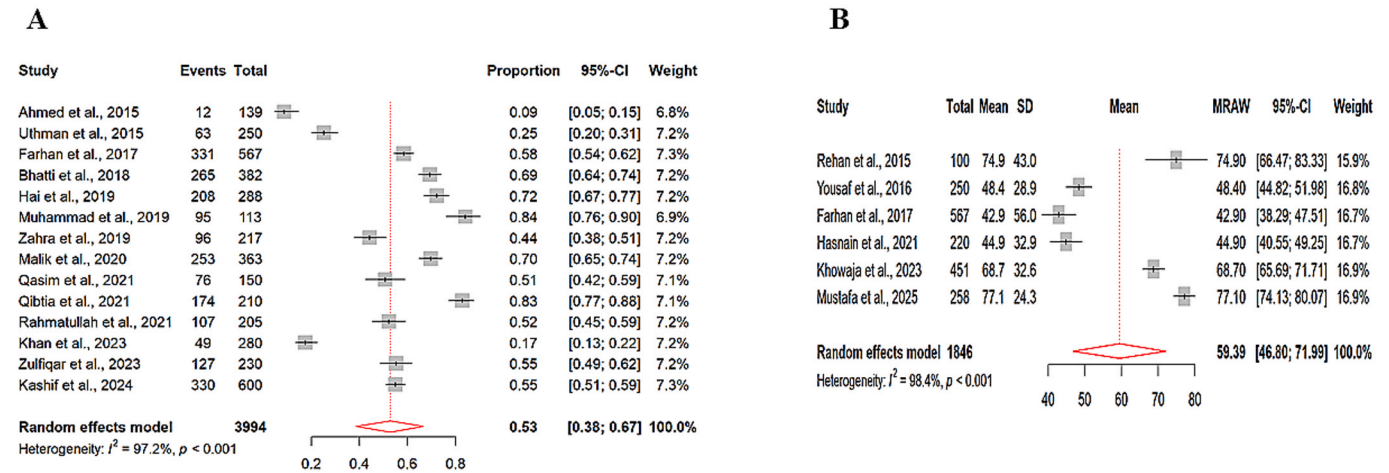


Fig. 5. A: Pooled SMBG adherence prevalence; B: Pooled SMBG mean adherence score.

Among 3,994 patients, 53% (95% CI: 38%–67%; $I^2 = 97.2\%$) adhered to SMBG practices. The pooled mean standard score among 1,846 patients was 59.4% (95% CI: 46.8%–72%; $I^2 = 98.4\%$) (Fig. 5). LOO sensitivity analysis showed no significant change after excluding any study (Fig. S18 – S19). Egger’s test showed no publication bias for prevalence ($p = 0.46$), and Begg’s test showed no publication bias for the standard score ($p = 0.53$) (Fig. S20 – S21).

3.7. Overall Self-Care

Twelve studies reported overall self-care (Table S11). We included 7 studies in the prevalence meta-analysis. The pooled prevalence of adherence was 47% (95% CI: 29%–66%, $I^2 = 97.3\%$; Fig. S22). We also included 7 studies in the score meta-analysis. The pooled mean standard score was 53.6% (95% CI: 47.8%–59.4%, $I^2 = 99.1\%$; Fig. S23). Results of sensitivity analysis and publication bias assessment are provided in the Supplementary material (Fig. S24 – S27).

3.8. Patients with type 2 diabetes mellitus

Among patients with T2DM, self-care patterns were largely similar to those observed in the overall analysis. The pooled prevalence of adherence was 55% (95% CI: 41%–67%) for diet, 39% (95% CI: 30%–48%) for physical activity, 73% (95% CI: 60%–83%) for medication adherence, 62% (95% CI: 49%–73%) for foot care, 50% (95% CI: 35%–65%) for SMBG, and 54% (95% CI: 30%–76%) for overall self-care. Corresponding pooled standardized adherence scores were 63.3% (95% CI: 48.9%–77.7%), 42.8% (95% CI: 34.8%–50.8%), 69.2% (95% CI: 57.4%–81.1%), 72.4% (95% CI: 59.3%–85.5%), 55.7% (95% CI: 42.9%–68.5%), and 53.6% (95% CI: 47.8%–59.4%), respectively (Fig. S28 – S33). Medication adherence showed the highest prevalence of adherence, whereas physical activity showed the lowest prevalence of adherence. Heterogeneity was substantial across all analyses ($I^2 > 90\%$), consistent with the findings of the overall meta-analysis.

3.9. Meta-Regression

Due to substantial heterogeneity across studies, we performed univariate meta-regression analyses to investigate potential sources of between-study variability in adherence prevalence. Covariates were evaluated only when data were available from at least 10 studies and included publication year, mean age, proportion of females, proportion with no formal education, family history of DM, and use of an investigator-structured questionnaire. Only publication year showed a significant association with physical activity adherence prevalence (slope = 0.067, SE = 0.030; $p = 0.02$). Publication year explained 23.2%

of the between-study variance. None of the other variables showed a significant association with adherence prevalence in any of the self-care domains (Table S12).

4. Discussion

This systematic review and meta-analysis evaluated diabetes self-care behaviors among patients in Pakistan using data from 65 studies published between 2003 and 2025. Overall self-care adherence was low, with a pooled prevalence of 47% and a mean standardized score of 53.6%. Among the individual self-care domains, medication adherence showed the highest adherence, with a pooled prevalence of 74% and a mean standardized score of 72.7%. Foot care, dietary practices, and SMBG showed moderate adherence, with pooled prevalence estimates of 55%, 56%, and 53%, respectively. Physical activity showed the poorest performance, with only 37% of patients meeting recommended practices and a mean standardized score of 45.5%.

Overall, the pattern of self-care among patients reveals a clear imbalance between medication-focused behaviors and lifestyle-based behaviors. The highest adherence prevalence was observed for medication intake (74%), whereas physical activity (37%) and SMBG (53%) showed the lowest levels. This finding indicates that patients have better compliance with pharmacological recommendations than with lifestyle modifications. This pattern was also confirmed in the level of adherence, with medication adherence achieving the highest score (72.7%) and physical activity the lowest (45.5%).

In addition to more reinforcement of medication adherence within the healthcare system, this difference may reflect the structured nature of medication adherence, which is less dependent on environmental factors, whereas lifestyle modifications require sustained changes in daily routines, high individual motivation, and social and environmental support. Consequently, patients show greater willingness to follow pharmacological interventions than to adopt lifestyle-related behavioral changes.

Among the domains examined, physical activity showed the poorest adherence prevalence (37%). This may reflect multidimensional barriers—including cultural, social, and environmental constraints—that inhibit the adoption of regular exercise behaviors among diabetic patients. Furthermore, the lack of structured intervention programs and the failure to integrate physical activity into routine diabetes care may contribute to the persistence of this situation. Meta-regression results indicated that only the year of publication was significantly associated with this indicator ($p = 0.02$), with more recent studies showing slight improvements in the prevalence of physical activity. However, the trend was weak and explained only 23.2% of variability between studies.

Medication adherence showed the highest prevalence and level of adherence among all domains and was consistent with findings from some studies in the South Asian region [13]. However, significant variation was observed in reported rates across studies, ranging from 2.7% for complete adherence to over 90% in some reports [22–24]. This heterogeneity is primarily related to differences in measurement definitions of adherence. While some studies employed simple self-report methods, standardized instruments such as the MMAS-8 provide more accurate and typically more conservative estimates. This underscores the necessity of using valid and uniform tools for assessing medication adherence.

For dietary management, adherence prevalence varied widely, ranging from 4.3% to 71.7% [25,26]. A similar dispersion was observed for physical activity, with adherence prevalence reported from approximately 26% to over 65% [27–29]. This variation is likely due to differences in definitions, measurement instruments, and study populations.

In the domains of foot care and SMBG, the prevalence of adherence was moderate (55% and 53% respectively). However, both domains exhibited considerable heterogeneity. For foot care, reported rates ranged from 6% to 81.8% [30,31]. This variation is primarily attributable to differences in assessment tools and criteria for defining adequate care; while some studies employed standardized instruments based on ADA guidelines, others relied on simpler, self-reported measures. A similar pattern was observed for SMBG, with adherence rates varying from very low levels to over 80% [27,32,33]. This heterogeneity highlights the lack of a unified standard for defining and measuring these behaviors. The moderate prevalence of adherence observed in these domains may reflect dependence on resource availability (such as blood glucose monitoring devices) and patients' awareness levels. Additionally, the absence of uniform national guidelines for diabetes self-care may be related to variation in adherence rates.

The similar patterns observed between prevalence estimates and standardized scores suggest that the findings were generally consistent across different measurement approaches and were unlikely to be driven only by differences in assessment tools. In addition, *meta*-regression showed that most demographic variables did not significantly explain the heterogeneity observed across studies. Together, these findings suggest that poor lifestyle-related self-care cannot be explained by individual-level characteristics alone, and that broader structural, systemic, cultural, and methodological factors may play a more important role.

The subgroup analysis of patients with T2DM produced findings that were largely consistent with the overall analysis. This similarity was expected, as the majority of included studies were conducted exclusively among patients with T2DM. Both adherence prevalence and standardized adherence scores showed the same general pattern observed in the overall population, with medication adherence demonstrating the highest adherence and physical activity the lowest. However, there were insufficient data to conduct a meaningful synthesis focused exclusively on patients with T1DM. This highlights an important evidence gap and underscores the need for more primary studies assessing diabetes self-care behaviors among individuals with T1DM in Pakistan.

In summary, the findings show a significant gap between clinical recommendations and actual patient behaviors. Although medication adherence is relatively high, lifestyle-related behaviors remain at sub-optimal levels, representing a major challenge in diabetes management.

The robustness of the results was confirmed through sensitivity analysis (LOO), with the exclusion of any single study not materially affecting the overall findings. Additionally, no evidence of publication bias was detected. However, high heterogeneity ($I^2 > 90\%$) was present in most analyses and should be considered when interpreting the results. This elevated level of heterogeneity indicates that the findings are likely influenced by contextual differences, measurement methodologies, and study designs, underscoring the need for standardized assessment tools in future research.

From a practical perspective, the results of this study suggest that diabetes management should shift from a purely pharmacological approach toward a more comprehensive, patient-centered model. Structured educational interventions, culturally tailored programs, and improved access to monitoring tools could play a significant role in enhancing self-care practices.

This study also has certain limitations. First, all included studies were cross-sectional that limits causal inference. Second, variations in measurement instruments and definitions, coupled with very high heterogeneity ($I^2 > 90\%$), substantially restrict the comparability of results across studies. Third, the predominant focus of studies on urban areas limits the generalizability of findings to rural populations. Fourth, nearly all included studies assessed diabetes self-care behaviors using subjective, self-reported questionnaires. Such measures are susceptible to recall bias and social desirability bias, whereby participants may over-report adherence to recommended behaviors such as healthy dietary practices, medication use, physical activity, or foot care. As a result, the pooled adherence estimates reported in this review may overestimate actual self-care practices. Fifth, most primary studies did not evaluate the relationship between self-care behaviors and objective clinical indicators, such as glycated hemoglobin (HbA1c), fasting blood glucose, or other metabolic outcomes, limiting the ability to assess the clinical significance and validity of reported self-care adherence. Finally, only studies published in English were included. Although English is the predominant language of scientific publication in Pakistan and both international databases and PakMediNet were searched, some relevant studies published in local languages may have been missed. Therefore, language bias cannot be completely excluded. Nevertheless, this study provides one of the most comprehensive synthesis of diabetes self-care behaviors among Pakistani patients and offers valuable direction for designing future interventions and research.

5. Conclusion

This systematic review and *meta*-analysis identified important gaps in diabetes self-care behaviors in Pakistan. Medication adherence was relatively high, while physical activity showed consistently poor adherence. Dietary practices, SMBG, and foot care remained at moderate levels. These findings highlight the need for patient-centered and culturally appropriate interventions that focus on improving lifestyle-related self-care behaviors, particularly physical activity, to support better diabetes management outcomes in Pakistan.

6. Availability of data and materials

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

CRedit authorship contribution statement

Amirali Azizpour: Writing – original draft, Formal analysis. **Reza Ghanei Gheshlagh:** Writing – review & editing, Methodology, Formal analysis, Conceptualization. **Sasan shafiei:** Writing – original draft, Investigation, Data curation. **Muhammad Ayaz:** Writing – review & editing, Methodology, Conceptualization. **Ali Parouhan:** Writing – review & editing, Supervision, Project administration, Methodology, Conceptualization.

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Declaration of competing interest

The authors declare that they have no known competing financial

interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.diabres.2026.113428>.

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