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# Medication Adherence Assessed By MMAS-8 Among Outpatients With Chronic Cardiometabolic Diseases In Northern Vietnam: A Multicenter Cross-Sectional Study

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## Abstract

**Background:** Medication adherence is essential for long-term control of hypertension and type 2 diabetes mellitus, yet data from multicenter outpatient populations in Vietnam remain limited. This study described medication adherence using the 8-item Morisky Medication Adherence Scale (MMAS-8) and identified factors associated with adequate adherence among outpatients with chronic cardiometabolic diseases.
**Methods:** This multicenter cross-sectional study used harmonized outpatient datasets from Saint Paul Hospital, Phu Tho Provincial General Hospital, and 108 Military Central Hospital in northern Vietnam. A total of 819 adults with hypertension, type 2 diabetes mellitus, or both were included. MMAS-8 scores were recalculated from item-level responses and categorized as high adherence (score 8), medium adherence (score 6 to <8), and low adherence (score <6). Adequate adherence was defined as an MMAS-8 score ≥6. Bivariable analyses and multivariable logistic regression were used to identify factors associated with adequate adherence.
**Results:** The mean age was 70.8 ± 8.5 years, and 66.4% were male. Among 819 patients with complete MMAS-8 data, adequate adherence was observed in 598 patients (73.0%), including high adherence in 226 (27.6%) and medium adherence in 372 (45.4%); 221 patients (27.0%) had low adherence. Adequate adherence was highest at 108 Military Central Hospital (82.7%) and lowest at Phu Tho Provincial General Hospital (62.9%). After adjustment, dietary adherence (adjusted OR 3.75, 95% CI 2.60-5.42) and exercise adherence (adjusted OR 4.43, 95% CI 2.87-6.82) remained strongly associated with adequate medication adherence. Patients at Phu Tho Provincial General Hospital also had lower adjusted odds of adequate adherence than those at Saint Paul Hospital (adjusted OR 0.61, 95% CI 0.39-0.97). Item-level analysis showed that Q1 was the most frequent non-adherent response overall, reported by 457/819 patients (55.8%).
**Conclusions:** Approximately three-quarters of outpatients achieved adequate medication adherence, but only about one-quarter achieved high adherence. The strong associations between medication adherence and lifestyle adherence suggest that medication-taking behavior is part of a broader self-management pattern. Integrated interventions combining medication counseling, lifestyle support, reminder strategies, and site-specific quality improvement are warranted.

**Keywords:** medication adherence; MMAS-8; hypertension; type 2 diabetes mellitus; self-management; Vietnam; outpatient care.

## Introduction

Medication adherence is a central determinant of the effectiveness of long-term treatment for non-communicable diseases. The World Health Organization has emphasized that poor adherence to long-term therapy reduces treatment benefit, increases preventable complications, and imposes substantial costs on patients and health systems [1]. This problem is particularly important in chronic cardiometabolic diseases.

Hypertension remains a leading global cardiovascular risk factor and a major contributor to stroke, coronary heart disease, heart failure, kidney disease, and premature death [2]. Similarly, diabetes mellitus continues to increase worldwide and is closely linked to cardiovascular, renal, neurological, and metabolic complications [3].

Unlike acute therapy, treatment for hypertension and type 2 diabetes mellitus usually requires daily medication use for many years, regular follow-up, and repeated adjustment of regimens. Non-adherence may involve failure to initiate therapy, missed doses, irregular timing, early discontinuation, or intermittent medication use [4-6]. These behaviors can undermine blood pressure and glycemic control even when effective medicines are available. Because many outpatients are clinically stable and asymptomatic, adherence may depend not only on clinical need but also on patient beliefs, health literacy, regimen complexity, cost, social support, and the quality of communication with healthcare professionals.

Medication-taking behavior should also be understood as part of a broader self-management process. Contemporary diabetes care emphasizes structured self-management education, medical nutrition therapy, physical activity, psychosocial support, and shared decision-making in addition to pharmacotherapy [7]. Previous studies in patients with diabetes have shown that medication adherence often clusters with other self-care behaviors, including adherence to dietary recommendations and physical activity [8,9]. Therefore, evaluating medication adherence alongside lifestyle behaviors may provide more useful information for designing integrated interventions than assessing medication use alone.

The 8-item Morisky Medication Adherence Scale (MMAS-8) is one of the most widely used self-reported instruments for identifying medication-taking behaviors in clinical and epidemiological research. The original validation study demonstrated its predictive value in hypertensive outpatients [10], and subsequent work has examined the relationship between MMAS-8 scores and blood pressure control [11]. Self-reported adherence scales are practical in outpatient settings and in low- and middle-income countries, although their interpretation requires attention to cultural context, recall bias, and differences in cut-off definitions [12].

In Vietnam, the evidence base on medication adherence in chronic diseases has expanded but remains heterogeneous. A multicenter study from southern Vietnam using the General Medication Adherence Scale reported an adherence level of 61.1% among patients with cardiovascular or endocrine-metabolic diseases, with financial constraints as an important barrier [13]. A single-center study in patients with type 2 diabetes at Thong Nhat Hospital reported an MMAS-defined adherence prevalence of 73.7%, with good adherence in only 19.7% [14]. More recent Vietnamese studies have also shown wide variation in adherence among hypertensive and diabetic patients, partly reflecting differences in patient age, disease profile, clinical setting, adherence instrument, and scoring definition [15,16]. Multicenter data using harmonized MMAS-8 item-level responses remain limited, especially among older outpatients with hypertension, diabetes, or both.

This study aimed to describe medication adherence assessed by MMAS-8 among outpatients with hypertension, type 2 diabetes mellitus, or both at three hospitals in northern Vietnam. The secondary objectives were to identify factors associated with adequate medication adherence and to explore differences in adherence patterns across study sites. The findings are intended to inform integrated adherence-support strategies that combine medication counseling with broader chronic disease self-management support in routine outpatient care.

## Methods

### Study design and setting

This was a multicenter cross-sectional study conducted using harmonized outpatient datasets from three hospitals in northern Vietnam: Saint Paul Hospital, Phu Tho Provincial General Hospital, and 108 Military Central Hospital. The study included patients receiving outpatient care for hypertension, type 2 diabetes mellitus, or both, depending on the source cohort at each participating center.

The study was designed to describe medication adherence assessed by MMAS-8 and to identify factors associated with adequate medication adherence in a pooled multicenter outpatient population.

### Study population

Eligible participants were adult outpatients diagnosed with hypertension, type 2 diabetes mellitus, or both, who had available MMAS-8 item-level responses. Patients were included if their records contained sufficient data to calculate the total MMAS-8 score and classify adherence status. Patients with incomplete MMAS-8 responses or missing key information required for adherence classification were excluded from the final analytic dataset. After data harmonization and eligibility assessment, 819 patients were included in the final analysis.

**Data sources and harmonization**

Data were obtained from pre-existing datasets collected at the three participating hospitals. Because the original datasets were developed independently and used partially different coding structures, a standardized analytic dataset was created before pooled analysis.

The harmonization process included identifying shared variables across centers, standardizing variable names and coding definitions, and mapping comparable categories into a common format. Variables included in the pooled dataset were age, sex, educational attainment, overweight or obesity status, disease duration, smoking exposure, dietary adherence, exercise adherence, hospital site, and MMAS-8 item-level responses. Original source files were preserved without modification; all recoding and harmonization procedures were performed in a separate analytic dataset to ensure traceability and reproducibility.

**Measurement of medication adherence**

Medication adherence was assessed using MMAS-8. The total MMAS-8 score was recalculated directly from the eight item-level responses in each dataset to ensure consistency across study sites.

Patients were classified into three adherence levels according to the total MMAS-8 score: high adherence, defined as a score of 8; medium adherence, defined as a score of 6 to less than 8; and low adherence, defined as a score of less than 6 [10,11]. For regression analysis, medication adherence was dichotomized into adequate adherence and low adherence. Adequate adherence was defined as an MMAS-8 score of 6 or higher, including both high and medium adherence categories. Low adherence was defined as an MMAS-8 score of less than 6. Item-level MMAS-8 responses were also examined descriptively to identify common patterns of non-adherent behavior across study sites.

**Study variables**

The primary outcome was adequate medication adherence, defined as MMAS-8 score ≥6. Independent variables included hospital site, age group, sex, educational attainment, overweight or obesity status, disease duration, smoking exposure, dietary adherence, and exercise adherence. Age was analyzed both as a continuous variable and as a categorical variable using a threshold of 60 years. Disease duration was categorized as less than 5 years and 5 years or longer. Educational attainment was harmonized into lower and higher education categories according to available information in each source dataset. Lifestyle-related variables included adherence to dietary recommendations and regular exercise, as recorded in the original datasets.

**Statistical analysis**

Continuous variables were summarized as mean and standard deviation. Categorical variables were presented as frequencies and percentages. Baseline characteristics and adherence profiles were described for the overall study population and by hospital site.

Patients with adequate adherence were compared with those with low adherence. Continuous variables were compared using the independent-samples t-test or an appropriate non-parametric test when distributional assumptions were not met. Categorical variables were compared using the chi-square test or Fisher's exact test, as appropriate.

A multivariable logistic regression model was used to identify factors independently associated with adequate medication adherence. The dependent variable was adequate adherence, defined as MMAS-8 score ≥6. Candidate predictors included hospital site, age group, sex, educational attainment, overweight or obesity status, disease duration ≥5 years, smoking exposure, dietary adherence, and exercise adherence. Results were reported as adjusted odds ratios (ORs), 95% confidence intervals (CIs), and p values. All statistical tests were two-sided, and $p<0.05$ was considered statistically significant.

**Ethical considerations**

The study was conducted in accordance with the Declaration of Helsinki and relevant institutional regulations on research involving human participants. The Saint Paul Hospital source study was approved by the Institutional Ethics Committee in Biomedical Research of Saint Paul General Hospital (Certificate No. 12/2026/GCN-HDDD; study code 12-26/HDDD; approval date: 9 June 2026).

The present analysis used pre-existing outpatient datasets collected for academic research purposes. Before analysis, the datasets were harmonized and processed without direct personal identifiers. No additional intervention, change in treatment, or direct patient contact was undertaken.

## Results

### Characteristics of the study population

A total of 819 outpatients from three hospitals in northern Vietnam were included in the harmonized dataset. Among them, 279 patients were from Saint Paul Hospital, 240 from Phu Tho Provincial General Hospital, and 300 from 108 Military Central Hospital. The mean age of the overall study population was 70.8 ± 8.5 years, and 544 patients (66.4%) were male. Most participants were aged 60 years or older. Hypertension was present in 732 patients (89.4%), while diabetes mellitus was present in 579 patients (70.7%). More than half of the study population had both hypertension and diabetes mellitus. Nearly two-thirds of patients reported adherence to dietary recommendations, fewer than half reported regular exercise.

**Table 1. General characteristics of the study population**

| Characteristic | Overall, n/N (%) or mean ± SD |
|---|---|
| Total patients | 819 |
| Age, years | 70.8 ± 8.5 |
| Age ≥60 years | 744 (90.8%) |
| Male sex | 544 (66.4%) |
| Higher education | 470 (57.4%) |
| Hypertension | 732 (89.4%) |
| Diabetes mellitus | 579 (70.7%) |
| Hypertension only | 240 (29.3%) |
| Diabetes only | 87 (10.6%) |
| Both hypertension and diabetes | 492 (60.1%) |
| Disease duration ≥5 years | 573 (70.0%) |
| Smoking exposure | 160 (19.5%) |
| Overweight/obesity | 162 (19.8%) |
| Dietary adherence | 517 (63.1%) |
| Exercise adherence | 400 (48.8%) |

### Medication adherence assessed by MMAS-8 across study sites

Among 819 patients with complete MMAS-8 data, adequate medication adherence, defined as an MMAS-8 score of 6 or higher, was observed in 598 patients (73.1%). High adherence, defined as an MMAS-8 score of 8, was observed in 226 patients (27.6%), while medium adherence was observed in 372 patients (45.5%). Low adherence was identified in 221 patients (27.0%).

**Table 2. Medication adherence assessed by MMAS-8 across study sites**

| Study site | n | Mean MMAS-8 score | Adequate adherence | High adherence | Medium adherence | Low adherence |
|---|---|---|---|---|---|---|
| Saint Paul Hospital | 279 | 6.24 ± 1.52 | 199/279 (71.3%) | 78/279 (28.0%) | 121/279 (43.4%) | 80/279 (28.7%) |
| Phu Tho Provincial General Hospital | 240 | 6.08 ± 1.43 | 151/240 (62.9%) | 49/240 (20.5%) | 102/240 (42.7%) | 89/240 (37.1%) |
| 108 Military Central Hospital | 300 | 6.64 ± 1.31 | 248/300 (82.7%) | 99/300 (33.0%) | 149/300 (49.7%) | 52/300 (17.3%) |
| Overall | 819 | 6.3 ± 1.4 | 598/819 (73.0%) | 226/819 (27.6%) | 372/819 (45.4%) | 221/819 (27.0%) |

### MMAS-8 item-level non-adherent responses

Item-level analysis was performed to identify common patterns of non-adherent behavior by study site. Overall, the most frequent non-adherent response was observed for item Q1, with 457 of 819 patients (55.8%) reporting this behavior. Phu Tho Provincial General Hospital had relatively high non-adherent responses for Q2 (31.2%),

Q5 (28.3%), and Q8 (28.8%). In contrast, 108 Military Central Hospital showed the lowest proportions for several items, especially Q2 (4.7%), Q3 (3.7%), and Q5 (1.7%). Across the total population, after Q1, the most common non-adherent responses were Q4 (26.7%), Q8 (20.6%), and Q7 (20.1%).

**Table 3. Item-level non-adherent responses on the MMAS-8**

| MMAS-8 item | Saint Paul Hospital (n=279) | Phu Tho Provincial General Hospital (n=240) | 108 Military Central Hospital (n=300) | Overall |
|---|---|---|---|---|
| Q1 | 190/279 (68.1%) | 108/240 (45.0%) | 159/300 (53.0%) | 457/819 (55.8%) |
| Q2 | 24/279 (8.6%) | 75/240 (31.2%) | 14/300 (4.7%) | 113/819 (13.8%) |
| Q3 | 32/279 (11.5%) | 29/240 (12.1%) | 11/300 (3.7%) | 72/819 (8.8%) |
| Q4 | 81/279 (29.0%) | 49/240 (20.4%) | 89/300 (29.7%) | 219/819 (26.7%) |
| Q5 | 12/279 (4.3%) | 68/240 (28.3%) | 5/300 (1.7%) | 85/819 (10.4%) |
| Q6 | 35/279 (12.5%) | 18/240 (7.5%) | 27/300 (9.0%) | 80/819 (9.8%) |
| Q7 | 59/279 (21.1%) | 45/240 (18.8%) | 61/300 (20.3%) | 165/819 (20.1%) |
| Q8 | 59/279 (21.1%) | 69/240 (28.8%) | 41/300 (13.7%) | 169/819 (20.6%) |

**Factors associated with adequate medication adherence**

The dependent variable was adequate adherence (MMAS-8 ≥6 points) versus low adherence (MMAS-8 <6 points).

In bivariable analysis, adequate adherence was significantly more common among male patients, higher educational attainment, adhering to dietary recommendations, and regular exercise. After adjustment, dietary adherence and exercise adherence remained strongly associated with adequate medication adherence. In addition, patients at Phu Tho Provincial General Hospital had lower odds of adequate adherence than those at Saint Paul Hospital. Patients adhering to dietary recommendations had nearly four times higher odds of adequate adherence, while those reporting regular exercise had more than four times higher odds of adequate adherence. Male sex and higher education were no longer statistically significant in the adjusted model.

**Table 4. Bivariable comparison and multivariable logistic regression for adequate medication adherence**

| Variable | Adequate adherence n=598 | Low adherence n=221 | Bivariable p value | Adjusted OR | 95% CI | Adjusted p value |
|---|---|---|---|---|---|---|
| Age, years | 70.5 ± 8.6 | 71.5 ± 8.3 | 0.116 | -- | -- | -- |
| Age ≥60 years | 539/598 (90.1%) | 205/221 (92.8%) | 0.308 | 0.99 | 0.51–1.92 | 0.979 |
| Male sex | 416/598 (69.6%) | 128/221 (57.9%) | 0.002 | 1.05 | 0.70–1.59 | 0.810 |
| Higher education | 381/598 (63.7%) | 89/221 (40.3%) | <0.001 | 1.53 | 0.94–2.51 | 0.089 |
| Overweight/obesity | 120/598 (20.1%) | 42/221 (19.0%) | 0.810 | 1.29 | 0.83–2.01 | 0.260 |
| Disease duration ≥5 years | 425/598 (71.1%) | 148/221 (67.0%) | 0.293 | 1.23 | 0.83–1.84 | 0.302 |
| Smoking exposure | 113/598 (18.9%) | 47/221 (21.3%) | 0.509 | 1.24 | 0.78–1.97 | 0.362 |
| Dietary adherence | 432/598 (72.2%) | 85/221 (38.5%) | <0.001 | 3.75 | 2.60–5.42 | <0.001 |
| Exercise adherence | 356/598 (59.5%) | 44/221 (19.9%) | <0.001 | 4.43 | 2.87–6.82 | <0.001 |
| Study site | | | <0.001 | | | |
| Saint Paul Hospital | 199/598 (33.3%) | 80/221 (36.2%) | | 1.00 | Reference | |
| Phu Tho Provincial General Hospital | 151/598 (25.3%) | 89/221 (40.3%) | | 0.61 | 0.39–0.97 | 0.038 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 108 Military Central Hospital | 248/598 (41.5%) | 52/221 (23.5%) | | 0.66 | 0.34–1.28 | 0.224 |

Note: OR, odds ratio; CI, confidence interval. Continuous age was included only in bivariable comparison; age ≥60 years was used in the multivariable model. Saint Paul Hospital was the reference category for study site.

**Discussion**

This multicenter study assessed medication adherence using the MMAS-8 among 819 outpatients with hypertension, type 2 diabetes mellitus, or both at three hospitals in northern Vietnam. Four findings are particularly relevant. First, 73.0% of participants had adequate adherence, although only 27.6% achieved high adherence. Second, adherence differed substantially across study sites: adequate adherence was highest at 108 Military Central Hospital and lowest at Phu Tho Provincial General Hospital. After adjustment, patients at Phu Tho Provincial General Hospital had lower odds of adequate adherence than those at Saint Paul Hospital. Third, adherence to dietary recommendations and regular exercise showed strong independent associations with adequate medication adherence. Fourth, Q1 was the most frequent non-adherent response, indicating that forgetfulness was the predominant item-level problem.

The overall adequate adherence rate of 73.0% appears relatively favorable, but it should not be interpreted as optimal medication-taking behavior. The definition of adequate adherence combined the high- and medium-adherence categories, and medium adherence represented the largest group, accounting for 45.4% of the sample. Only 27.6% obtained the maximum MMAS-8 score. Thus, many patients classified as adequately adherent still reported at least some difficulty with medication-taking, which may leave them vulnerable to missed doses, inconsistent timing, or treatment interruption when routines, health status, or treatment regimens change.

The present estimate is broadly comparable with some Vietnamese studies but differs from others. Ly et al. reported 61.1% adherence among Vietnamese outpatients with cardiovascular or endocrine-metabolic diseases using the General Medication Adherence Scale during the COVID-19 period [13]. Their lower estimate may partly reflect differences in measurement instrument, inclusion of cost-related barriers, and disruption of routine care during the pandemic. In contrast, the 73.7% adherence reported among patients with type 2 diabetes at Thong Nhat Hospital was close to our overall result [14]. However, the proportion with good adherence in that study was 19.7%, lower than the 27.6% with high adherence in our pooled sample, suggesting that the distribution of adherence levels may vary across clinical settings and patient populations.

Our findings also contrast with the study by Nguyen and Dam, in which 52.9% of hypertensive patients had low adherence and only 8.0% had high adherence [15]. Differences in age distribution, disease composition, hospital type, follow-up systems, counseling practices, medication burden, and health insurance coverage may contribute to this variation. Conversely, a 2025 study of older Vietnamese outpatients with type 2 diabetes reported non-adherence in 23.9% of participants [16], which is reasonably close to the 27.0% low-adherence prevalence in our study. These comparisons highlight the importance of considering the adherence instrument, cut-off definition, and characteristics of the source population when interpreting prevalence estimates.

International evidence similarly demonstrates substantial heterogeneity in medication adherence for chronic cardiometabolic diseases. A systematic review and meta-analysis from low- and middle-income countries found wide variation in non-adherence to antihypertensive therapy according to study design, measurement method, socioeconomic context, and health-system characteristics [17]. Although the adequate-adherence proportion in our study was higher than that reported in many resource-constrained settings, the modest proportion achieving high adherence indicates that consistent long-term medication use remains difficult even among patients receiving regular hospital-based outpatient care.

Dietary adherence and exercise adherence were the strongest patient-level correlates in the adjusted model. Participants who adhered to dietary recommendations had 3.75 times the odds of adequate medication adherence, while those reporting regular exercise had 4.43 times the odds. These findings are consistent with previous research showing that medication-taking tends to cluster with other diabetes self-care and health-maintenance behaviors [8,9,18,19]. Patients who sustain dietary and physical-activity routines may have greater disease knowledge, self-efficacy, family support, or ability to organize daily activities. Nevertheless, because this study was cross-sectional, the observed associations do not establish that lifestyle adherence causes medication adherence or vice versa.

The association with regular exercise was particularly strong and is consistent with the Vietnamese study by Nguyen et al., in which low physical activity was associated with medication non-adherence among older patients with type 2 diabetes [16]. Taken together, these findings suggest that medication adherence should be assessed within the broader context of chronic-disease self-management. Counseling focused solely on drug

names and dosing instructions may miss important behavioral and contextual barriers. A more integrated assessment should consider daily routines, meal patterns, physical activity, family support, and access to follow-up care.

The differences across hospitals also warrant attention. Adequate adherence was 82.7% at 108 Military Central Hospital, 71.3% at Saint Paul Hospital, and 62.9% at Phu Tho Provincial General Hospital. In the adjusted analysis, the odds of adequate adherence at Phu Tho Provincial General Hospital remained lower than at Saint Paul Hospital (adjusted OR 0.61, 95% CI 0.39-0.97), whereas the difference between 108 Military Central Hospital and Saint Paul Hospital was not statistically significant. Hospital site should not be interpreted as a direct causal factor, however. It likely captures a combination of differences in patient case mix, socioeconomic background, disease profile, outpatient workflow, refill systems, continuity of care, counseling intensity, and the original measurement procedures used before data harmonization.

The item-level findings provide information that is not apparent from the total MMAS-8 score alone. Q1 was the most frequent non-adherent response, reported by 55.8% of participants, suggesting that forgetting medication was the most widespread problem. This pattern is consistent with Vietnamese studies in which forgetfulness was a common reason for non-adherence among patients with diabetes or hypertension [14,15], and with international literature describing unintentional non-adherence as a major challenge in chronic treatment [4,5]. At Phu Tho Provincial General Hospital, relatively high non-adherent responses were also observed for Q2, Q5, and Q8, indicating that adherence problems at this site may extend beyond occasional forgetfulness.

Different adherence patterns require different interventions. Forgetfulness may be addressed through pill boxes, medication calendars, mobile-phone reminders, linkage of dosing to meals or other established routines, family support, and simplification of dosing schedules when clinically appropriate. By contrast, intentional non-adherence related to adverse effects, doubts about treatment necessity, or medication fatigue requires individualized counseling and shared decision-making. When cost, refill access, or continuity of care is problematic, organizational and health-system interventions may be required. Evidence suggests that multifaceted and sustained interventions are generally more effective than a single brief educational encounter [20-22].

Pharmacist-supported care may be particularly relevant for this population. Older adults with hypertension and diabetes frequently receive multiple long-term medicines and may experience regimen complexity, adverse effects, or uncertainty about dose timing. Pharmacists can identify specific adherence barriers, reconcile medication lists, review adverse effects, provide written dosing plans, reinforce reminder strategies, and work with prescribers to simplify regimens where possible. Previous systematic reviews indicate that adherence interventions can improve medication-taking behavior, although effectiveness varies according to intervention intensity, duration, and patient selection [20-22].

The findings have several implications for outpatient chronic-disease management. Routine care should distinguish high, medium, and low adherence rather than treating all patients with MMAS-8 scores of 6 or higher as a homogeneous group. Patients with medium adherence constituted nearly half of the study population and may benefit from early, low-intensity support before more persistent non-adherence develops. Adherence interventions should also combine medication counseling with lifestyle support, and hospitals should use site-specific and item-level patterns to identify local priorities rather than implementing an identical intervention at every center.

This study has several strengths. It included a relatively large sample from three hospitals and covered patients with hypertension, type 2 diabetes mellitus, and coexisting disease. MMAS-8 scores were recalculated from item-level responses using a harmonized analytic dataset, which improved consistency across centers. The analysis examined overall adherence categories, item-level responses, lifestyle-related correlates, and differences between hospitals, thereby providing clinically useful information for intervention planning.

Several limitations should be acknowledged. First, the cross-sectional design precludes causal inference. Second, MMAS-8 is a self-reported measure and may be affected by recall and social-desirability bias; objective measures such as refill records, pill counts, or electronic monitoring were unavailable. Third, the study pooled pre-existing datasets developed independently at the three hospitals. Despite harmonization, residual differences in variable definitions, data-collection procedures, disease composition, and patient selection may remain. Fourth, dietary and exercise adherence were based on variables available in the source datasets, and their measurement may not have been fully identical across centers. Fifth, several potentially important determinants were unavailable, including number of medicines, dosing frequency, treatment cost, adverse drug reactions, cognitive impairment, depression, health literacy, family support, and patient-provider communication. Finally, adherence was measured at a single time point and may change over the course of treatment.

Future studies should use longitudinal designs to determine whether MMAS-8 categories predict blood-pressure control, glycemic control, hospitalization, cardiovascular events, and other clinical outcomes. Standardized multicenter data collection should include regimen complexity, refill history, adverse effects, medication cost, health literacy, cognitive and psychological factors, and social support. Qualitative research could clarify the reasons underlying forgetfulness and the site-specific adherence patterns observed here. Intervention studies should evaluate pharmacist-led or multidisciplinary programs that combine medication counseling, reminder tools, lifestyle support, and repeated follow-up.

## Conclusion

In this three-center dataset of outpatients with hypertension, type 2 diabetes mellitus, or both in northern Vietnam, adequate medication adherence by MMAS-8 was achieved by 73.0% of patients, but high adherence remained limited. Dietary adherence and exercise adherence were the most consistent independent correlates of adequate medication adherence. Forgetfulness-related non-adherence was the most common item-level pattern, while several adherence gaps varied across hospitals. These findings support integrated, pharmacist-supported, and site-specific adherence interventions that combine medication counseling with lifestyle self-management support.

## Declarations

### Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki and relevant institutional regulations. The Saint Paul Hospital source study was approved by the Institutional Ethics Committee in Biomedical Research of Saint Paul General Hospital (Certificate No. 12/2026/GCN-HDDD; study code 12-26/HDDD; approval date: 9 June 2026). The pooled analysis used de-identified pre-existing outpatient datasets and involved no additional patient contact or intervention.

### Consent for publication

Not applicable; the manuscript does not contain identifiable individual patient data, images, or case descriptions.

### Availability of data and materials

The anonymized analytic dataset may be made available by the corresponding author upon reasonable request and subject to institutional approval.

### Competing interests

The authors declare that they have no competing interests.

### Funding

No external funding was reported for this study.

### Authors' contributions

Nguyen Van Trieu: conceptualized the study and contributed to data collection, analysis, and manuscript drafting. Nguyen Thi Hai Yen: contributed to data interpretation, manuscript drafting, and critical revision. Nguyen Dinh Hien: contributed to data collection, analysis, and critical revision. All authors reviewed and approved the final manuscript.

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