


RESEARCH

Received: 07 March 2026
Last revision: 06 August 2026
Accepted : 24 August 2026
Published: 18 September 2026

The Association Between Blood Pressure Control and Renal Function in Hypertensive Patients: Evidence from a Community Health Center in Indonesia

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Abstract

Introduction: Adherence to antihypertensive therapy (AHT) plays a crucial role in achieving optimal blood pressure control and preventing long-term complications, including impaired renal function. This study aimed to analyze the association between medication adherence and blood pressure control and to evaluate renal function in hypertensive patients. **Methods:** This observational analytic study used a retrospective cohort design. This study was conducted at the Pakem Community Health Center using medical records of hypertensive patients participating in the Chronic Disease Management Program (Program Pengelolaan Penyakit Kronis [PROLANIS]). Blood pressure control was determined based on the average blood pressure measurements over six months. Medication adherence was assessed using the medication possession ratio (MPR) from January to June 2025, while renal function was assessed based on changes in the estimated glomerular filtration rate (ΔeGFR) in January and July 2025. Statistical analyses were performed using IBM SPSS Statistics version 26. Statistical significance was defined as $p < 0.05$. **Results:** A total of 101 patients met the inclusion criteria. Most patients had high adherence (78.2%) and controlled blood pressure (72.3%). The proportion of blood pressure control was higher in the high-adherence group than in the low-adherence group (81.0% vs. 40.9%; $p < 0.001$), patients with high adherence had 6.16 times higher odds of achieving blood pressure control (OR 6.16; 95% CI 2.22–17.08). No significant difference in ΔeGFR was observed between patients with controlled and uncontrolled blood pressure (3.25 ± 7.66 vs. 3.93 ± 10.19 mL/min/1.73 m²; $p = 0.970$). **Conclusion:** Medication adherence was significantly associated with blood pressure control, whereas changes in renal function did not differ significantly between patients with controlled and uncontrolled blood pressure.

Keywords: Blood pressure control, hypertension, medication adherence, renal function.

https://doi.org/10.55175/cdk.v53i09.2402
e-ISSN: 2503-2720

INTRODUCTION

Hypertension is a chronic condition characterized by elevated arterial pressure. It is one of the most common non-communicable diseases worldwide and is a major risk factor for various cardiovascular complications.[1] The latest data from the World Health Organization (WHO) indicates that by 2024, approximately 1.4 billion people aged 30–79 years were living with hypertension, accounting for approximately 33% of the population in that age group.[2] The burden of this disease continues to increase significantly, with the number of affected individuals doubling in 2019 compared to 1990.[3] In Indonesia, data show a hypertension prevalence of 31.6% in the adult population in 2023. However, the diagnosis rate remains relatively low, at only 26.5%. Although treatment coverage has nearly doubled in a decade—from 11.2% to 22.8%—blood pressure control rates remain very low at 4.4%.[4] This indicates that hypertension is a serious health problem that has not been optimally addressed in Indonesia.

Antihypertensive therapy (AHT) is an important pillar in the treatment of patients with hypertension. The widespread use of antihypertensive medications globally has resulted in global mean blood pressure remaining constant or slightly decreasing over the past four decades.[5] A meta-analysis study showed that poor adherence to AHT significantly increases the risk of all-cause mortality and the risk of death from cardiovascular disease.[6] Several factors are associated with medication non-adherence, such as older age, longer duration of hypertension diagnosis, patient comorbidities, moderate stress levels, unsatisfactory family support, the presence of depressive symptoms, and inadequate patient-physician interactions.[7,8] Misconceptions about the side effects of antihypertensive medications are have also been associated with medication non-adherence. A qualitative study found that some patients were non-adherent due to fear that it may cause kidney failure.[9] Similarly, a study conducted in Indonesia reported misconceptions among the public regarding the long-term treatment of hypertension and diabetes mellitus and their perceived association with kidney failure.[10] Despite these findings, to the best of our knowledge, no previous study has evaluated the relationship between medication adherence, blood

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pressure control, and renal function among hypertensive patients in Indonesian primary healthcare settings. Therefore, this study aimed to analyze the association between medication adherence over six months and blood pressure control and to evaluate renal function according to blood pressure control among hypertensive patients.

METHODS

This observational analytic study employed a retrospective cohort design and was conducted at the Pakem Community Health Center, Sleman Regency, Yogyakarta, Indonesia. This study used anonymized retrospective medical record data. Permission to access the data for research purposes was obtained from the Head of the Pakem Community Health Center, Chronic Disease Management Program (PROLANIS) coordinator, and the relevant healthcare personnel at the Pakem Community Health Center. All patient identifiers were removed prior to analysis to ensure confidentiality.

The study included hypertensive patients enrolled in PROLANIS who underwent renal function testing in January 2025 for baseline assessment and had follow-up renal function data available in July 2025 from medical records. Patients with diabetes mellitus, cardiovascular diseases (heart failure, acute coronary syndrome, or stroke), chronic kidney disease (CKD), incomplete medical records, or referral to a hospital during the six-month observation period were excluded. We selected a six-month follow-up period because it was sufficient to evaluate medication adherence, blood pressure control, and short-term changes in renal function while minimizing loss to follow-up. This follow-up duration is consistent with previous real-world studies evaluating laboratory testing and antihypertensive medication adherence among patients with uncomplicated hypertension.[11] Baseline characteristics, including age, sex, duration of hypertension, baseline systolic blood pressure (SBP), baseline diastolic blood pressure (DBP), and baseline renal function, were obtained from patients' medical records. All eligible patients who met the inclusion and exclusion criteria during the study period were included using a total sampling approach. Therefore, no formal sample size calculation was performed.

All patients received antihypertensive treatment according to a standardized local hypertension management protocol. Initial treatment consisted of either monotherapy or combination therapy based on the patient's baseline blood pressure. During routine follow-up, the antihypertensive dose was increased if the blood pressure target was not achieved. If blood pressure remained above the target despite dose escalation, additional antihypertensive agents were prescribed according to the protocol. Patients were routinely reminded of their monthly follow-up visits via WhatsApp. Healthcare staff contacted and visited those who missed scheduled visits for a prolonged period to encourage continued follow-up.[12] Because treatment intensification followed the same standardized protocol for all patients, antihypertensive drug intensification was not included as a separate variable in the analysis. We extracted follow-up blood pressure data from medical records between February and July 2025, beginning one month after the initiation of the adherence observation period. We calculated mean systolic and diastolic blood pressure values during the six-month follow-up. Blood pressure was categorized as controlled (< 140/90 mmHg) or uncontrolled (≥ 140/90 mmHg) according to the Indonesian National Clinical Practice Guideline for Adult Hypertension (2021).[13]

Medication adherence was assessed using the Medication Possession Ratio (MPR) obtained from patient medical records. This assessment was conducted by observing patient visits to collect hypertension medication for six months, from January to June 2025. Patients with an MPR value ≥ 0.80, indicating that antihypertensive medication was available for at least 80% of the observation period, were categorized as having high medication adherence, whereas those with an MPR value < 0.80 were categorized as having low medication adherence.[14,15]

We assessed renal function using the estimated glomerular filtration rate (eGFR), calculated with the 2021 CKD-EPI creatinine formula.[16] Baseline renal function was determined from serum creatinine measurements obtained in January 2025, while follow-up renal function was assessed using serum creatinine measurements obtained in July 2025. Changes in renal function were quantified as the difference between follow-up and baseline eGFR (ΔeGFR).

Data were analyzed using IBM SPSS Statistics v.26. Descriptive statistics summarized participants' baseline characteristics. We assessed data normality using the Shapiro–Wilk test. We analyzed the association between medication adherence and blood pressure control using the Chi-square test. Baseline and follow-up eGFR were summarized descriptively, whereas ΔeGFR was compared between patients with controlled and uncontrolled blood pressure using the independent-samples t-test for normally distributed data or the Mann–Whitney U test for non-normally distributed data. Statistical significance was defined as a two-sided p-value < 0.05.

RESULT

A total of 208 patients with hypertension from the PROLANIS hypertension cohort at the Pakem Community Health Center who underwent kidney function tests in January 2025 were initially identified. Among them, 36 patients were excluded because they met exclusion criteria, including diabetes mellitus (n = 2), cardiovascular disease (n = 20; including stroke, chronic heart failure, and coronary artery disease), incomplete medical records (n = 8), and referral to a hospital during the observation period (n = 6). Thus, 172 patients met the inclusion criteria. However, during the six-month follow-up period, 71 patients did not undergo a follow-up renal function test in July 2025, leaving 101 patients with available follow-up data **(Figure 1)**.

The patients' ages ranged from 34 to 84 years, with a mean age of 62.58 ± 10.32 years. Most participants were female (85.1%). Most participants had been diagnosed with hypertension for more than two years (57.4%). The mean baseline systolic and diastolic blood pressures were 132.49 ± 14.77 mmHg and 77.71 ± 9.84 mmHg, respectively. The mean baseline eGFR was 85.39 ± 17.01 mL/min/1.73 m². Most

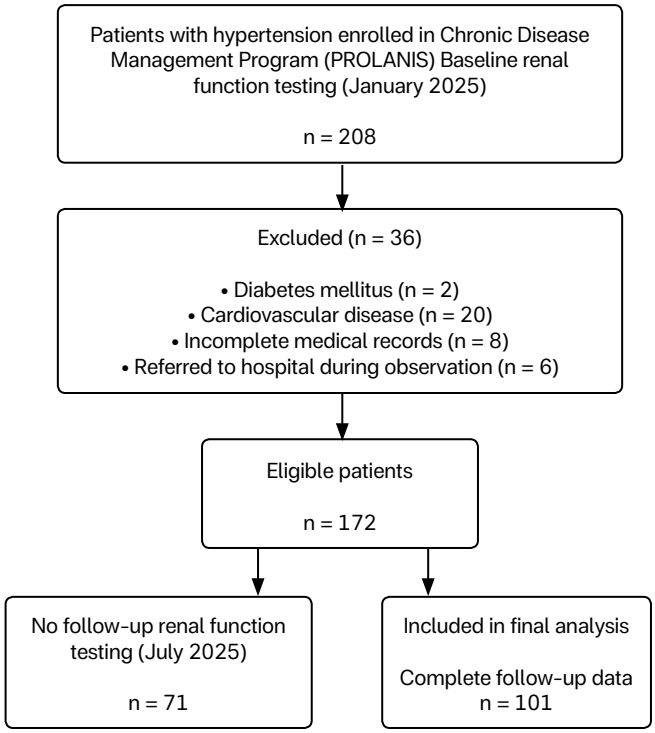

Figure 1. Flow diagram of the study participants.

Table 1. Baseline characteristics of the study participants.

Characteristics of Patients	n (%)	Mean ± SD
Gender		
Male	15 (14.9)	
Female	86 (85.1)	
Age (years)		62.58 ± 10.32
Duration of Hypertension		
< 1 year	11 (10.9)	
1–2 years	32 (31.7)	
> 2 years	58 (57.4)	
Baseline SBP (mmHg)		132.49 ± 14.77
Baseline DBP (mmHg)		77.71 ± 9.84
Baseline eGFR (mL/min/1.73 m²)		85.39 ± 17.01
Number of Antihypertensive Medications		
Monotherapy	62 (61.4)	
Combination therapy	39 (38.6)	
Antihypertensive Medication Classes		
Calcium channel blocker	90 (89.1)	
ACE inhibitor	21 (20.8)	
Thiazide diuretic	8 (7.9)	
Angiotensin Receptor Blocker	14 (13.9)	
Beta-blocker	11 (10.9)	
Other	3 (2.9)	

Abbreviations: SD: Standard deviation; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; eGFR: estimated glomerular filtration rate; ACE: Angiotensin-converting enzyme.

patients received monotherapy (61.4%), and calcium channel blockers were the most commonly prescribed antihypertensive class. **Table 1** presents the baseline characteristics of the study participants.

Bivariate analysis revealed a significant association between medication adherence and blood pressure control. Patients with high adherence had a greater proportion of controlled blood pressure than patients with low adherence (81.0% vs. 40.9%). A Chi-square test showed statistical significance ($p < 0.001$). Patients with high adherence were approximately 6.16 times more likely to achieve controlled blood pressure than those with low adherence (OR = 6.16; 95% CI: 2.22–17.08) **(Table 2)**.

Table 3 compares baseline eGFR, follow-up eGFR, and ΔeGFR according to blood pressure control. Patients with controlled blood pressure had a mean baseline eGFR of 86.47 ± 17.15 mL/min/1.73 m² and a follow-up eGFR of 89.71 ± 16.87 mL/min/1.73 m², whereas patients with uncontrolled blood pressure had a mean baseline eGFR of 82.57 ± 16.62 mL/min/1.73 m² and a follow-up eGFR of 86.50 ± 17.53 mL/min/1.73 m². The Shapiro–Wilk test demonstrated that ΔeGFR was not normally distributed in the controlled blood pressure group ($p = 0.036$) but was normally distributed in the uncontrolled blood pressure group ($p = 0.188$). Therefore, we used the Mann–Whitney U test to compare ΔeGFR between the two groups. The Mann–Whitney U test showed no significant difference in ΔeGFR between patients with controlled and uncontrolled blood pressure (median [IQR]: 3.00 [8.00] vs. 1.50 [14.25] mL/min/1.73 m², $p = 0.970$).

DISCUSSION

The analysis showed a significant relationship between 6-month medication adherence, as measured by the MPR Score, and blood pressure control in hypertensive patients. This finding aligns with previous research. A study evaluating patient adherence using the Hill–Bone Compliance to High Blood Pressure Therapy Scale showed that adherent patients had significantly better blood pressure control than non-adherent patients.[17] Meanwhile, another study evaluating adherence using the Girerd Medication Adherence Scale


Table 2. Association between medication adherence and blood pressure control.

Medication Adherence	Blood Pressure		Patients (n)	*p*-value	OR (95% CI)
	Controlled	Uncontrolled			
High	64 (81.0%)	15 (19.0%)	79 (78.2%)	< 0.001	6.16 (2.22–17.08)
Low	9 (40.9%)	13 (59.1%)	22 (21.8%)		

Abbreviations: OR: Odds ratio; CI: Confidence interval.

Table 3. Comparison of renal function according to blood pressure control.

Blood Pressure	Baseline eGFR (Mean ± SD)	Follow-up eGFR (Mean ± SD)	ΔeGFR Mean ± SD	ΔeGFR Median (IQR)	Patients (n)	*p*-value
Controlled	86.47 ± 17.15	89.71 ± 16.87	3.25 ± 7.66	3.00 (8.00)	73 (72.3%)	0.970
Uncontrolled	82.57 ± 16.62	86.50 ± 17.53	3.93 ± 10.19	1.50 (14.25)	28 (27.7%)	

Abbreviations: ΔeGFR: change in estimated glomerular filtration rate; SD: Standard deviation; IQR: interquartile range.

showed that low adherence was significantly associated with poor blood pressure control.[18] Given that uncontrolled hypertension is a major risk factor for cardiovascular disease,[19] effective blood pressure management is essential to prevent long-term complications. In Indonesia, the government-led PROLANIS program under the National Health Insurance system supports blood pressure control among patients with hypertension at primary healthcare facilities.[20] Improving adherence to antihypertensive medication should be prioritized in clinical practice, particularly within primary healthcare settings, to achieve optimal blood pressure control and reduce the risk of long-term cardiovascular complications.

The present study found no significant difference in changes in renal function between patients with controlled and uncontrolled blood pressure during the six-month follow-up. The mean eGFR did not decline in either group during the six-month follow-up, and the magnitude of change was comparable between patients with controlled and uncontrolled blood pressure. These findings differ from those of the Multi-Ethnic Study of Atherosclerosis (MESA), which demonstrated that increases in systolic blood pressure were associated with subsequent rapid eGFR decline among individuals with preserved renal function, whereas stable systolic blood pressure was associated with the slowest rate of kidney function decline. This discrepancy may be explained by the substantially shorter follow-up period in the present study, as the MESA study reported an average annual decline in eGFR of less than 2.5 mL/min/1.73 m^2 across all blood pressure change groups.[21] Similarly, the Atherosclerosis Risk in Communities (ARIC) study reported that individuals with hypertension experienced a more rapid decline in kidney function during 30 years of follow-up. However, this difference was attenuated among those receiving antihypertensive treatment.[22]

In addition to pharmacological therapy, non-pharmacological interventions, including dietary modification, salt restriction, weight reduction, smoking cessation, stress management, and regular physical activity, are recommended to improve blood pressure control and reduce cardiovascular risk.[23,24] Nevertheless, the success of hypertension control, whether through pharmacological or non-pharmacological therapy, is greatly influenced by the patient's level of knowledge, attitudes, and behaviors regarding their disease.[25] Therefore, ongoing health education and health promotion strategies are needed to improve patients' understanding and support optimal hypertension control.

This study has several limitations that should be considered when interpreting the results. First, the retrospective cohort design relied on routinely collected medical record data, which may be subject to incomplete documentation and limited control over potential sources of bias. Second, medication adherence was assessed using the MPR, which reflects medication availability rather than actual medication consumption. Third, the relatively short observation period (six months) may not have been sufficient to detect progressive and long-term changes in renal function. In addition, most patients had relatively preserved baseline renal function and a high proportion achieved controlled blood pressure, which may have limited the ability to detect significant differences in ΔeGFR between groups. Fourth, this study was conducted at a single primary healthcare facility with a relatively limited sample size, so the findings should be generalized with caution. Fifth, a substantial proportion of eligible patients lacked follow-up renal function data; therefore, attrition bias cannot be completely excluded. Finally, multivariable analysis was not performed; therefore, the influence of potential confounding factors on renal function outcomes could not be fully adjusted.

CONCLUSION

This study demonstrates that medication adherence is strongly associated with blood pressure control in hypertensive patients. Patients with high adherence were 6.16 times more likely to achieve controlled blood pressure than those with low adherence. However, no significant difference in renal function changes was observed between patients with controlled and uncontrolled blood pressure during the six-month follow-up.

These findings emphasize the importance of improving medication adherence as a primary strategy in primary healthcare facilities to achieve optimal blood pressure control. Chronic disease management programs should optimize educational interventions, strengthen doctor-patient communication, and improve regular adherence monitoring. The results of this study also support public health education efforts to address misconceptions regarding the long-term use of antihypertensive medications.


Further research should be conducted at a multicenter scale and with a longer follow-up period to evaluate the long-term impact of blood pressure control on renal function. Future research should also consider multivariate analysis by incorporating other risk factors that influence renal function and using more comprehensive adherence measurement methods. Consequently, this will provide a more accurate and representative depiction of hypertension management at the primary healthcare level in Indonesia.

Ethics Statement

As this study used secondary data retrospectively without direct patient intervention or contact, no formal ethical approval number was issued. Authorization to access and use the required data was obtained from the Head of Pakem Community Health Center, the PROLANIS coordinator, and relevant healthcare personnel.

Consent for Publication

Consent for publication, including the use of the institutional name, was obtained from the institution through the Head of Pakem Community Health Center.

Funding

This study received no financial support or funding.

Author Contributions

MIA contributed to the study design, data collection, data analysis, and preparation of the draft manuscript and its revision. TMC contributed to data collection, manuscript review, and editing. DA and TTT contributed to data collection and manuscript review. All authors reviewed and approved the final version of the manuscript.

Conflict of Interest

The authors declare no conflicts of interest.

Declaration on the Use of Artificial Intelligence (AI)

The authors used ChatGPT (OpenAI) and Grammarly to assist with language editing, grammar correction, and sentence refinement during the preparation of this manuscript. The final manuscript was reviewed and approved by all authors, who take full responsibility for its content.

Acknowledgments

The authors sincerely thank the Head of Pakem Community Health Center, the PROLANIS coordinator, and all healthcare staff for their support and assistance in facilitating access to medical record data for this study.

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