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ORIGINAL ARTICLE

Assessing HbA1c and Oral Antidiabetic Drug Adherence Outcomes in Community-Based Diabetes Management at Primary Care Level: An Observational Study of Indonesian PROLANIS Participants

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Abstract

Background/Aim: Poor glycaemic control remains a persistent challenge in patients with type 2 diabetes mellitus (T2DM), particularly within primary healthcare settings in Indonesia. Medication adherence is a key modifiable factor that may influence glycaemic outcomes. This study aimed to evaluate the correlation between glycated haemoglobin (HbA1c) levels and medication adherence among type 2 diabetes mellitus (T2DM) patients participating in the PROLANIS.

Methods: This observational study examined the relationship between adherence to oral antidiabetic drugs (OADs) and glycaemic control in patients with T2DM enrolled in the PROLANIS programme at Gending Primary Healthcare Centre, East Java. Fifty adult patients were enrolled in December 2024. Medication adherence was measured using the 8-item Morisky Medication Adherence Scale (MMAS-8) and glycaemic control was defined as HbA1c ≤ 7.0 %.

Results: High adherence was significantly associated with better glycaemic control ($p = 0.011$). Patients with high adherence were over six times more likely to improve glycaemic status (OR = 6.69, 95 % CI: 1.32–34.5). ANCOVA revealed that adherence independently predicted change in HbA1c ($p < 0.001$, $\eta^2_p = 0.478$), while age and baseline HbA1c were non-significant covariates. A strong negative correlation was observed between MMAS-8 scores and HbA1c ($r = –0.483$, $p < 0.001$).

Conclusion: High OAD adherence was independently associated with improved glycaemic control among T2DM patients in a primary care setting. Interventions targeting medication adherence could enhance the effectiveness of community-based chronic disease management programmes such as PROLANIS.

Key words: Diabetes mellitus, type 2; Medication adherence; Glycated haemoglobin; Primary healthcare; Hypoglycaemic agents.

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Introduction

Diabetes mellitus (DM) is a metabolic disorder characterised by chronic hyperglycaemia and has become a major global health concern due to its high morbidity and mortality rates. Based on its aetiology, DM is classified into four main types: type 1 DM, type 2 DM, gestational DM, and other specific types. Among these, type 2 diabetes is the most prevalent and is strongly linked to lifestyle

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factors.[1] In 2021 the World Health Organization (WHO) listed diabetes among the top five causes of death worldwide, affecting approximately 537 million individuals (10.5 % of the global population) and accounting for an estimated USD 966 billion in global healthcare expenditures.[2] It is projected that the prevalence of diabetes cases in Indonesia will rise from 9.19 % in 2020, which corresponds to about 18.69 million cases, to an estimated 16.09 % in 2045, equating to around 40.7 million cases.[3] According to the 2023 Indonesian Health Survey (SKI), the national prevalence of diabetes in Indonesia was 11.7 %, with East Java ranking among the top five provinces with the highest prevalence of type 2 diabetes mellitus (2.7 %).[4]

Effective diabetes management aims to prevent complications and improve patients' quality of life.[5] As DM is a chronic non-curable condition, treatment primarily focuses on long-term glycaemic control. This requires not only appropriate medication regimens but also consistent patient adherence. Medication adherence plays a critical role in achieving optimal glycaemic targets. Poor adherence can result in uncontrolled blood glucose, leading to severe complications, diminished functional status, reduced quality of life, and even death.[6] In Indonesia, among those aged 19–59 years with diagnosed DM (1.6 %), only 1.46 % were undergoing treatment, 1.3 % adhered to treatment guidelines, and 0.9 % revisited healthcare facilities.[4] These figures highlight the urgent need to strengthen strategies that enhance treatment adherence to improve long-term outcomes for people living with diabetes in Indonesia.

Previous studies have highlighted the impact of adherence on glycaemic outcomes. A 2020 study by Saibi et al reported that 40.6 % of type 2 DM patients in East Jakarta had moderate adherence based on the 8-item Morisky Medication Adherence Scale (MMAS-8).[7] The most common reason cited for non-adherence was treatment fatigue. That study also found a significant correlation between adherence level and glycaemic control, with higher adherence associated with better blood glucose regulation. Similarly, a study by Zairina et al, involving 266 patients from 63 primary health centres (*Puskesmas*) in Surabaya, revealed that only 30 % of patients—most of whom were around 60 years old—maintained good medication adherence.[8] The study demonstrated a significant association between adherence and controlled blood glucose levels. Many non-adherent patients expressed concern about the side effects of oral antidiabetic drugs, leading to discontinued medication use. Another study conducted in Semarang by Sa'dyah et al further supported these findings, showing a significant relationship between medication adherence and HbA1c levels in patients with type 2 diabetes.[9]

This study aimed to evaluate the correlation between HbA1c levels and medication adherence among type 2 diabetes mellitus patients participating in the PROLANIS (Program Pengelolaan Penyakit Kronis) at Gending Primary Health Centre, Gresik.

Methods

This was an observational study comprising a primary cross-sectional analysis and a secondary retrospective longitudinal component. The study was conducted at Puskesmas Gending, a government-funded primary healthcare centre in Gresik, East Java, Indonesia. The facility provided routine diabetes care and chronic disease management for patients enrolled in the Program Pengelolaan Penyakit Kronis (PROLANIS), a chronic disease management programme implemented by BPJS Kesehatan. Written informed consent was obtained from all participants before enrolment.

Study design

The primary analysis evaluated the cross-sectional association between oral antidiabetic drug (OAD) adherence and glycaemic control at the study visit on 18 December 2024. Medication adherence was assessed using the 8-item Morisky Medication Adherence Scale (MMAS-8), while glycaemic control was assessed using HbA1c measured from venous blood collected during the same visit.

A secondary retrospective longitudinal analysis was undertaken using historical HbA1c data obtained from participants' medical records. The most recent HbA1c measurement available approximately 26 weeks before the study visit was compared with the HbA1c measured on 18 December 2024. This analysis was performed to describe changes in glycaemic status over the preceding 26 weeks. Because medication adherence was assessed only at the December 2024 visit, the

longitudinal analysis was considered exploratory and was not used to establish a temporal or causal effect of medication adherence on changes in HbA1c.

PROLANIS program

PROLANIS is a chronic disease management programme implemented by BPJS Kesehatan through primary healthcare facilities. At the study site, routine PROLANIS activities included periodic medical consultations, group education, monitoring of chronic disease management, reminder services and home visits when indicated. These activities were delivered as part of routine care and were not modified for the purposes of this study.

Participants and recruitment

The study population comprised patients with T2DM who were registered in PROLANIS at Puskesmas Gending. Participants were identified from the registered PROLANIS patient list. The inclusion criteria were: (i) a diagnosis of T2DM based on ICD-10 code E11; (ii) enrolment in PROLANIS; and (iii) ongoing OAD therapy for at least six months before the study. The exclusion criteria were: (i) pregnancy or lactation; (ii) significant communication barriers, including cognitive or mental impairment that could interfere with questionnaire completion; (iii) a history of alcohol or drug abuse or dependence; and (iv) refusal to provide informed consent.

A total population sampling approach was used. All eligible patients attending the scheduled PROLANIS health screening session on 18 December 2024, were invited to participate. The minimum required sample size was calculated using the Slovin formula, assuming a known population of 50 PROLANIS patients and a 5 % margin of error, resulting in a minimum sample size of 44 participants. All 50 eligible patients were approached, and participants who met the eligibility criteria and provided informed consent were enrolled.

Data collection

Participant recruitment and primary data collection were conducted during a scheduled PROLANIS health screening event on 18 December 2024. Demographic characteristics and medication adherence were obtained by structured face-to-face interview, while clinical information was extracted from medical records. Medication adherence was assessed using the 8-item Morisky Medication Adherence Scale (MMAS-8). Trained data collectors administered the questionnaire directly to participants following standardised procedures. HbA1c was measured from venous blood samples collected during the same visit and represented the primary glycaemic outcome for the cross-sectional analysis. Historical HbA1c data were retrospectively retrieved from archived medical records. The most recent HbA1c measurement available approximately 26 weeks before the study visit was considered the historical baseline measurement. No prospective follow-up or study-related intervention was conducted.

To minimise measurement bias, data collectors received standardised training, the MMAS-8 was administered using consistent procedures, and HbA1c measurements followed the laboratory's standard protocols. Confidentiality was maintained during questionnaire administration to reduce potential social desirability and self-reporting bias.

Study variables and outcome definition

The primary outcome was glycaemic control, assessed using HbA1c. HbA1c ≤ 7 % was classified as controlled glycaemia whereas HbA1c > 7 % was classified as uncontrolled glycaemia, based on recommendations from the Indonesian Ministry of Health. The primary exposure was OAD adherence, assessed using the MMAS-8. Adherence scores were categorised as low adherence (< 6), medium adherence (6–7) and high adherence (8), according to established MMAS-8 categorisation. Age and sex were collected as potential confounding variables. HbA1c and MMAS-8 scores were initially retained as continuous variables and were additionally categorised when required for clinically relevant analyses. Age was analysed as both a continuous and categorical variable, as appropriate.

For the secondary longitudinal analysis, HbA1c change was calculated as the difference between the December 2024 HbA1c and the historical HbA1c obtained approximately 26 weeks earlier. Changes in glycaemic status between the two time points were also categorised as controlled or uncontrolled and were descriptively presented as transitions.

Statistical analysis

Statistical analyses were performed using *Graph-*

*Pad Prism 9 (*GraphPad Software, California, USA) and *IBM SPSS Statistics* version 26.0 (IBM Corp, Chicago, IL, USA). Continuous variables were assessed for distribution and are presented as mean ± standard deviation (SD) or median (range), as appropriate. Categorical variables are presented as frequencies and percentages.

For the primary cross-sectional analysis, differences in continuous variables between two independent groups were assessed using the independent-samples t-test or Mann–Whitney U test, as appropriate. Comparisons of categorical variables were performed using the Chi-square test or Fisher's exact test, as appropriate. Odds ratios (ORs) with 95 % confidence intervals (CIs) were calculated to evaluate the association between medication adherence and glycaemic control. Differences in December 2024 HbA1c across the three medication-adherence categories were evaluated using one-way analysis of variance (ANOVA) or the corresponding non-parametric test when assumptions for ANOVA were not met. Appropriate *post hoc* comparisons were performed when applicable. Spearman's rank correlation was used to assess the relationship between MMAS-8 scores and HbA1c levels.

For the secondary retrospective longitudinal analysis, changes in HbA1c between the historical measurement and December 2024 were evaluated using the paired t-test or Wilcoxon signed-rank test, as appropriate. Analysis of covariance (ANCOVA) was used to compare HbA1c change across medication-adherence categories while adjusting for age and historical baseline HbA1c. Because adherence was measured only at the December 2024 visit, this analysis was considered exploratory and was interpreted as an association rather than evidence of a causal effect of adherence on HbA1c change.

The distribution of participants by medication adherence level and corresponding HbA1c status or change was illustrated using a Sankey plot generated with *ChiPlot* (https://www.chiplot.online/). Changes in the proportion of participants classified as having controlled versus uncontrolled glycaemia between the two time points were assessed using McNemar's test. Missing historical HbA1c values were handled by multiple imputation under the assumption that data were missing at random (MAR). Imputed datasets were analysed using the prespecified statistical models and estimates were combined according to standard multiple-imputation procedures. Effect sizes were reported where appropriate, including partial eta squared (η^2_p) for ANOVA and ANCOVA. All statistical tests were two-sided and a p-value < 0.05 was considered statistically significant.

Results

Among 50 T2DM patients who regularly participated in the PROLANIS programme and received care at the Gending primary health centre, 50 patients who fulfilled the eligibility criteria were included in this study conducted in December 2024. At baseline (week 0), 27 participants had controlled glycaemic status (HbA1c ≤ 7 %), and 23 were uncontrolled (HbA1c > 7 %). By the time of data collection, the proportion was evenly distributed with 25 controlled and 25 uncontrolled participants based on their most recent HbA1c values. Regarding medication adherence, based on the MMAS-8 score, 20 participants were classified as high adherence, 12 as moderate and 18 as low adherence. Figure 1 presents the flow of participant inclusion.

The characteristics of participants differed between those with controlled and uncontrolled glycaemic status (Table 1). The controlled group was significantly older than the uncontrolled group (66.16 ± 6.73 vs 60.48 ± 7.51 years, p = 0.007). A higher proportion of elderly individuals (≥ 60 years) was observed in the controlled group (84 %) compared with the uncontrolled group (56 %), with an odds ratio (OR) of 4.12 (95 % CI: 1.17–13.30). There was no significant gender difference between groups and females constituted the majority in both.

Medication adherence was significantly associated with glycaemic control. High adherence was reported by 76 % of the controlled group, whereas 72 % of the uncontrolled group had low adherence (p < 0.001). Participants with low or moderate adherence had substantially greater odds of poor glycaemic control compared with those with high adherence (OR = 76.0; 95 % CI: 9.09–814.7). Mean HbA1c was also significantly higher in the uncontrolled group (8.81 ± 2.10 %) than in the controlled group (6.41 ± 1.48 %; p < 0.001).

HbA1c levels differed significantly across adherence levels as measured by MMAS-8 (F(2.47) =

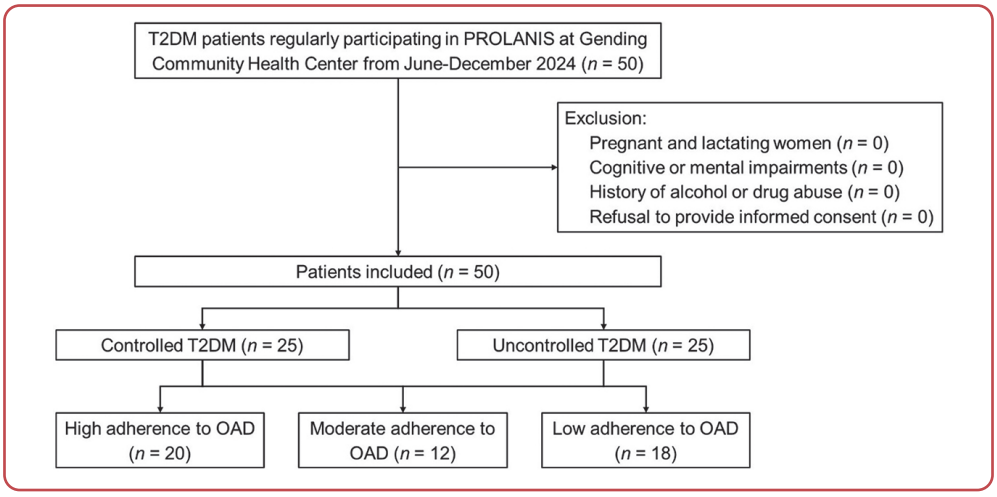


Figure 1: Patient selection flowchart

All 50 patients regularly attending PROLANIS at Gending Primary Health Centre were included; 25 had controlled and 25 had uncontrolled glycaemic status at the December 2024 assessment. OAD: oral antidiabetic drug; T2DM: type 2 diabetes mellitus.

Table 1: Characteristics of study participants by glycaemic control status

Characteristic	Glycaemic control status (HbA1c)		OR (95 % CI)	p-value
	Uncontrolled (> 7 %)	Controlled (≤ 7 %)		
Participants, n	25	25	–	–
Age (years), mean ± SD	60.48 ± 7.51	66.16 ± 6.73	–	0.007[a]*
Age groups, n (%)				
Pre-elderly (40–59 years)	11 (44 %)	4 (16 %)	4.12	0.062[b]
Elderly (≥60 years)	14 (56 %)	21 (84 %)	(1.17–13.30)	
Sex, n (%)				
Male	5 (20 %)	4 (16 %)	1.31	> 0.999[b]
Female	20 (80 %)	21 (84 %)	(0.31–4.75)	
Historical baseline HbA1c (%), mean ± SD	8.81 ± 2.10	6.41 ± 1.48	–	< 0.001[c]*
Historical baseline HbA1c, n (%)				
Uncontrolled (>7 %)	17 (68 %)	6 (24 %)	6.73	0.791[d]
Controlled (≤7 %)	8 (32 %)	19 (76 %)	(1.94–23.35)	
Adherence, n (%)				
Low	18 (72 %)	0 (0 %)	76.0 (9.09–814.7)	< 0.001[e]*
Moderate	6 (24 %)	6 (24 %)		
High	1 (4 %)	19 (76 %)		

*[a] Independent-samples t-test; [b] Fisher's exact test; [c] Wilcoxon signed-rank test; [d] McNemar's test; [e] chi-square contingency test using dichotomised adherence (low–moderate vs high). *Statistically significant (p < 0.05). CI: confidence interval; OR: odds ratio; SD: standard deviation.*

60.22, p < 0.0001) (Figure 2A). *Post hoc* Tukey's test revealed significantly lower mean HbA1c in the high adherence group (5.81 ± 0.91 %) compared with the moderate (6.82 ± 1.30 %; p = 0.041) and low adherence groups (9.67 ± 0.86 %; p < 0.0001). Likewise, the moderate group showed significantly lower HbA1c than the low adherence group (p < 0.0001). Consistently, Spearman's correlation showed a strong negative association between adherence score and HbA1c (r = –0.83, 95 % CI –0.90 to –0.71, p < 0.0001), indicating that higher adherence was associated with better glycaemic control (Figure 2B). These findings reinforce the response pattern between medication adherence and glycaemic outcome at the end of the observation period.

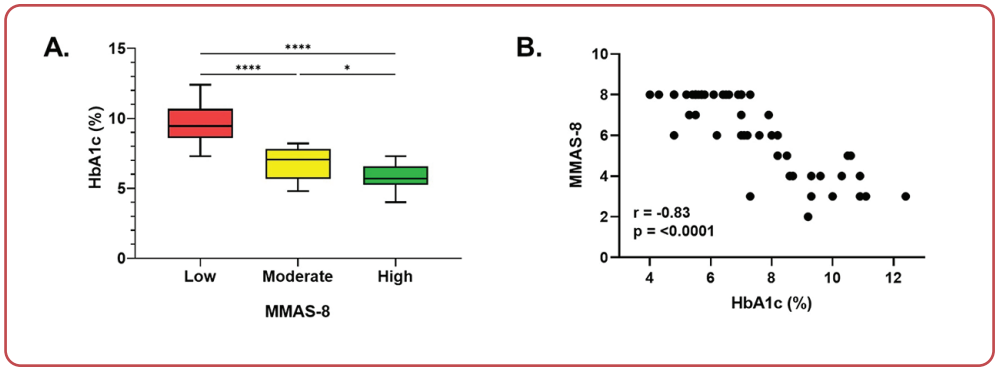


Figure 2: HbA1c and MMAS-8 adherence score among PROLANIS participants
(A) HbA1c by adherence category. (B) Spearman rank correlation between HbA1c and MMAS-8 score. Data are presented as median ± range (n = 50) for panel A. *p < 0.05; ****p < 0.0001; HbA1c: glycated haemoglobin; MMAS-8: 8-item Morisky Medication Adherence Scale.

To further explore the temporal relationship between adherence and glycaemic control, changes in HbA1c status over the 26 weeks were analysed. Sankey plot analysis of 50 participants showed that most individuals with high medication adherence remained controlled (24 %) or improved (12 %) in glycaemic status (Figure 3). In contrast, low adherence was predominantly associated with sustained poor control (26 %), with no cases of improvement. Deterioration in glycaemic control occurred most frequently among those with medium adherence (10 %). These findings suggest that higher levels of medication adherence are associated with more favourable glycaemic outcomes. Fisher's exact test comparing improvement between dichotomised adherence groups (low–moderate vs high) yielded a statistically significant result ($p = 0.041$), with an odds ratio of 6.69 (95 % CI: 1.32–34.50), indicating that patients with high adherence were nearly seven times more likely to achieve improved glycaemic control than those with lower adherence (Table 2).

To account for potential confounding factors, an ANCOVA was conducted with glycaemic control change as the dependent variable, adherence level as the fixed factor, and age and baseline HbA1c as covariates (Table 3). The model confirmed that adherence level remained a significant predictor of glycaemic improvement ($F(2.45) = 10.309$, $p < 0.001$), with a large effect size ($\eta^2c = 0.478$). Among covariates, baseline HbA1c significantly influenced glycaemic control change ($F(1,45) = 14.739$, $p < 0.001$) whereas age did not

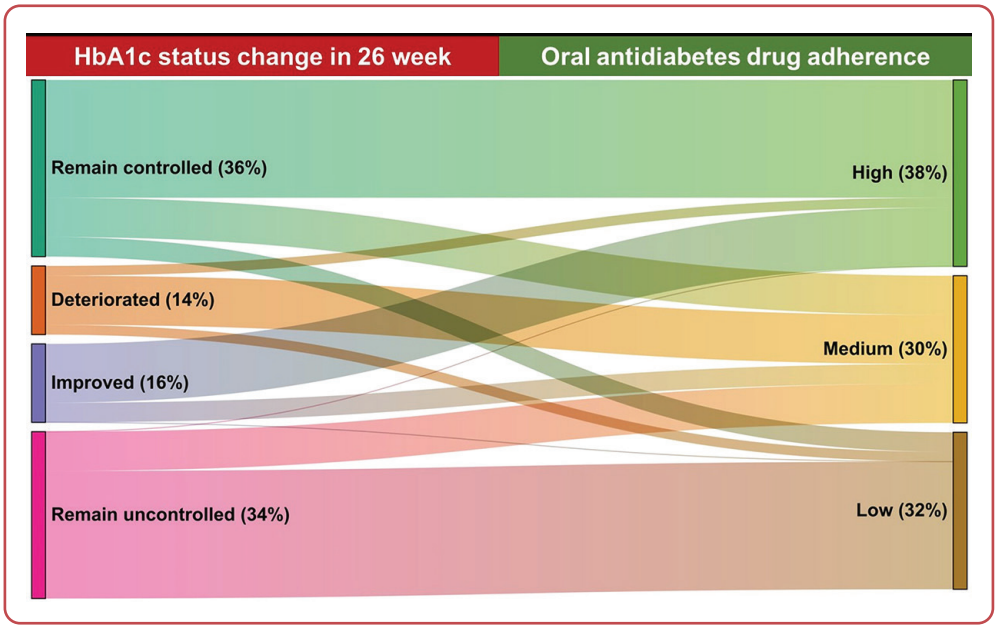


Figure 3: Sankey plot of transitions in glycaemic control over 26 weeks and oral antidiabetic drug adherence levels

Table 2: Change in glycaemic control by oral antidiabetic drug adherence

Adherence (MMAS-8)	Glycaemic control status (HbA1c), n (%)				OR (95 % CI)	p-value
	Uncontrolled (> 7 %)		Controlled (≤ 7 %)			
	Previously controlled	Previously uncontrolled	Previously controlled	Previously uncontrolled		
Low	1 (14.3 %)	13 (76.5 %)	2 (11.1 %)	0 (0.0 %)	6.69 (1.32–34.5)	0.041[a]*
Moderate	5 (71.4 %)	4 (23.5 %)	4 (22.2 %)	2 (25.0 %)		
High	1 (14.3 %)	0 (0.0 %)	12 (66.7 %)	6 (75.0 %)		

*[a] Fisher's exact test comparing low–moderate versus high adherence and improvement (previously uncontrolled, currently controlled) versus no improvement. *Statistically significant (p < 0.05). CI: confidence interval; OR: odds ratio; MMAS-8: 8-item Morisky Medication Adherence Scale;*

Table 3: Adjusted analysis of the association between adherence and change in glycaemic control

Dependent variable	Covariate effect			Adherence-level effect		
	Covariate	F(1.45)	p-value	F(2.45)	p-value	Partial η²
Change in glycaemic control	Age	0.175	0.678	10.309	< 0.001*	0.478
	Historical baseline HbA1c	14.739	< 0.001*			

*ANCOVA with age and historical baseline HbA1c as covariates and adherence as a fixed factor (n = 50). *Statistically significant (p < 0.05). F: test statistic; η²: partial eta squared.*

(F(1.45) = 0.175, p = 0.678). These findings indicate that better medication adherence predicts improved glycaemic outcomes independent of age while accounting for the significant effect of baseline HbA1c.

Discussion

This study examined the association between oral antidiabetic drug (OAD) adherence and glycaemic control among patients with type 2 diabetes mellitus (T2DM) enrolled in a community-based chronic disease management programme. The principal findings demonstrated a strong and consistent relationship between higher medication adherence and favourable glycaemic outcomes. The direction of the association was consistent across the reported analyses, although causality cannot be inferred.

Rather than reiterating numerical outcomes, the interpretation of the data yields several critical insights. Adherence appears to be associated both with maintenance of glycaemic control and with the likelihood of improvement. Patients who adhered well to their medication regimen tended to sustain or transition into better glycaemic states, whereas poor adherence was generally associated with persistent or worsening glycaemic profiles. This distinction suggests that adherence is not merely a background factor but an important correlate of glycaemic outcomes.[10]

The inverse relationship between adherence and glycaemic dysregulation aligns with longstanding evidence in diabetes care. Previous studies have consistently reported that nonadherence contributes significantly to suboptimal glycaemic control and the progression of complications.[6, 11] By employing a structured and validated adherence measure, this study adds further credibility to the proposition that adherence-support interventions warrant evaluation in public health interventions.

An important observation is that adherence outperformed age as a predictor of change in glycaemic control when confounding factors were accounted for. Although older individuals might be presumed to be more adherent due to lifestyle stability or greater awareness of health risks, this study suggests that age itself is not an adequate proxy for medication-taking behaviour.[12, 13] The implication is that adherence-enhancing strategies must be tailored across all age groups and should not assume compliance based solely on demographic characteristics.

The methodological approach, combining self-reported adherence scores with longitudinal glycaemic tracking and statistical control for confounders, provides complementary perspectives on the reported associations. Particularly valuable is the use of Sankey plot analysis to visualise transitions in glycaemic status relative to adherence levels. This approach enables intuitive comprehension of how medication behaviour relates to clinical outcomes, emphasising that adherence levels were related to both cross-sectional measures and recorded changes in glycaemic status.

The public health implications are substantial. In programmes such as PROLANIS, where resources may be limited and patient loads are high, scalable interventions that target adherence might improve population-level outcomes but require prospective evaluation. Strategies might include personalised counselling, simplification of regimens, digital and conventional adherence reminders, community health worker follow-up or family engagement.[14] Given the modifiable nature of adherence, these approaches present an opportunity to shift outcomes without requiring new pharmacological agents or infrastructure.

In this context, screening tools such as the MMAS-8 are especially valuable as they are inexpensive, non-invasive and simple to administer, thus well suited for integration into routine primary care workflows.[15,16] Identifying patients at risk of poor adherence enables timely intervention, potentially preventing chronic disease progression and avoiding the need for more intensive and costly treatments in the future.

The findings also suggest that initial HbA1c level influences the degree of potential improvement, supporting the notion of clinical inertia when glycaemic control is already acceptable.[17] Nevertheless, adherence remains the actionable element; without it, even favourable baselines do not guarantee continued control. This supports the view that glycaemic targets should be pursued within a framework that prioritises behavioural consistency.

While the study offers important insights, several limitations should be acknowledged. The observational design limits causal inference, although retrospective tracking of glycaemic change provides partial temporal context. The relatively small sample size may restrict generalisability, and the precision and clinical significance of the reported effects require further assessment. Self-reported adherence, while practical, may be subject to overreporting. Triangulation with objective metrics such as prescription refill data or electronic monitoring would further enhance validity.

Conclusion

In summary, higher oral antidiabetic drug adherence was associated with better glycaemic control among patients with type 2 diabetes mellitus participating in PROLANIS at the primary care level. The findings highlight medication adherence as an important factor associated with glycaemic outcomes in community-based chronic disease management. However, given the observational design, cross-sectional assessment of medication adherence, relatively small sample size, and limited precision of some effect estimates, the findings should be interpreted cautiously and should not be considered evidence of a causal relationship. The observed changes in HbA1c over the preceding 26 weeks provide additional exploratory evidence of an association between adherence level and glycaemic outcomes, but cannot establish that adherence caused changes in glycaemic control. Further prospective studies with larger samples and repeated assessments of medication adherence and glycaemic control are warranted to clarify the temporal and causal relationship.

Ethics

This study was reviewed and study protocol was approved by the Health Research Ethics Committee of the Faculty of Medicine, Universitas Katolik Widya Mandala Surabaya (Decision No 0002/WM12/KEPK/MHS/T/2025, dated 8 January 2025). Written informed consent was obtained from all participants before enrolment. Participant confidentiality and data anonymity were maintained throughout the study and the data were used exclusively for research purposes.

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Conflicts of interest

The authors declare that there is no conflict of interest.

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Data access

The data that support the findings of this study are available from the corresponding author upon reasonable individual request.

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