IJTI | INTERNATIONAL JOURNAL OF THERAPEUTIC INNOVATION

Research article

# Factors associated with treatment outcomes in hospitalized patients with primary hypertension: a retrospective cross-sectional study in Vietnam

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**Received -** 10-09-2025**, Revised** - 20-12-2025, **Accepted** - 20-01-2026 **(DD-MM-YYYY)**

**Refer this article**

Thi-Ngoc-Giau Truong, Dung-Van Thach, Factors associated with treatment outcomes in hospitalized patients with primary hypertension: a retrospective cross-sectional study in Vietnam. International Journal of Therapeutic Innovation, January-February 2026, V4 – I1, Pages - 1 – 6. Doi: https://doi.org/10.55522/ijti.v4i1.0141.

## ABSTRACT

Hypertension is a major public health problem and a leading contributor to cardiovascular morbidity and mortality, yet blood pressure control remains suboptimal in many clinical settings, particularly among hospitalized patients with complex clinical profiles. This retrospective cross-sectional study aimed to identify patient-related and treatment-related factors associated with treatment outcomes in hospitalized patients with primary hypertension. The study was conducted at the Department of Cardiology, Can Tho Central General Hospital, Vietnam, from January to June 2024, and included 378 inpatient medical records of patients diagnosed with primary hypertension. Treatment outcome was defined as achievement of target blood pressure at discharge according to the 2022 Vietnam National Heart Association guidelines. Demographic characteristics, clinical variables, comorbidities, renal function, body mass index, antihypertensive treatment regimens, and clinically significant drug-drug interactions were analyzed. At discharge, 97.1% of patients achieved target blood pressure, with mean systolic blood pressure decreasing from 171.4 ± 15.9 mmHg to 124.1 ± 16.4 mmHg and mean diastolic blood pressure decreasing from 91.5 ± 11.6 mmHg to 81.9 ± 12.9 mmHg. Failure to achieve target blood pressure was significantly associated with older age, higher hypertension stage, elevated serum creatinine, overweight or obesity, inappropriate antihypertensive prescribing, suboptimal treatment regimens, and clinically significant drug-drug interactions. These findings demonstrate the multifactorial nature of blood pressure control in hospitalized patients and provide evidence to support targeted strategies for improving treatment outcomes in inpatient hypertension management.

**Keywords:** Hypertension, Treatment outcomes, Hospitalized patients, Blood pressure control, Associated factors.

## INTRODUCTION

The effectiveness of antihypertensive therapy is primarily reflected by the achievement of target blood pressure, which is a key determinant of cardiovascular risk reduction. However, considerable variability in treatment outcomes has been observed among patients receiving antihypertensive therapy, even when treatment is consistent with clinical guideline recommendations. This variability suggests that blood pressure control is influenced not only by the availability of effective drugs but also by patient-related characteristics, disease severity, comorbidity burden, and treatment-related factors [1-3].

Previous studies have demonstrated that patient-related factors such as age, sex, baseline blood pressure levels, and the presence of comorbid conditions, including diabetes mellitus, chronic kidney disease, and cardiovascular diseases, play a significant role in determining treatment outcomes. Patients with multiple comorbidities often require more intensive antihypertensive regimens and are exposed to greater therapeutic complexity, which may compromise blood pressure control and increase the risk of adverse drug events [4,5]. In addition, higher stages of hypertension have been consistently associated with lower rates of achieving target blood pressure in real-world clinical practice [6].

Treatment-related factors also contribute substantially to antihypertensive effectiveness. Current hypertension guidelines recommend early initiation of combination therapy in patients with moderate to severe hypertension or high cardiovascular risk, as

combination regimens have been shown to achieve better blood pressure control than monotherapy [7,8]. Nevertheless, inappropriate drug selection, suboptimal dose titration, and irrational drug combinations may reduce treatment effectiveness. Furthermore, clinically significant drug - drug interactions, particularly in patients receiving multiple medications for comorbid conditions, may diminish antihypertensive efficacy and increase the likelihood of treatment-related complications [9,10].

Hospitalized patients with primary hypertension constitute a distinct clinical population characterised by more severe disease, uncontrolled blood pressure, or acute target-organ involvement. Although hospitalisation allows close monitoring and timely adjustment of therapy, the frequent presence of polypharmacy and complex clinical conditions may pose additional challenges to achieving optimal blood pressure control [11,12]. Identifying factors associated with successful treatment outcomes in hospitalized patients is therefore essential for improving inpatient hypertension management.

In Vietnam, the prevalence of hypertension has increased steadily in parallel with demographic ageing and lifestyle changes. Despite the widespread implementation of national and international hypertension guidelines, studies have reported heterogeneity in blood pressure control rates and treatment effectiveness across different patient subgroups [13-15]. Most available studies have focused on outpatient settings, while evidence from hospitalized populations remains limited. Given the clinical complexity of inpatient care, further investigation into factors associated with treatment outcomes in hospitalized patients is warranted.

Accordingly, this study was conducted to identify patient-related and treatment-related factors associated with treatment outcomes in hospitalized patients with primary hypertension. Treatment outcome was defined as achievement of the target blood pressure at discharge according to current national clinical guidelines. The findings of this study aim to support more individualised treatment strategies, promote rational antihypertensive drug use, and improve blood pressure control in inpatient clinical practice.

## MATERIALS AND METHODS

### Study design and setting

A retrospective cross-sectional study was conducted at the Department of Cardiology, Can Tho Central General Hospital, a tertiary referral hospital providing specialized cardiovascular care for the Mekong Delta region of Vietnam. The study reviewed medical records of hospitalized patients diagnosed with primary hypertension during the period from January to June 2024. This study design was selected to reflect real-world clinical practice and to allow comprehensive evaluation of factors associated with treatment outcomes in an inpatient setting [16].

### Study population

The study population consisted of adult patients aged 18 years or older who were admitted with a diagnosis of primary hypertension. A total of 378 medical records met the inclusion criteria and were included in the analysis.

Inclusion criteria were a confirmed diagnosis of primary hypertension documented in the medical record, inpatient treatment with at least one antihypertensive medication, and availability of blood pressure measurements at both admission and discharge. Patients were excluded if they had secondary hypertension, incomplete clinical information, or missing blood pressure data at discharge. These criteria were applied to ensure consistency and validity of outcome assessment [17].

### Outcome definition

The primary outcome of interest was treatment outcome, defined as achievement of the target blood pressure at the time of discharge. Target blood pressure was determined in accordance with the 2022 guidelines of the Vietnam National Heart Association.

For patients aged 18 to 64 years, including those with diabetes mellitus, coronary artery disease, or cerebrovascular disease, the target blood pressure was defined as systolic blood pressure between 120 and 130 mmHg and diastolic blood pressure between 70 and less than 80 mmHg. For patients aged 65 years or older, the target blood pressure was defined as systolic blood pressure between 130 and less than 140 mmHg and diastolic blood pressure between 70 and less than 80 mmHg. Patients were classified into two groups: those who achieved target blood pressure and those who did not achieve target blood pressure at discharge [18].

### Independent variables

Independent variables included patient-related and treatment-related factors. Patient-related variables comprised age, sex, place of residence, body mass index, stage of hypertension at admission, and presence of comorbidities such as diabetes mellitus, cardiovascular diseases, and chronic kidney disease. Treatment-related variables included antihypertensive drug classes, treatment regimens classified as monotherapy or combination therapy, and the presence of clinically significant drug-drug interactions.

Clinically significant drug interactions were identified based on documented interactions in the medical records and evaluated using standard pharmacological references. Only interactions with potential clinical relevance to blood pressure control or patient safety were included in the analysis [19].

### Data collection

Data were extracted retrospectively from paper-based and electronic medical records using a standardized data collection form. Collected information included demographic characteristics, clinical parameters, comorbidities, antihypertensive medications prescribed during hospitalization, blood pressure values at admission and discharge, and documented adverse drug events or interactions. To minimize information bias, data extraction was

performed consistently using predefined variables and definitions [20].

**Statistical analysis**

Descriptive statistics were used to summarise patient characteristics and treatment outcomes. Continuous variables were presented as mean and standard deviation, while categorical variables were expressed as frequencies and percentages. Comparative analyses were conducted to assess associations between independent variables and achievement of the target blood pressure. A p-value of less than 0.05 was considered statistically significant. Statistical analyses were performed using standard statistical software commonly applied in clinical research [21].

**Ethical considerations**

The study protocol was reviewed and approved by the hospital administration. As a retrospective study using existing medical records, informed consent was waived. All patient data were anonymized before analysis, and confidentiality was strictly maintained in accordance with ethical principles for medical research involving human subjects [22].

## RESULTS

**Overall treatment outcomes and blood pressure changes**

A total of 378 hospitalized patients with primary hypertension were included in the analysis. At discharge, 367 patients (97.1%) achieved target blood pressure, whereas 11 patients (2.9%) failed to achieve target blood pressure, according to the 2022 Vietnam National Heart Association guidelines.

A marked reduction in blood pressure was observed during hospitalization. Mean systolic blood pressure decreased by 47.3 mmHg, from 171.4 ± 15.9 mmHg at admission to 124.1 ± 16.4 mmHg at discharge. Mean diastolic blood pressure decreased by 9.6 mmHg, from 91.5 ± 11.6 mmHg to 81.9 ± 12.9 mmHg, indicating substantial improvement in blood pressure control under inpatient management.

**Table 1:** Blood pressure values at admission and discharge (n = 378)

| Parameter | Admission (Mean ± SD) | Discharge (Mean ± SD) |
|---|---|---|
| SBP (mmHg) | 171.4 ± 15.9 | 124.1 ± 16.4 |
| DBP (mmHg) | 91.5 ± 11.6 | 81.9 ± 12.9 |

**Association between age, sex, and treatment outcomes**

Age was significantly associated with treatment outcomes. Patients aged 60 years or older were more likely to fail in achieving target blood pressure compared with younger patients, with an odds ratio (OR) of 1.48 (95% CI: 1.02-3.99; p = 0.016).

With respect to sex, the proportion of patients achieving target blood pressure was slightly higher among female patients (97.4%) than male patients (96.6%). However, this difference was not statistically significant (p > 0.05), indicating that sex was not an independent determinant of treatment outcome.

**Table 2:** Association between age, sex, and treatment outcomes

| Variable | Achieved target BP n (%) | Not achieved target BP n (%) | OR (95% CI) | p-value |
|---|---|---|---|---|
| Age ≥60 years | Lower | Higher | 1.48 (1.02-3.99) | 0.016 |
| Male | 96.6 | 3.4 | NS | >0.05 |
| Female | 97.4 | 2.6 | Reference | |

**Association between hypertension stage and treatment outcomes**

Hypertension severity at admission showed a strong association with treatment outcomes. Patients with stage II hypertension had a 3.70-fold increased likelihood of failing to achieve target blood pressure compared with patients with stage I hypertension (OR = 3.70; 95% CI: 2.64-4.37; p = 0.001). This risk was even higher among patients with stage III hypertension, who exhibited a 4.23-fold increased risk of treatment failure (OR = 4.23; 95% CI: 2.46-6.18; p = 0.009).

A clear gradient relationship was observed, with progressively poorer treatment outcomes as the hypertension stage increased.

**Table 3:** Association between hypertension stage and treatment outcomes

| Hypertension stage | Achieved target BP n (%) | Not achieved target BP n (%) | OR (95% CI) | p-value |
|---|---|---|---|---|
| Stage I | Highest | Lowest | Reference | |
| Stage II | Lower | Higher | 3.70 (2.64-4.37) | 0.001 |
| Stage III | Lowest | Highest | 4.23 (2.46-6.18) | 0.009 |

**Association between renal function and treatment outcomes**

Renal function emerged as a significant factor associated with treatment outcomes. Patients with elevated serum creatinine levels had a markedly higher likelihood of failing to achieve target blood pressure compared with those with normal creatinine levels, with an OR of 4.02 (95% CI: 1.19-13.58, p = 0.016).

This finding highlights the impact of renal impairment on antihypertensive treatment effectiveness in hospitalized patients.

**Table 4:** Association between comorbidities and treatment outcomes

| Renal function | Achieved target BP n (%) | Not achieved target BP n (%) | OR (95% CI) | p-value |
|---|---|---|---|---|
| Normal creatinine | Higher | Lower | Reference | |
| Elevated creatinine | Lower | Higher | 4.02 (1.19-13.58) | 0.016 |

**Association between body mass index and treatment outcomes**

Body mass index was significantly associated with treatment outcomes. Patients classified as overweight or obese were less likely to achieve target blood pressure compared with patients with a normal body mass index. Overweight or obese patients had a 1.63-fold increased risk of treatment failure (OR = 1.63; 95% CI: 1.16-3.65; p = 0.001).

**Table 5:** Association between BMI and treatment outcomes

| BMI category | Achieved target BP n (%) | Not achieved target BP n (%) | OR (95% CI) | p-value |
|---|---|---|---|---|
| Normal | Higher | Lower | Reference | |
| Overweight/obese | Lower | Higher | 1.63 (1.16-3.65) | 0.001 |

**Association between antihypertensive treatment regimens and treatment outcomes**

Regarding antihypertensive treatment regimens, 43.1% of patients received monotherapy, while 43.7% received two-drug combination therapy. Compared with two-drug combination therapy, monotherapy was associated with a higher likelihood of failing to achieve target blood pressure (OR = 2.51; 95% CI: 1.34-4.02; p = 0.004). Patients receiving four-drug combination therapy also had a substantially higher risk of treatment failure (OR = 9.10; 95% CI: 4.71-12.19; p = 0.001).

Three-drug combination therapy did not show a statistically significant association with treatment outcomes.

**Table 6:** Association between antihypertensive treatment regimens and treatment outcomes

| Treatment regimen | Achieved target BP n (%) | Not achieved target BP n (%) | OR (95% CI) | p-value |
|---|---|---|---|---|
| Two-drug combination | 98.8 | 1.2 | Reference | |
| Monotherapy | 97.0 | 3.0 | 2.51 (1.34-4.02) | 0.004 |
| Three-drug combination | 92.5 | 7.5 | NS | 0.647 |
| Four-drug combination | 90.0 | 10.0 | 9.10 (4.71-12.19) | 0.001 |

**Association between rational antihypertensive drug use and treatment outcomes**

Most patients received antihypertensive therapy that was appropriate in terms of indication, contraindication, and dosing. However, 7.4% of cases were inappropriate regarding dosing frequency, and 14.3% were classified as irrational overall.

Patients receiving irrational antihypertensive therapy had a significantly higher risk of failing to achieve target blood pressure compared with those receiving rational therapy (OR = 2.30; 95% CI: 1.59-9.01; p = 0.012).

**Table 7:** Association between rational drug use and treatment outcomes

| Drug use | Achieved target BP n (%) | Not achieved target BP n (%) | OR (95% CI) | p-value |
|---|---|---|---|---|
| Rational | Higher | Lower | Reference | |
| Irrational | Lower | Higher | 2.30 (1.59-9.01) | 0.012 |

**Association between drug-drug interactions and treatment outcomes**

Clinically significant drug-drug interactions were identified in 27 patients (7.1%). These interactions occurred both between antihypertensive agents and between antihypertensive agents and other medications.

Patients with interactions between antihypertensive agents had a markedly increased risk of treatment failure (OR = 18.25; 95% CI: 5.94-25.64; p = 0.021). Similarly, interactions between antihypertensive agents and other drugs were associated with a 13.73-fold increased risk of failing to achieve target blood pressure (95% CI: 7.48-19.41; p = 0.030).

**Table 8:** Association between drug-drug interactions and treatment outcomes

| Interaction type | OR (95% CI) | p-value |
|---|---|---|
| Antihypertensive-antihypertensive | 18.25 (5.94-25.64) | 0.021 |
| Antihypertensive-other drugs | 13.73 (7.48-19.41) | 0.030 |
| No interaction | Reference | |

**Multivariable logistic regression analysis**

After adjustment for potential confounding factors, multivariable logistic regression analysis identified several independent predictors of failure to achieve target blood pressure. These included age ≥60 years (aOR = 1.41; 95% CI: 1.01-3.43; p = 0.010), elevated serum creatinine (aOR = 3.74; 95% CI: 1.15-10.31; p = 0.040), stage II hypertension (aOR = 3.51; 95% CI: 2.51-4.19; p = 0.031), stage III hypertension (aOR = 3.98; 95% CI: 2.18-6.01; p = 0.003), irrational antihypertensive drug use (aOR = 2.14; 95% CI: 1.29-7.68; p = 0.019), and clinically significant drug-drug interactions.

**Table 9:** Multivariable logistic regression analysis of factors associated with failure to achieve target blood pressure

| Factor | aOR | 95% CI | p-value |
|---|---|---|---|
| Age ≥60 years | 1.41 | 1.01-3.43 | 0.010 |
| Elevated creatinine | 3.74 | 1.15-10.31 | 0.040 |
| Hypertension stage II | 3.51 | 2.51-4.19 | 0.031 |
| Hypertension stage III | 3.98 | 2.18-6.01 | 0.003 |
| Irrational drug use | 2.14 | 1.29-7.68 | 0.019 |
| Drug-drug interactions | 12.61-16.74 | Significant | <0.05 |

**Summary of results**

In summary, treatment outcomes among hospitalized patients with primary hypertension were influenced by multiple interrelated factors. Advanced age, higher hypertension stage, impaired renal function, overweight or obesity, inappropriate antihypertensive regimens, irrational drug use, and clinically significant drug-drug interactions were associated with poorer blood pressure control. In contrast, rational antihypertensive drug use and two-drug combination therapy were associated with a higher likelihood of achieving target blood pressure at discharge.

## DISCUSSION

This study identified multiple patient-related and treatment-related factors associated with treatment outcomes among hospitalized patients with primary hypertension. Although the

overall rate of achieving target blood pressure was high, several factors were found to significantly influence blood pressure control during hospitalization.

Age was an important determinant of treatment outcome. Patients aged 60 years or older had a significantly higher risk of failing to achieve target blood pressure. This finding is consistent with previous studies indicating that age-related vascular stiffness, impaired baroreceptor sensitivity, and higher comorbidity burden contribute to poorer blood pressure control in older patients [3,6]. The lack of a significant association between sex and treatment outcomes in this study is also in line with prior reports suggesting that sex differences in hypertension control may be attenuated in inpatient settings where treatment is closely monitored [4].

Hypertension stage at admission showed a strong and graded association with treatment outcomes. Patients with stage II and stage III hypertension were substantially less likely to achieve target blood pressure compared with those with stage I hypertension. This gradient effect reflects the impact of baseline disease severity on short-term blood pressure control and has been consistently reported in real-world studies [5,7]. Severe hypertension often requires more intensive and complex treatment strategies, which may limit the rapid achievement of the target blood pressure during hospitalization.

Renal function emerged as a critical clinical factor influencing treatment outcomes. Elevated serum creatinine was independently associated with failure to achieve the target blood pressure. Renal impairment may reduce the effectiveness of antihypertensive therapy through mechanisms such as volume overload, altered drug pharmacokinetics, and activation of the renin-angiotensin-aldosterone system [8,9]. This finding underscores the importance of individualized blood pressure targets and careful drug selection in patients with impaired renal function.

Body mass index was also significantly associated with treatment outcomes. Overweight and obese patients had a higher likelihood of treatment failure compared with patients with a normal body mass index. Excess adiposity is known to contribute to hypertension through increased sympathetic nervous system activity, insulin resistance, and low-grade inflammation, which may reduce responsiveness to antihypertensive therapy [5]. These findings highlight the relevance of body weight as an important factor influencing inpatient blood pressure control.

Treatment-related factors played a substantial role in determining outcomes. Patients receiving monotherapy or four-drug combination therapy were less likely to achieve target blood pressure compared with those receiving two-drug combination therapy. Current hypertension guidelines recommend early combination therapy for patients with moderate to severe hypertension, as it improves efficacy and reduces dose-related adverse effects [7]. The poorer outcomes observed with more complex regimens may reflect higher disease severity and greater clinical complexity among these patients.

Rational use of antihypertensive drugs was another key determinant of treatment outcome. Patients receiving irrational therapy had a significantly higher risk of failing to achieve the target blood pressure. Inappropriate prescribing practices, including suboptimal dosing frequency and unsuitable drug combinations, may compromise treatment effectiveness even in a hospital setting where adherence is generally high [2,9]. This finding emphasises the importance of regular prescription review and adherence to guideline-based treatment principles.

Clinically significant drug-drug interactions were strongly associated with treatment failure. Interactions between antihypertensive agents and between antihypertensive agents and other medications markedly increased the risk of poor blood pressure control. Polypharmacy is common among hospitalized patients with multiple comorbidities, increasing the likelihood of interactions that may reduce antihypertensive efficacy or increase adverse effects [9,10]. These results highlight the need for systematic medication review and pharmacovigilance in inpatient care.

In multivariable analysis, advanced age, higher hypertension stage, elevated serum creatinine, irrational drug use, and drug-drug interactions remained independent predictors of failure to achieve target blood pressure. These findings confirm that blood pressure control in hospitalized patients is influenced by a combination of clinical severity and treatment-related factors, reinforcing the multifactorial nature of hypertension management in inpatient settings.

## CONCLUSION

This study demonstrates that treatment outcomes among hospitalized patients with primary hypertension are determined by a complex interplay of patient-related and treatment-related factors. Advanced age, higher hypertension stage at admission, impaired renal function as reflected by elevated serum creatinine levels, and excess body weight were consistently associated with a lower likelihood of achieving target blood pressure during hospitalization. These findings indicate that baseline clinical severity and comorbidity burden play a critical role in short-term blood pressure control in inpatient settings.

In addition to patient-related characteristics, treatment-related factors significantly influenced outcomes. Irrational antihypertensive prescribing, including inappropriate dosing frequency and suboptimal treatment selection, was associated with poorer blood pressure control. Patients receiving monotherapy or highly complex regimens involving multiple antihypertensive agents were also less likely to achieve target blood pressure compared with those treated with guideline-recommended combination therapy. Furthermore, clinically significant drug–drug interactions markedly increased the risk of treatment failure,

highlighting the challenges of polypharmacy in hospitalized patients with multiple comorbidities.

Conversely, rational antihypertensive drug use and appropriate combination therapy were associated with improved treatment outcomes, underscoring the importance of adherence to evidence-based guidelines and individualized treatment strategies. These results emphasize the need for comprehensive clinical assessment, regular medication review, and careful consideration of potential drug–drug interactions to optimize antihypertensive therapy in hospitalized patients.

Overall, the findings provide important evidence to support more targeted and patient-centered approaches to hypertension management in inpatient clinical practice. Implementing structured treatment protocols, strengthening multidisciplinary collaboration, and integrating clinical pharmacy services may contribute to improved blood pressure control and better clinical outcomes among hospitalized patients with primary hypertension.

## ACKNOWLEDGEMENT

We would like to thank our management for providing all the facilities for the conduct of this Study.

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