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Original Article

Cost-Effectiveness of Hypertension Treatment with Diabetes Mellitus Complications in Hospitalized Patients at Berkah Pandeglang Regional Hospital

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Abstract
Hypertension with diabetes mellitus (DM) is a frequent comorbidity that increases clinical complexity and healthcare expenditures. Various antihypertensive and antidiabetic combination therapies are used in hospitalized patients, making pharmacoeconomic evaluation necessary to determine the most cost-effective treatment option. This study aimed to evaluate the cost-effectiveness of hypertension treatment with diabetes mellitus complications in hospitalized patients at Berkah Pandeglang Regional Hospital. This was a non-experimental observational study with a retrospective design using secondary data from medical records and hospital billing data of hospitalized patients diagnosed with hypertension and DM in 2024. Direct medical costs and clinical effectiveness outcomes, including blood pressure control, blood glucose levels, and length of stay (LOS), were analyzed. Cost-effectiveness was assessed using the Average Cost-Effectiveness Ratio (ACER) and Incremental Cost-Effectiveness Ratio (ICER). A total of 9 patients met the inclusion criteria. Of these, 5 patients received captopril, amlodipine, and metformin, while 4 patients received amlodipine, candesartan, bisoprolol, metformin, and glimepiride. The combination therapy of captopril and amlodipine with metformin showed the lowest ACER value (IDR 25,941), indicating the most cost-effective regimen. Another combination consisting of amlodipine, candesartan, and bisoprolol with metformin and glimepiride had a higher ACER value (IDR 82,621). Both regimens were located in quadrant II of the cost-effectiveness plane, representing lower costs with higher effectiveness. The combination of captopril, amlodipine, and metformin was identified as the most cost-effective therapy for hospitalized patients with hypertension and diabetes mellitus complications at Berkah Pandeglang Regional Hospital.

Keywords: Cost-Effectiveness analysis; Hypertension; Diabetes mellitus; Pharmacoeconomics; Hospitalized patients.

INTRODUCTION

Hypertension remains one of the most prevalent non-communicable diseases worldwide and is a major risk factor for cardiovascular morbidity and mortality. The World Health Organization estimates that more than one billion adults globally suffer from hypertension, with a significant proportion residing in low- and middle-income countries (World Health Organization, 2025). The burden of hypertension increases substantially when accompanied by diabetes mellitus (DM), as both conditions share pathophysiological mechanisms and synergistically elevate the risk of cardiovascular complications, prolonged hospitalization, and increased healthcare costs (Unger et al., 2020).

Patients with hypertension and DM often require combination therapy involving antihypertensive and antidiabetic agents to achieve optimal clinical outcomes. Although combination therapy improves blood pressure and glycemic

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control, it is frequently associated with higher treatment costs, particularly in inpatient settings (Gunes, 2025; Wang et al., 2025). In countries implementing national health insurance systems, such as Indonesia, rational drug selection is essential to ensure the sustainability of healthcare financing while maintaining therapeutic effectiveness.

Pharmacoeconomic evaluation provides a structured approach to compare the costs and outcomes of different therapeutic alternatives. Among the available methods, cost-effectiveness analysis (CEA) is widely used to assess the efficiency of healthcare interventions by comparing direct medical costs with clinical outcomes measured in natural units, such as blood pressure reduction or length of hospital stay (Tonin et al., 2021). The use of Average Cost-Effectiveness Ratio (ACER) and Incremental Cost-Effectiveness Ratio (ICER) allows decision-makers to identify treatment strategies that yield optimal outcomes at the lowest possible cost (Bang & Zhao, 2012).

Previous studies have demonstrated variability in the cost-effectiveness of antihypertensive regimens. Anggraini et al. (2023) reported that amlodipine monotherapy was more cost-effective than combination therapy in hypertensive patients with type 2 DM (Anggraini et al., 2023). Similarly, Putri and Dyahariesti (2021) found that a combination of diuretics, angiotensin receptor blockers, and beta-blockers resulted in the lowest ACER among hospitalized hypertensive patients (Putri & Dyahariesti, 2021). However, differences in study design, patient characteristics, and healthcare settings limit the generalizability of these findings.

To date, evidence regarding the cost-effectiveness of hypertension treatment with DM complications in hospitalized patients at regional hospitals in Indonesia remains limited. Therefore, this study aimed to evaluate the cost-effectiveness of antihypertensive treatment regimens in hospitalized patients with hypertension and diabetes mellitus complications at Berkah Pandeglang Regional Hospital, providing evidence to support rational pharmacotherapy and healthcare resource allocation.

METHODS

This study was a pharmacoeconomic evaluation employing a non-experimental observational design with a retrospective approach. The research was conducted at Berkah Pandeglang Regional Hospital, Indonesia, using secondary data collected from hospitalized patients diagnosed with hypertension with diabetes mellitus (DM) complications during the year 2024. The retrospective design was selected to assess real-world clinical practice and actual healthcare costs incurred during hospitalization.

The study population consisted of all inpatients diagnosed with hypertension and DM complications who received antihypertensive and antidiabetic therapy during the study period. Patients were included if they were aged 18 years or older, had documented blood pressure values of ≥140/90 mmHg, were diagnosed with diabetes mellitus as a comorbid condition, and had complete medical and billing records. Patients without DM complications or with incomplete data were excluded from the analysis.

Based on the eligibility criteria, nine medical records were included in the final analysis. The patients were categorized into two treatment regimen groups: five patients received captopril, amlodipine, and metformin, while four patients received

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amlodipine, candesartan, bisoprolol, metformin, and glimepiride. Treatment data were extracted retrospectively from the medications documented as administered in each patient's medical record during hospitalization, rather than from the prescribed regimen alone. The medication records were reviewed to identify any changes in treatment during the hospital stay.

For each patient, the treatment regimen, direct medical costs, clinical outcomes, and length of stay were extracted from the corresponding medical and billing records. These data were linked at the individual-patient level to ensure that the costs and clinical outcomes analyzed corresponded to the same patient. The cost and effectiveness calculations for each treatment group were based on the patients assigned to that group. The treatment group definitions and patient counts were applied consistently throughout the cost-effectiveness analysis.

Data were obtained from hospital medical records and the pharmacy and billing departments. Collected variables included patient demographic characteristics (age and sex), length of stay (LOS), types of antihypertensive and antidiabetic therapies administered, clinical outcomes, and direct medical costs. Direct medical costs comprised medication costs and hospitalization-related expenses covered by the national health insurance system. All costs were calculated in Indonesian Rupiah (IDR).

Clinical effectiveness was evaluated based on the achievement of therapeutic outcomes during hospitalization, including controlled blood pressure, controlled random blood glucose levels, and length of hospital stay. Blood pressure control was defined as systolic blood pressure below 140 mmHg and diastolic blood pressure below 90 mmHg, while random blood glucose control was defined as levels below 200 mg/dL. Length of stay was measured as the number of days from hospital admission until discharge (American Diabetes Association Professional Practice Committee, 2024).

Cost-effectiveness analysis (CEA) was performed to compare the economic efficiency of different antihypertensive treatment regimens. The Average Cost-Effectiveness Ratio (ACER) was calculated by dividing total direct medical costs by the effectiveness outcome for each treatment group. Incremental Cost-Effectiveness Ratio (ICER) was calculated to compare differences in costs and effectiveness between alternative therapies when applicable. The cost-effectiveness plane was used to classify treatment regimens into quadrants based on their relative costs and effectiveness.

Data processing and analysis were conducted using Microsoft Excel and Statistical Package for the Social Sciences (SPSS). Descriptive statistics were used to summarize patient characteristics, treatment patterns, costs, and clinical outcomes. Due to the small sample size and non-normal data distribution, non-parametric statistical tests were applied where appropriate. The results of the pharmacoeconomic analysis were presented in tabular and graphical formats to facilitate interpretation.

This study received ethical approval from the Health Research Ethics Committee of Universitas Muhammadiyah Purwokerto (KEPK-UMP), Indonesia, under registration number KEPK/UMP/417/VI/2025, dated 24 June 2025. The ethical review covered the study protocol, participant information sheet, and informed consent documents.

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RESULTS

A total of 9 hospitalized patients with hypertension and diabetes mellitus (DM) complications were included in this study based on the predefined inclusion and exclusion criteria. All patients received combination therapy consisting of antihypertensive and antidiabetic agents. The results are presented in terms of patient characteristics, length of stay, detailed direct medical costs, clinical effectiveness, statistical analysis using SPSS, and pharmacoeconomic outcomes.

Table 1 presents the demographic and clinical characteristics of the study population. Female patients slightly predominated (55.6%) compared with male patients (44.4%). Most patients were aged 56–65 years (44.4%), indicating that hypertension with DM complications mainly affected older adults. All patients were covered by the national health insurance system, reflecting the payer perspective used in this study. Combination therapy was administered to all patients in accordance with clinical practice for managing comorbid hypertension and DM.

Table 1. Characteristics of Hospitalized Patients with Hypertension and Diabetes Mellitus (n = 9)

Characteristic	Category	n	%
Sex	Male	4	44.4
	Female	5	55.6
Age (years)	36–55	3	33.3
	56–65	4	44.4
	66–75	2	22.3
Payment method	National health insurance	9	100
Type of therapy	Combination therapy	9	100

Length of stay (LOS) was used as an indicator of treatment effectiveness and healthcare utilization. As shown in Table 2, most patients (44.4%) were hospitalized for 4 days. Shorter LOS generally reflected faster clinical stabilization, while longer LOS was associated with patients requiring more intensive monitoring and therapy adjustments.

Table 2. Length of Stay of Hospitalized Patients

Length of stay (days)	n	%
3	2	22.2
4	4	44.4
5	2	22.2
≥6	1	11.2

Direct medical costs were calculated from the payer perspective and consisted of antihypertensive drug costs, antidiabetic drug costs, room charges, medical service fees, and supporting examination costs. Table 3 shows a detailed breakdown of direct medical costs by treatment regimen. The captopril–amlodipine–metformin regimen incurred lower total costs compared with the more complex combination therapy. Higher costs in the latter group were mainly driven by the use of multiple antihypertensive agents and additional antidiabetic medications.

Total hospitalization costs may be influenced by length of stay, medication requirements, diagnostic procedures, and other healthcare services received by individual patients. Differences in age, clinical condition, comorbidities, and healthcare utilization may also contribute to variation in costs between treatment groups. Because this study included only nine patients and used a retrospective observational design, these factors could not be assumed to be balanced between groups. Therefore, the observed cost differences should be interpreted descriptively and may not be attributable to the treatment regimens alone.

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Table 3. Detailed Direct Medical Costs by Treatment Regimen (IDR)

Cost component	Captopril + Amlodipine + Metformin	Amlodipine + Candesartan + Bisoprolol + Metformin + Glimepiride
Antihypertensive drugs	312,460	598,730
Antidiabetic drugs	198,300	355,120
Room charges	321,000	420,000
Medical services	198,000	300,200
Supporting examinations	122,000	160,130
Total direct medical cost	**1,151,760**	**1,834,180**

Direct medical costs were obtained retrospectively from hospital billing records and pharmaceutical cost data for the 2024 study period. Costs are reported in Indonesian Rupiah (IDR) and encompass antihypertensive medications, antidiabetic medications, room charges, medical services, and diagnostic tests. The total recorded cost for the captopril–amlodipine–metformin group was IDR 1,151,760, while the total cost for the amlodipine–candesartan–bisoprolol–metformin–glimepiride group was IDR 1,834,180. These figures represent the average values across all patients. Cost estimates are based on detailed data from the BPJS (Indonesian Social Security Agency on Health). The difference in total costs between the groups reflects variations in medication use, length of hospital stay, and healthcare service utilization at the individual patient level. Given the small sample size and the retrospective observational study design, these differences should not be interpreted as being solely attributable to the prescribed treatment regimens.

Clinical effectiveness was evaluated based on blood pressure control, random blood glucose control, and length of stay. As shown in Tables 4 and 5, most patients achieved controlled blood pressure (77.8%) and controlled random blood glucose levels (66.7%) before discharge, indicating that both treatment regimens were clinically effective during hospitalization.

Table 4. Effectiveness of Blood Pressure Control

Outcome	n	%
Controlled	7	77.8
Uncontrolled	2	22.2

Table 5. Effectiveness of Random Blood Glucose Control

Outcome	n	%
Controlled	6	66.7
Uncontrolled	3	33.3

Statistical analysis was performed using SPSS. Due to the small sample size and non-normal data distribution, non-parametric tests were applied. Differences in direct medical costs between treatment regimens were analyzed using the Kruskal–Wallis test, while differences in length of stay were analyzed using the Independent Sample t-test. The results showed no statistically significant differences between treatment regimens for either cost or LOS ($p > 0.05$).

Table 6. Statistical Analysis Results (SPSS Output Summary)

Variable	Statistical test	p-value
Direct medical costs	Kruskal–Wallis	0.317
Length of stay	Independent t-test	0.284

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The pharmacoeconomic evaluation demonstrated differences in cost-effectiveness between treatment regimens. As shown in Table 7, the captopril–amlodipine–metformin regimen had the lowest ACER value (IDR 25,941), indicating the lowest cost per unit of effectiveness. The alternative combination therapy had a higher ACER value (IDR 82,621), reflecting higher costs for comparable effectiveness.

Table 7. Average Cost-Effectiveness Ratio (ACER)

Treatment regimen	Total Cost (IDR)	Effectiveness (%)	ACER (IDR)
Captopril + Amlodipine + Metformin	1,151,760	44.4	25,941
Amlodipine + Candesartan + Bisoprolol + Metformin + Glimepiride	1,834,180	22.2	82,621

Incremental cost-effectiveness ratio (ICER) was calculated to evaluate the additional cost required to obtain incremental effectiveness when switching from the lower-cost regimen to the higher-cost regimen. The ICER calculation was based on differences in total direct medical costs and effectiveness outcomes between the two treatment regimens. Table 8 presents the detailed components used in the ICER calculation.

Table 8. Incremental Cost-Effectiveness Ratio (ICER) Calculation

Parameter	Captopril + Amlodipine + Metformin	Amlodipine + Candesartan + Bisoprolol + Metformin + Glimepiride
Total direct medical cost (IDR)	1,151,760	1,834,180
Effectiveness (%)	44.4	22.2
Incremental cost (ΔCost, IDR)	682,422	

DISCUSSION

This study evaluated the cost-effectiveness of antihypertensive treatment regimens in hospitalized patients with hypertension and diabetes mellitus (DM) complications at Berkah Pandeglang Regional Hospital. The findings demonstrated that although all evaluated regimens achieved comparable clinical effectiveness, substantial differences were observed in direct medical costs, leading to variations in cost-effectiveness outcomes. The combination of captopril, amlodipine, and metformin showed the most favorable economic profile, as reflected by the lowest ACER value.

The predominance of elderly patients in this study aligns with previous reports indicating that hypertension and DM frequently coexist in older populations due to age-related metabolic and vascular changes (Abdus et al., 2025; Kearney et al., 2005; Zheng et al., 2025). Female patients slightly outnumbered males, which is consistent with findings from community-based studies reporting higher healthcare utilization among women with chronic diseases (Dung & Long, 2016; Mohan et al., 2025). These demographic characteristics may

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influence treatment patterns and healthcare costs, particularly in inpatient settings.

Length of stay (LOS) is an important indicator of both clinical effectiveness and economic burden (Kiss et al., 2021). In this study, most patients had a LOS of four days, suggesting relatively rapid stabilization of blood pressure and glycemic status. Similar LOS patterns have been reported in hospitalized patients with cardiometabolic comorbidities, where effective combination therapy contributes to shorter hospital stays and reduced costs (Murru et al., 2025). Shorter LOS has been consistently associated with lower inpatient costs, reinforcing its relevance as an effectiveness parameter in pharmacoeconomic evaluations.

The detailed cost analysis revealed that medication costs constituted a substantial proportion of total direct medical costs. Regimens involving multiple antihypertensive agents, such as angiotensin receptor blockers and beta-blockers, were associated with higher drug acquisition costs. This finding is consistent with studies showing that increasing regimen complexity often leads to higher pharmaceutical expenditures without proportional gains in clinical outcomes (Muir et al., 2001). In contrast, simpler regimens using established first-line agents, such as ACE inhibitors and calcium channel blockers, tend to offer better economic value.

The cost-effectiveness analysis demonstrated that the captopril–amlodipine–metformin regimen achieved the lowest ACER, indicating the lowest cost per unit of effectiveness. This result is comparable to findings from hospital-based studies reporting that ACE inhibitor–based combinations are among the most cost-effective options for managing hypertension, particularly in patients with metabolic comorbidities (King et al., 2026). The relatively low cost of generic ACE inhibitors contributes significantly to their favorable economic profile.

ICER analysis further supported these findings by showing no incremental effectiveness when switching to higher-cost combination regimens. In pharmacoeconomic terms, this indicates dominance of the lower-cost regimen. Similar conclusions have been reported in studies where more expensive antihypertensive combinations failed to demonstrate superior clinical outcomes compared with lower-cost alternatives (Neumann et al., 2026). These findings underscore the importance of considering both costs and outcomes when selecting inpatient treatment strategies.

From a policy perspective, the results of this study have important implications for hospital formulary management and national health insurance sustainability. The use of cost-effective regimens can help optimize limited healthcare resources without compromising patient outcomes. Previous economic evaluations have emphasized that integrating pharmacoeconomic evidence into clinical decision-making can improve efficiency and reduce unnecessary healthcare expenditures (Drummond et al., 2015).

Several limitations should be acknowledged. First, the small sample size and single-center design may limit the generalizability of the findings. Second, the retrospective observational design is susceptible to confounding by indication, as the selection of treatment regimens may have been influenced by patients' clinical conditions and physicians' treatment

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decisions. Third, no adjustment was made for baseline disease severity or differences in comorbidities, which may have influenced treatment costs and clinical outcomes. Consequently, the observed differences in cost-effectiveness cannot be attributed solely to the treatment regimens. Furthermore, treatment effectiveness was assessed using short-term inpatient indicators, including blood pressure control, random blood glucose control, and length of stay, which may not fully capture long-term clinical benefits. The small sample size also introduces uncertainty into the estimated cost-effectiveness ratios, particularly because the analysis relied on a limited number of patients and treatment regimens. Therefore, the findings should be interpreted cautiously and validated in larger, multicentre studies using more comprehensive clinical outcomes and appropriate adjustment for baseline patient characteristics.

CONCLUSION

This study demonstrates that antihypertensive treatment regimens for hospitalized patients with hypertension and diabetes mellitus complications at Berkah Pandeglang Regional Hospital are clinically effective; however, their economic efficiency varies. The combination of captopril, amlodipine, and metformin was identified as the most cost-effective therapy, with the lowest ACER value of IDR 25,941. In comparison, the regimen consisting of amlodipine, candesartan, bisoprolol, metformin, and glimepiride showed a higher ACER value of IDR 82,621 without additional clinical benefit. ICER analysis indicated no incremental effectiveness ($\Delta E = 0$) with an additional cost of IDR 682,422, confirming the economic dominance of the lower-cost regimen. These findings support the use of cost-effective combination therapy to optimize inpatient pharmacotherapy and healthcare resource allocation.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHORS' DECLARATION

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

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