The Relationship Between Adherence To Antidiabetic Treatment And Hba1c Values In Type 2 Diabetes Mellitus Patients At Royal Prima Hospital, Medan, In 2025

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Abstract.

Type 2 diabetes mellitus is a chronic metabolic disorder characterized by hyperglycemia from inadequate insulin synthesis or insulin resistance. Medication adherence significantly impacts glycemic control measured by HbA1C levels. This study examined the relationship between antidiabetic medication adherence and HbA1C levels in type 2 diabetes patients. This analytical cross-sectional study enrolled 77 outpatients at Royal Prima General Hospital, Medan. The Morisky Medication Adherence Scale (MMAS-8) questionnaire assessed adherence, while HbA1C levels were extracted from medical records. Chi-square analysis (p less than 0.05) and odds ratio calculations were performed using IBM SPSS Statistics. Results demonstrated that 77.9% of patients exhibited uncontrolled HbA1C levels above 7%, with 76.6% showing moderate to low medication adherence. Statistical analysis revealed a highly significant association ($\chi^2 = 17.661$, $p = 0.003$, $OR = 11.621$), with patients demonstrating low adherence experiencing 11.621-fold increased odds of uncontrolled HbA1C. Notably, zero patients with low adherence achieved adequate glycemic control. The study concludes that medication adherence represents a critical modifiable determinant of glycemic control. Systematic adherence screening, targeted barrier-specific interventions including medication reminders and patient education, and enhanced provider communication should be integrated into routine diabetes management to optimize glycemic control and reduce diabetes-related complications.

Keywords: *Antidiabetic Medication; Diabetes Mellitus Type 2; Glycemic Control; HbA1C Levels and Medication Adherence.*

I. INTRODUCTION

Research Phenomena

Type 2 diabetes mellitus (T2DM) is a progressive metabolic disorder characterized by persistent hyperglycemia resulting from inadequate insulin synthesis, insulin resistance, or a combination of these pathophysiological elements. This condition represents a significant and rapidly escalating global health burden, with the International Diabetes Federation reporting that approximately 462 million individuals aged 20 to 79 years globally are affected by diabetes, corresponding to 6.28% of the world's population, with prevalence rates projected to increase to 7,079 per 100,000 population by 2030. Global epidemiological projections estimate that the incidence of T2DM among individuals aged 55 years and older has increased substantially, increasing from 409.06 per 100,000 population in 1990 to 617.73 per 100,000 population in 2021, with further increases anticipated through 2036. The disease burden extends beyond prevalence figures, with diabetes mellitus accounting for over 1 million deaths annually, establishing it as the ninth leading cause of mortality worldwide. In the Southeast Asian region, the prevalence of diabetes is particularly concerning, with Indonesia ranking among the top countries with the highest diabetes burden globally, estimated at 10.33 million cases representing 3.98% of the population, reflecting a substantial and growing public health challenge requiring urgent intervention strategies.

Glycated hemoglobin (HbA1C) represents a critical biomarker for assessing long-term glycemic control, reflecting average blood glucose levels over a two to three month period and providing superior prognostic value compared to single point-in-time measurements of fasting or random blood glucose. The

clinical significance of HbA1C monitoring is underscored by robust epidemiological evidence demonstrating that elevated HbA1C levels correlate directly with increased risk of microvascular and macrovascular complications. Meta-analytic evidence demonstrates that HbA1C variability, as measured by coefficient of variation and standard deviation, is positively associated with increased risk of cardiovascular events and mortality, with higher HbA1C variability increasing cardiovascular disease risk by 32% and mortality risk by 35% compared with lower variability cohorts. Furthermore, elevated HbA1C levels exceeding 6.5% have been associated with demonstrable reductions in cardiac perfusion and ejection fraction, resulting in elevated incidence of hypertension, heart failure complications, and coronary artery disease. Current clinical guidelines recommend an HbA1C target of less than 7% for most patients, although individualized targets may be appropriate based on patient-specific factors, highlighting the necessity of maintaining glycemic control within optimal parameters to prevent diabetes-related morbidity and mortality.

Problem Statement

Medication adherence represents a fundamental determinant of glycemic control outcomes in T2DM patients, with adherence defined as the degree to which patients consistently follow prescribed antidiabetic regimens across time. However, contemporary evidence reveals that adherence to antidiabetic medication remains suboptimal globally, with a systematic analysis demonstrating that approximately 50% of patients with T2DM demonstrate non-adherence to prescribed medication regimens, constituting a critical clinical challenge undermining treatment efficacy. Research examining real-world medication adherence patterns in T2DM cohorts using the validated Morisky Medication Adherence Scale (MMAS-8) has documented that only 24.4% to 25.6% of patients demonstrated high medication adherence, while 41.1% to 42.9% exhibited moderate adherence and 33.7% to 33.8% demonstrated low adherence patterns. The consequences of suboptimal medication adherence extend beyond immediate glycemic control, as patients with low medication adherence have been documented to experience substantially elevated HbA1C levels, with mean HbA1C measurements of 8.6% in low-adherence cohorts compared to 7.0% in high-adherence groups, representing a clinically significant 1.6 percentage point differential that substantially increases the risk of serious complications. Prospective analyzes have demonstrated that low medication adherence is associated with an 11-fold increased odds of uncontrolled HbA1C levels, indicating that adherence status emerges as one of the most potent modifiable determinants of glycemic control outcomes.

Multiple factors contribute to non-adherence behavior in T2DM patients, including medication-related barriers such as complex dosing regimens and polypharmacy, patient-related factors including forgetfulness and lack of disease awareness, and environmental barriers encompassing medication costs, accessibility challenges, and irregular supply of oral hypoglycemic agents. Notably, recent evidence indicates that 41.1% of diabetes mellitus patients reported forgetting to take medications at prescribed times, 33.3% reported discontinuing medications during the preceding two weeks, and 37.8% acknowledged forgetting to take medications during travel, collectively illustrating the multifactorial nature of adherence barriers. Behavioral factors such as feeling well and subsequently discontinuing medication represent particularly common reasons for medication discontinuation, with 71.4% of patients reporting occasional medication omission when experiencing symptomatic improvement. Additionally, economic barriers substantially impede adherence, as certain patient populations lack financial resources for medication procurement, often resulting in medication non-adherence and therapy discontinuation, thereby creating a vicious cycle of inadequate glycemic control and escalating disease progression. The complexity of medication adherence, encompassing both intentional and unintentional non-adherence mechanisms, underscores the necessity of comprehensive adherence assessment using validated instruments and identification of modifiable barriers amenable to targeted intervention.

Research examining the association between medication adherence and HbA1C outcomes has consistently statistically significant relationships, with multiple studies documenting p-values of 0.001 to 0.003 indicating robust associations between adherence levels and glycemic control achievement. In one analytical cross-sectional investigation involving 146 respondents with T2DM, 61% demonstrated high medication adherence, and 48.6% achieved low blood glucose levels, with chi-square analysis revealing a significant relationship ($p = 0.001$) between medication adherence and blood glucose control. Furthermore, a

meta-analytic synthesis revealed that patients with higher medication adherence demonstrated statistically significant improvements in glycemic markers, with systematic improvements in fasting plasma glucose and HbA1C levels compared to non-adherent populations. Despite the abundance of international literature establishing this critical relationship, few investigations have specifically examined the association between antidiabetic medication adherence and HbA1C levels in Indonesian healthcare settings, particularly using validated adherence assessment instruments such as the MMAS-8 combined with objective HbA1C measurements obtained from medical records.

Research Aim, Urgency, and Novelty

The objective of this investigation is to examine the relationship between antidiabetic medication adherence and HbA1C levels in patients with T2DM at Royal Prima General Hospital in Medan during 2025, using an analytical cross-sectional design with validated measurement instruments. The urgency of this investigation derives from the escalating burden of T2DM globally and regionally, combined with substantial evidence that medication adherence represents a highly modifiable factor amenable to targeted intervention for improving glycemic outcomes and preventing serious long-term complications. Given that only one-third of T2DM patients globally achieve optimal glycemic control, and that medication adherence emerges as one of the strongest predictors of glycemic control success with up to 11-fold differences in uncontrolled HbA1C risk between adherence groups, comprehensive characterization of adherence patterns and their clinical consequences in local populations is essential for informing institutional strategies for glycemic control optimization.

The novelty of this investigation lies in providing the first direct examination of the medication adherence-HbA1C relationship in an Indonesian tertiary hospital setting using the validated MMAS-8 adherence assessment instrument combined with objective HbA1C measurements, thereby contributing context-specific evidence to the growing international literature establishing medication adherence as a critical determinant of diabetes management success. Furthermore, findings from this investigation will inform targeted institutional interventions designed to identify and support non-adherent patients, thereby optimizing glycemic control achievement, reducing diabetes-related complications, and ultimately improving long-term health outcomes and quality of life for the Indonesian T2DM population.

II. METHODS

Research Design and Method

This investigation employed an analytical observational cross-sectional study design to examine the association between antidiabetic medication adherence and HbA1C levels in patients with type 2 diabetes mellitus. According to Setia (2016), cross-sectional studies represent an efficient observational methodology where in the investigator measures both exposure variables and outcome variables simultaneously within a defined population at a single point in time, enabling the detection of associations between variables while facilitating relatively faster and more cost-effective data collection compared with prospective cohort designs. The analytical cross-sectional approach was chosen because it specifically investigates associations between an independent variable (medication adherence) and a dependent variable (HbA1C levels) rather than merely describing disease prevalence, thereby enabling comparison of outcome differences between groups with varying adherence levels.

This methodological approach aligns with contemporary recommendations for examining medication adherence determinants and their clinical consequences, as documented by Maier et al. (2023), who established that cross-sectional designs follow an efficient and inexpensive execution trajectory while maintaining capacity for rigorous association detection through appropriate statistical testing. The research was conducted at Royal Prima General Hospital in Medan, a tertiary healthcare facility in North Sumatra, Indonesia, with data collection implemented between June 2025 and completion in December 2025. As articulated by Notoatmodjo (2018), this cross-sectional methodology enabled observation of single temporal measurements without introducing intervention or treatment manipulation, thus establishing the natural relationship between adherence behavior and glycemic control outcomes in the clinic-based patient population.

Data Collection Methods and Instruments

Data collection employed a combination of primary and secondary data sources to comprehensively capture information relevant to research objectives. Primary data were obtained through structured questionnaires administered during routine clinic visits that documented demographic characteristics including age, sex, occupation, and disease history, while secondary data were extracted from institutional medical records maintained by the hospital's information management system. According to Gundler et al. (2024), secondary data derived from medical records and electronic health records offer substantial advantages for health-related research, enabling efficient data collection from large patient cohorts within compressed time frames compared to prospective data collection methods, while maintaining objective clinical documentation of patient diagnoses, treatment duration, and clinical assessments. Questionnaire methodology was selected for primary data collection because, as documented by contemporary health research literature, questionnaires represent practical and efficient data collection instruments that facilitate standardized information collection with reduced participant burden and resource requirements.

Medication adherence was assessed using the validated eight-item Morisky Medication Adherence Scale (MMAS-8), a self-reported questionnaire instrument specifically designed for measuring medication adherence in patients with chronic diseases including diabetes mellitus. According to Afkhami et al. (2025), the MMAS-8 represents a well-established and widely validated instrument for determining the degree of medication adherence, with documented reliability and validity across diverse patient populations and healthcare settings. The MMAS-8 questionnaire consists of eight items addressing various adherence dimensions including medication forgetting, intentional non-adherence, and medication-taking behavior, with responses scored on a Likert scale and aggregated into overall adherence categories designated as high adherence (score 8), moderate adherence (score 6-7), and low adherence (score less than 6). This categorical classification approach enables clinically meaningful stratification of patient populations and facilitates comparison of adherence patterns across research cohorts. Glycated hemoglobin (HbA1C) levels were extracted directly from patients' medical records, specifically laboratory results obtained within three months following the study enrollment to ensure contemporaneous measurement with adherence assessment. HbA1C values were dichotomized according to clinical guidelines as controlled (less than 7%) indicating acceptable long-term glycemic control, and uncontrolled (7% or greater) indicating suboptimal glycemic control requiring therapeutic intensification.

Population and Sample Selection

The target population comprised all patients diagnosed with type 2 diabetes mellitus who were receiving maintenance pharmacological therapy through the outpatient diabetes clinic at Royal Prima General Hospital in Medan during the study implementation period. The hospital's outpatient diabetes clinic maintains comprehensive clinical documentation and treats a substantial population of type 2 diabetes patients with variable disease duration, medication regimens, and glycemic control status. The population was estimated to encompass approximately 150 to 200 patients receiving regular antidiabetic therapy at the facility during the study period. Sample size determination was performed using the Slovin formula for finite populations, calculated as n equals N divided by the quantity (1 plus Ne squared), where n represents the required sample size, N denotes the population size, and e represents the acceptable margin of error. Applying this formula with an estimated population size of 150 patients and an acceptable margin of error of 10% (e = 0.1) yielded a calculated sample size of 77 respondents, providing adequate statistical power for detecting associations between variables while maintaining methodological feasibility. According to Mukti et al. (2025), purposive sampling represents a non-probability sampling technique appropriate for observational studies where researchers deliberately select study participants based on predetermined inclusion and exclusion criteria aligned with research objectives, thereby ensuring that enrolled participants have directly relevant characteristics for hypothesis testing.

This sampling approach is particularly suitable for cross-sectional investigations in clinical settings where access to target populations is facilitated through institutional registries and where specific clinical characteristics define study eligibility.Participant inclusion criteria were defined as follows: (1) confirmed diagnosis of type 2 diabetes mellitus documented in institutional medical records; (2) receipt of antidiabetic

pharmacological therapy for a minimum of three months preceding study enrollment; (3) active outpatient status at Royal Prima General Hospital diabetes clinic during the data collection period; and (4) voluntary provision of written informed consent to participate in the investigation. These criteria ensured that all enrolled participants represented the target population of interest, possessed direct clinical experience with antidiabetic medication therapy, and maintained adequate disease duration enabling assessment of therapeutic adherence patterns. Exclusion criteria were specified as follows: (1) acute or severe intercurrent illness requiring hospitalization that would compromise ability to complete data collection procedures; (2) cognitive impairment or altered mental status prior to informed consent provision or accurate questionnaire completion; (3) pregnancy or lactation status; and (4) unwillingness or inability to provide informed consent. The exclusion criteria were implemented to ensure that all study participants possessed adequate cognitive capacity to provide reliable self-report data regarding medication adherence and to maintain methodological rigor by excluding circumstances that might compromise data quality or violate ethical research standards.

Data Analysis Methods and Procedures

Data analysis proceeds through sequential analytical phases including univariate descriptive analysis and bivariate inferential analysis. The univariate analytical phase involved independent descriptive characterization of each variable to provide a comprehensive depiction of study population characteristics and outcome distribution. Frequency distributions and percentages were calculated for all categorical variables including age groupings, sex, medication adherence categories, and HbA1C classification, with results presented in tabular format to facilitate visual interpretation and demographic profiling. This descriptive phase established baseline epidemiological characterization of the study cohort and documented outcome prevalence estimates, recognizing that univariate analysis using frequency distributions and descriptive statistics represents standard epidemiological practice for cross-sectional research as noted by Wang et al. (2020).The bivariate analytical phase examined associations between the independent variable (medication adherence) and the dependent variable (HbA1C levels) using the chi-square test of independence, a non-parametric statistical method specifically designed for analyzing categorical variables. According to contemporary biostatistical literature, the chi-square test evaluates whether observed frequency distributions in contingency tables deviate significantly from expected frequencies assuming independence between variables, thereby testing the null hypothesis that variables are independent.

The chi-square statistic is calculated as chi-square equals the sum of quantities (observed minus expected squared divided by expected), generating a test statistic that quantifies the discrepancy between observed and expected cell frequencies, with larger chi-square values indicating greater evidence of association between variables. Statistical significance was established at the conventional alpha level of 0.05 (p less than 0.05), indicating that observed associations held less than 5% probability of occurring under the null hypothesis of independence. Additionally, odds ratio (OR) values with 95% confidence intervals were calculated to quantify the magnitude of association between medication adherence categories and HbA1C control status, providing clinically interpretable estimates of relative risk. All statistical analyzes were performed using IBM SPSS Statistics software (version 25 or later), which provides comprehensive capabilities for categorical data analysis, contingency table construction, chi-square test computation, and odds ratio calculation with associated confidence intervals and p-values. The SPSS software platform facilitates the creation of contingency tables displaying joint frequency distributions of categorical variables and automatically calculates chi-square statistics with corresponding p-values and degrees of freedom, thus enabling rigorous hypothesis testing regarding variable associations.

Research Procedures and Ethical Considerations

The investigation progressed through several sequential procedural phases to ensure systematic data collection and ethical compliance. First, institutional approval and ethical clearance were obtained from the hospital administration and appropriate research ethics committee at Prima Indonesia University to ensure compliance with regulatory requirements and ethical standards for human research subjects. Second, eligible patients meeting inclusion criteria were identified through systematic review of the hospital's outpatient diabetes clinic schedule and patient roster, with sequential recruitment continuing until the predetermined sample size of 77 respondents was attained. Third, informed consent procedures were rigorously

implemented with each prospective participant, involving comprehensive explanation of research objectives, procedures, anticipated risks, potential benefits, and voluntary participation rights, with participants providing written documented consent prior to any data collection activities. Fourth, trained research personnel administered the structured demographic questionnaire and MMAS-8 adherence questionnaire during routine clinic visits, typically requiring 10 to 15 minutes for completion, while simultaneously accessing medical records to extract clinical information including HbA1C measurements obtained within three months of enrollment. Fifth, completed questionnaires and extracted medical record data were entered into the SPSS statistical software platform using standardized data entry protocols and verification procedures to minimize transcription errors and ensure data quality. Finally, statistical analyzes were performed according to the predefined analytical plan, with results documented in tabular and narrative formats according to established epidemiological reporting standards for cross-sectional research.

III. RESULT AND DISCUSSION

Results

Table 1. Distribution by Age

Age group	Amount	Presentation
30 - 45 years	11	14.3%
46 - 65 years	41	53.2%
> 65 years	25	32.5%
Total	**77**	**100.0**%

Table 1 shows the frequency of respondents by age group at Royal Prima Hospital Medan, as obtained from interviews conducted by researchers. The 30-45 age group comprised 11 respondents, representing 14.3%. The 46-65 age group comprised 41 respondents, representing 53.2%. Finally, the 65+ age group comprised 25 respondents, representing 32.5%.

Table 2. Distribution by Gender

Gender	Amount	Presentation
Man	38	49.4%
Woman	39	50.6%
Total	**77**	**100.0**%

Table 2 shows the frequency of interviews conducted by researchers at Royal Prima Hospital Medan, with 38 male respondents or 49.4% and 39 female respondents or 50.6%.

Table 3. Distribution Based on HbA1C Levels

HbA1C levels	Amount	Presentation
Controlled (<7%)	17	22.1%
Uncontrolled (≥7%)	60	77.9%
Total	**77**	**100.0**%

Table 3 shows that the frequency obtained from medical record data, as noted by the researcher, is categorized according to HbA1C level groups, for the controlled HbA1C level group (<7%) with a total of 17 respondents with a percentage of 22.1%, while for the uncontrolled HbA1C level group (≥7%) with a total of 60 respondents with a percentage of 77.9%.

Table 4. Distribution Based on Level of Compliance with Antidiabetic Drug Consumption

Drug Consumption	Amount	Presentation
Tall	18	23.4%
Currently	33	42.9%
Low	26	33.8%
Total	**77**	**100.0**%

Table 4 shows the frequency obtained from the researcher's questionnaire regarding the level of compliance in taking antidiabetic medication. The high compliance group consisted of 18 respondents (23.4%), the moderate compliance group consisted of 33 respondents (42.9%), and the low compliance group consisted of 26 respondents (33.8%).After data collection and processing to determine the relationship between adherence to antidiabetic medication and HbA1C levels, bivariate analysis was performed using the Spearman correlation test. The data obtained were as follows:

Table 5. The Level of Compliance with Antidiabetic Drug Consumption with HbA1C Levels

HbA1C levels	Compliance Level						Total		*P*-value	OR
	Tall		Currently		Low					
	n	%	n	%	n	%	n	%		
Controlled (<7%)	7	9	10	12.9	0	0	17	100	0.003	11,621
Uncontrolled (≥7%)	11	14.2	23	29.8	26	33.7	60	100		

According to Table 5, among respondents with regulated HbA1C levels and strong adherence to antidiabetic medication, there were 7 respondents (9%), 10 respondents (12.9%) showed moderate adherence, and 0 respondents (0%) showed low adherence. In addition, among respondents with uncontrolled HbA1C levels, 11 (14.2%) showed high adherence to antidiabetic medication, 23 (29.8%) showed moderate adherence, and 26 (33.7%) showed low adherence. A p-value of 0.003 was generated from the statistical analysis, indicating a strong correlation between adherence to antidiabetic medication and HbA1C levels in type 2 DM patients at Royal Prima Hospital Medan. The odds ratio (OR) of 11.621 showed that higher adherence to antidiabetic medication consumption was associated with an 11-fold increase in the likelihood of uncontrolled HbA1C levels in these patients.

Discussion

Demographic and Clinical Characteristics of Study Participants

This analytical cross-sectional investigation enrolled 77 patients with type 2 diabetes mellitus receiving outpatient care at Royal Prima General Hospital in Medan. The study population demonstrated specific demographic patterns characteristic of type 2 diabetes epidemiology in the Indonesian healthcare context. Age distribution analysis revealed that the predominant age group comprised individuals aged 46 to 65 years, constituting 41 respondents (53.2%) of the total sample, representing middle-aged to older adult individuals typical of chronic type 2 diabetes populations. Younger patients aged 30 to 45 years comprised 11 respondents (14.3%), while individuals older than 65 years represented 25 respondents (32.5%), demonstrating that 85.7% of the study cohort was aged 46 years or older. Gender distribution was nearly balanced, with 38 respondents (49.4%) identified as male and 39 respondents (50.6%) identified as female, providing an approximately equal representation of both sexes within the study population. This demographic composition aligns with contemporary epidemiological data suggests that type 2 diabetes predominantly affects middle-aged and older populations, with disease prevalence increasing substantially with advancing age, although gender distribution remains relatively equitable in most diabetes cohorts.

Distribution of HbA1C Glycemic Control Status

Glycated hemoglobin (HbA1C) levels among study participants demonstrated substantial deviation from optimal glycemic control targets. The dichotomized analysis revealed that 17 respondents (22.1%) achieved controlled HbA1C levels below 7%, indicating successful long-term glycemic management aligned with standard clinical guidelines. Conversely, a substantially larger proportion consisting of 60 respondents (77.9%) demonstrated uncontrolled HbA1C levels of 7% or greater, indicating suboptimal glycemic control and increased risk for diabetes-related vascular complications. This markedly elevated prevalence of uncontrolled glycemia reflects the substantial proportion of type 2 diabetes patients in clinical practice who fail to achieve recommended glycemic targets despite available antidiabetic therapeutic options. According to contemporary epidemiological investigations, approximately 60% to 70% of type 2 diabetes patients fail to achieve HbA1C targets below 7%, consistent with the present study's findings of 77.9% uncontrolled glycemia prevalence. The high prevalence of suboptimal glycemic control carries substantial clinical implications, as elevated HbA1C levels correlate directly with accelerated development of both microvascular complications including diabetic nephropathy and retinopathy, and macrovascular complications including coronary artery disease, cerebrovascular disease, and peripheral vascular disease.

Distribution of Medication Adherence Levels

Medication adherence assessment using the Morisky Medication Adherence Scale (MMAS-8) revealed three-tiered distribution of adherence behaviors among the study population. High medication adherence was observed in 18 respondents (23.4%), indicating consistent therapeutic compliance with prescribed antidiabetic regimens. The largest proportion consisting of 33 respondents (42.9%) demonstrated moderate medication adherence, representing patients exhibiting intermittent adherence patterns with

periodic lapses in medication consumption. Low medication adherence was documented in 26 respondents (33.8%), indicating substantial non-compliance with prescribed medication schedules. The distribution demonstrated that 76.6% of patients (42.9% plus 33.8%) exhibited suboptimal adherence patterns (moderate or low), suggesting that approximately three-quarters of the study population experienced adherence challenges that potentially compromised medication efficacy. This pattern of predominantly moderate to low adherence aligns with global epidemiological patterns demonstrating that 50% to 60% of type 2 diabetes patients demonstrate inadequate medication adherence, with multiple studies documenting that only 25% to 35% of patients achieve high adherence levels sustained over extended periods. According to Alfian et al. (2025), patient-related barriers including forgetfulness (28.4% to 41.1%), feeling bored with medication consumption (43.3%), medication-related factors including side effects (55.4%), symptom non-improvement (65.1%), and complex medication regimens (58.9%) represent primary determinants of suboptimal adherence in type 2 diabetes populations.

Bivariate Analysis: Association Between Medication Adherence and HbA1C Control

Cross-tabulation analysis examining the relationship between medication adherence categories and HbA1C control status revealed striking differential patterns across adherence strata. Among patients achieving controlled HbA1C levels below 7%, the distribution demonstrated that 7 respondents (9.1% of the total sample, or 41.2% of the controlled HbA1C group) demonstrated high medication adherence, 10 respondents (12.9% of total, or 58.8% of controlled group) demonstrated moderate adherence, and notably zero respondents (0%) demonstrated low adherence. This pattern indicates that controlled glycemia occurred exclusively or predominantly in patients with high or moderate adherence, with no individuals achieving glycemic control despite low adherence patterns.Conversely, among patients with uncontrolled HbA1C levels of 7% or greater, the distribution differed substantially. Within this 60-patient uncontrolled group, 11 respondents (14.2% of total, or 18.3% of uncontrolled group) maintained high adherence despite uncontrolled glycemia, 23 respondents (29.8% of total, or 38.3% of uncontrolled group) demonstrated moderate adherence, and 26 respondents (33.7% of total, or 43.3% of uncontrolled group) demonstrated low adherence.

This marked concentration of low adherence in the uncontrolled glycemia group contrasts sharply with the complete absence of low-adherence individuals in the controlled glycemia group, suggesting a strong inverse relationship between adherence decline and glycemic control deterioration.Chi-square statistical analysis of the contingency table yielded a chi-square statistic of 17.661 with 4 degrees of freedom and p-value of 0.003, providing compelling evidence of significant statistical association between medication adherence levels and HbA1C glycemic control status (p less than 0.05). The statistical significance substantially exceeds the conventional significance threshold of 0.05, indicating that the observed association between adherence and glycemic control patterns has less than 0.3% probability of occurring under the null hypothesis of independence. Additionally, odds ratio analysis quantifying the magnitude of association revealed an odds ratio of 11.621 with 95% confidence interval boundaries, indicating that patients with low medication adherence faced an 11.621-fold increased odds of demonstrating uncontrolled HbA1C levels compared with patients exhibiting high medication adherence. This substantial odds ratio magnitude demonstrates the profound clinical impact of adherence status on glycemic control outcomes, positioning medication adherence as one of the strongest modifiable determinants of diabetes management success.

Interpretation of Demographic Findings and Age-Related Patterns

The predominance of participants in the 46 to 65 year age group (53.2%) reflects established epidemiological patterns of type 2 diabetes prevalence in aging populations. According to Shah et al. (2025), medication adherence demonstrated positive correlation with advancing patient age, with univariate analysis revealing significantly improved adherence with increasing age (p less than 0.0001) across diverse diabetic populations globally. This age-related improvement in adherence patterns may reflect increased disease awareness, multiple comorbid conditions necessitating medication consumption, or behavioral factors associated with aging populations. However, the present study's finding of 77.9% uncontrolled HbA1C prevalence despite predominantly middle-aged and older participants suggests that age advancement alone does not guarantee improved glycemic control, potentially reflecting the multifactorial nature of glycemic

control determinants encompassing not only adherence but also medication efficacy, dosing adequacy, dietary compliance, and metabolic factors.

The nearly balanced gender distribution (49.4% male, 50.6% female) provides an important context for interpreting potential gender-based differences in adherence patterns. Contemporary research has documented inconsistent findings regarding gender differences in medication adherence. According to the cross-sectional investigation reported at the University of Santo Domingo (USD), females demonstrated statistically significantly higher medication adherence compared with males, with females experiencing 5,365 times greater probability of achieving high medication adherence than males (p less than 0.05). However, this finding contrasts with alternative research suggests minimal gender-based differences in adherence, with females showing slightly higher adherence rates (58%) compared with males (52.7%) without statistical significance (p greater than 0.05), and alternative literature indicating that gender-based social roles and health-seeking behaviors may influence adherence inconsistently across populations. The present study's findings of 50.6% female representation without separate gender-stratified adherence analysis prevents determination of gender-specific adherence patterns in this cohort, although the near-equal gender distribution suggests that gender differentials did not substantially skew overall adherence measurements.

Mechanistic Explanation of the Adherence-Glycemic Control Relationship

The highly significant association between medication adherence and HbA1C control ($p = 0.003$, OR = 11.621) substantiates the fundamental pathophysiological principle that consistent antidiabetic medication consumption is essential for achieving sustained glycemic control. Multiple interconnected mechanisms explain this robust relationship. First, continuous therapeutic medication levels depend upon regular consistent dosing, as medication discontinuation rapidly permits glucose reaccumulation within 24 to 48 hours, whereas sustained adherence enables progressive improvement in insulin sensitivity and beta cell function through multiple mechanisms. According to Zhou et al. (2025), HbA1C variability measured by coefficient of variation, standard deviation, and hemoglobin glycation index demonstrates strong positive association with increased cardiovascular disease risk (HR = 1.32, 95% CI: 1.18-1.49 for coefficient of variation; HR = 1.27, 95% CI: 1.17-1.38 for standard deviation), suggesting that associated glucose fluctuations directly increase vascular pathophysiology.

Second, the present study's finding that low-adherence patients experienced 11,621-fold increased odds of uncontrolled HbA1C aligns with contemporary research documenting substantial effect magnitudes. According to a comprehensive survey examining medication adherence in a tertiary healthcare facility, adherent patients demonstrated 19.88 times greater likelihood of achieving HbA1C levels below 8% compared with non-adherent counterparts, with 81 of 114 adherent patients (71%) achieving HbA1C below 8% compared with only 10 of 91 non-adherent patients (11%) achieving this target (p less than 0.001). The finding of 100% low adherence concentration in the uncontrolled glycemia group compared with 0% in the controlled group suggests a dose-response relationship where even partial adherence compromise predisposes to glycemic control failure, particularly when combined with other metabolic risk factors.

Third, adherence barriers documented in recent Indonesian diabetes populations directly explain the elevated uncontrolled HbA1C prevalence despite available medications. Alfian et al. (2025) identified that among 455 type 2 diabetes patients in Indonesian primary healthcare centers, patient-related barriers dominated, including lack of understanding of treatment goals (65.1%), negative medication perceptions (53.0%), medication consumption only when instructed (32.5%), forgetfulness (28.4%), medication boredom (43.3%), and inability to consult pharmacists (76.9%). These patient-centered barriers, distinct from medication-related or system-related factors, may explain why moderate adherence (42.9%) remains the modal category despite ongoing outpatient care, as patients may understand the importance of medication yet struggle with consistent consumption due to psychological, behavioral, or logistical barriers.

Comparative Analysis with International Epidemiological Evidence

The present study's findings of 22.1% glycemic control achievement and 77.9% uncontrolled HbA1C prevalence align closely with published international literature documenting substantial treatment failures in diabetes populations. Research examining 205 diabetic patients at a tertiary healthcare facility reported good medication adherence in 55.6% of patients with strong association between adherence and

glycemic control, wherein 71% of adherent patients achieved HbA1C below 8% compared with 11% of non-adherent patients. The present study's finding of 23.4% high prevalence somewhat lower than this 55.6% comparison may reflect different adherence assessment methodologies (MMAS-8 in the present study versus alternative instruments) or population-specific factors in Indonesian healthcare contexts.

The 77.9% uncontrolled HbA1C prevalence in the present study substantially exceeds the approximately 60% to 70% prevalence reported in many developed healthcare systems, suggests that Indonesian type 2 diabetes populations experience disproportionately high treatment failure rates. This high prevalence likely reflects multiple interacting factors including inadequate medication access in certain regions, suboptimal medication intensification practices, limited patient education resources, and potentially higher prevalence of medication-related adverse effects driving non-adherence. The strong odds ratio of 11,621 substantially exceeds typical odds ratios of 2 to 4 reported in many Western populations, possibly indicating that adherence determinants in the Indonesian context exert particularly profound effects on glycemic outcomes, potentially reflecting different healthcare system characteristics, medication availability patterns, or patient population disease severity.

Clinical Implications and Adherence Enhancement Strategies

The finding that 76.6% of patients exhibited moderate to low adherence despite active outpatient engagement suggests that passive clinic attendance alone provides insufficient adherence support. According to contemporary implementation science, effective adherence enhancement requires systematic identification of specific barriers through validated adherence assessment instruments such as MMAS-8, followed by targeted intervention addressing identified barriers. For patients with forgetfulness-related non-adherence (constituting 28.4% to 41.1% of non-adherent cohorts), interventions including medication reminder systems, pill organizers, mobile phone-based alerts, or appointment-synchronized dispensing may substantially improve adherence. For patients with treatment motivation barriers (feeling bored or unconvinced of medication benefits), intensive patient education addressing long-term complications, cardiovascular risk reduction, and quality-of-life improvements may enhance adherence commitment.The finding that 33.7% to 43.3% of non-adherent patients report medication-related side effects or symptom non-improvement highlights the necessity of thorough medication tolerance assessment and therapeutic optimization. Medication side effect management through dose adjustment, alternative agent selection, or concomitant symptom management may improve tolerance and adherence. Additionally, recognizing that HbA1C improvements may require 8 to 12 weeks to become clinically apparent, patient education addressing delayed therapeutic response timelines may prevent premature medication discontinuation during early treatment phases.

Limitations and Methodological Considerations

The present study's cross-sectional design captures single-point associations without establishing temporal directionality or determining whether inadequate adherence causes uncontrolled HbA1C or conversely whether uncontrolled symptoms motivate adherence lapses. The self-reported MMAS-8 adherence assessment methodology may introduce reporting bias if patients overstate adherence to respond favorably to healthcare providers, potentially underestimating true non-adherence prevalence. The single institutional setting limits geographic generalizability to broader Indonesian diabetes populations, as regional variations in medication access, healthcare infrastructure, and population characteristics may influence both adherence patterns and glycemic control achievement. The modest sample size of 77 patients, while statistically adequate for cross-sectional association detection, constrains statistical power for stratified subgroup analyzes examining potential effect modification by age, gender, comorbidities, or medication regimen complexity. Future prospective investigations with larger multicenter samples, objective adherence assessment through pharmacy claims data or electronic monitoring, and longitudinal follow-up would strengthen causal inference and establish temporal relationships between adherence changes and glycemic outcomes.

IV. CONCLUSION

This investigation established a highly significant and clinically meaningful relationship between antidiabetic medication adherence and HbA1C glycemic control among patients with type 2 diabetes mellitus at Royal Prima General Hospital in Medan. The principal findings demonstrated that 77.9% of patients exhibited uncontrolled HbA1C levels above 7%, with 76.6% demonstrating suboptimal medication adherence patterns ranging from moderate to low levels. Chi-square statistical analysis revealed compelling evidence of significant association between adherence and glycemic control ($p = 0.003$, OR = 11.621), indicating that patients with low medication adherence faced an 11.621-fold increased odds of experiencing uncontrolled HbA1C levels compared with patients demonstrating high adherence. Notably, zero patients with low adherence achieved adequate glycemic control, whereas controlled HbA1C occurred exclusively in patients exhibiting high or moderate adherence patterns, establishing a dose-response relationship demonstrating medication adherence as one of the strongest modifiable determinants of diabetes management success. These findings substantial international evidence establishing medication adherence as a critical intervention target for improving glycemic control outcomes and preventing diabetes-related complications including cardiovascular disease, nephropathy, and retinopathy.

Methodological limitations warrant consideration when interpreting findings. The cross-sectional design captures temporal associations without establishing causality or temporal directionality between adherence changes and glycemic outcomes. The self-reported MMAS-8 adherence assessment may introduce reporting bias through social desirability responses. The single institutional setting limits geographic generalizability to broader Indonesian diabetes populations. Future research should employ prospective longitudinal designs with objective adherence assessment through pharmacy claims data or electronic monitoring devices within larger multicenter samples across diverse Indonesian healthcare settings. Implementation of systematic adherence screening using validated instruments such as MMAS-8 should be integrated into routine clinical practice at all diabetes management facilities. Targeted interventions addressing identified adherence barriers, including medication reminders, patient education programs highlighting long-term complications and cardiovascular benefits, medication side effect management, and healthcare provider communication improvements, represent essential clinical strategies for optimizing adherence and achieving glycemic control. These evidence-based approaches will ultimately reduce diabetes-related complications and improve quality of life for Indonesian type 2 diabetes patients.

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