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Original Research Article

Cost minimization analysis of antihypertensive drugs available in the pharmacy of tertiary care hospital

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ABSTRACT

Background: Hypertension is a major preventable cause of cardiovascular morbidity and mortality and poses a significant public health burden in India. Its rising prevalence is linked to urbanization, lifestyle changes, and an aging population. As lifelong treatment is required, medication adherence is crucial, but high out-of-pocket costs can affect it. Despite similar therapeutic effects, antihypertensive drugs show significant inter-brand price variation, highlighting the need for cost-minimization to support rational prescribing.
Methods: A three-month cross-sectional cost-minimization study was conducted in a tertiary care hospital pharmacy to assess inter-brand price variation among oral, single-molecule antihypertensive drugs. Data from pharmacy stock records were analysed using cost difference, cost ratio, and percentage cost variation. Only drugs with multiple brands of the same strength were included.
Results: Enalapril and ramipril showed minimal inter-brand price variation (≤10%), indicating stable pricing. Among ARBs, telmisartan had low variability (≤16%) and remained close to NLEM prices, while losartan showed moderate variation (~56%). Atenolol also maintained stable NLEM-compliant pricing. Verapamil and diltiazem showed minimal variation, whereas amlodipine 5 mg had higher variability (~97%). Among diuretics, frusemide (~84%) and spironolactone (~68%) showed notable variation. Clonidine showed minimal variation at 100 µg but moderate variability at 150 µg (~23%).
Conclusions: This cost-minimization analysis shows significant inter-brand price variation among antihypertensive drugs despite therapeutic equivalence. Greater prescriber awareness, stricter price regulation, and cost-effective prescribing are needed to reduce patient burden and improve adherence.

Keywords: Cost minimization, Pharmacoeconomics, Hypertension

INTRODUCTION

Hypertension is one of the leading preventable causes of cardiovascular morbidity and mortality worldwide and represents a major public health challenge, particularly in developing countries.[1] Recent global estimates indicate that approximately 1.4 billion adults aged 30-79 years were living with hypertension in 2024, representing nearly 33% of the population in this age group, with almost two-thirds of affected individuals residing in low- and middle-income countries.[2] The burden of hypertension is therefore disproportionately higher in resource-limited settings where access to healthcare and long-term treatment may be limited. In India, cardiovascular diseases are the leading cause of mortality, accounting for nearly 28% of all deaths, with hypertension recognized as a major modifiable risk

factor. Epidemiological studies suggest that the prevalence of hypertension is approximately 25% in urban populations and around 10% in rural areas, and its burden continues to rise due to rapid urbanization, demographic transition, sedentary lifestyles, and diets high in sodium.[3] Effective management of hypertension requires lifelong pharmacotherapy and consistent adherence to prescribed treatment in order to prevent serious complications such as stroke, myocardial infarction, heart failure, and chronic kidney disease. However, in the Indian healthcare system, where a substantial proportion of healthcare expenditure is borne out-of-pocket, the affordability of antihypertensive medications plays a crucial role in determining treatment adherence and long-term disease control.[4] The Indian pharmaceutical market offers a wide range of branded generic versions of the same antihypertensive drugs. Although these brands demonstrate comparable therapeutic efficacy and meet regulatory standards for quality and bioavailability, considerable differences in their market prices are often observed. These variations may arise due to differences in manufacturing costs, marketing strategies, distribution channels, and the degree of price regulation under the Drug Price Control Order (DPCO) implemented by the National Pharmaceutical Pricing Authority.[5] Such price variability can impose a financial burden on patients, potentially leading to poor medication adherence or discontinuation of therapy. Therefore, pharmacoeconomic evaluation of drug pricing is essential to identify cost-effective treatment alternatives without compromising clinical effectiveness.

Antihypertensive therapy generally includes six major classes of medications: angiotensin-converting enzyme inhibitors (ACE inhibitors), angiotensin II receptor blockers (ARBs), beta-blockers, calcium channel blockers (CCBs), diuretics, and centrally acting α_2-adrenergic agonists.[6] Since these medications are required for long-term management, even small differences in their prices can significantly influence the overall cost of treatment. Although antihypertensive drugs are widely available, limited research has evaluated inter-brand price variation within hospital pharmacy settings, where procurement and dispensing practices may differ from those in the general pharmaceutical market. Therefore, the present study was conducted to assess the price variation among commonly prescribed antihypertensive drugs available in a tertiary care hospital pharmacy and to compare these prices with the ceiling prices specified in the National List of Essential Medicines (NLEM).[7] Identifying cost-effective alternatives may assist clinicians in making economically rational prescribing decisions and help reduce the financial burden on patients requiring long-term antihypertensive therapy.

METHODS

Study design

This was a cost-minimization study conducted using a cross-sectional design. The study assessed inter-brand price variation among antihypertensive medications available during the study period.

Study site

The study was conducted in the pharmacy store of a tertiary care hospital at Parul Sevashram Hospital, Vadodara, Gujarat, India.

Study duration

The study was conducted over a period of three months, from September 2025 to November 2025.

Data source and collection

Information was gathered from the hospital pharmacy's stock register. For each drug molecule, the generic name, brand name and manufacturer, dose and dosage form, pack size, and price per pack as well as per tablet were recorded.

Data analysis

For each drug molecule, the minimum and maximum prices per 10 tablets were determined. The parameters for cost variation were calculated as follows:

Cost difference: Maximum Cost - Minimum Cost

Cost ratio: Maximum Cost / Minimum Cost

Percentage cost variation: Maximum Cost - Minimum Cost / Minimum Cost×100

Inclusion criteria

Oral, single-molecule antihypertensive drugs stocked during the study period and drugs with two or more brands of the same dose were included in the study.

Exclusion criteria

Injectables, suspensions, sustained-release or extended-release formulations, fixed-dose combinations or varying doses, discontinued or unverified price data, and drugs with primary indications other than hypertension were excluded.

RESULTS

Among the ACE inhibitors available in the hospital pharmacy, enalapril (2.5 mg and 5 mg) and ramipril (2.5 mg and 5 mg) were assessed for cost variation. Enalapril 2.5 mg showed a cost difference of ₹1.3, with a cost ratio of 1.05 and 5.6% cost variation, while enalapril 5 mg demonstrated a cost difference of ₹2, a cost ratio of 1.05, and 5.07% cost variation, indicating minimal inter-brand price variation. Ramipril 2.5 mg showed a cost difference of ₹1.6, a cost ratio of 1.03, and 3.01% cost variation,

whereas ramipril 5 mg exhibited a higher cost difference of ₹8.3, a cost ratio of 1.09, and 9.96% cost variation. (Table 1). However, many ACE inhibitors exceed the NLEM pricing limits, particularly enalapril (by ₹9.4) and ramipril (by ₹7.5). Therefore, while ACE inhibitors have stable variations, they do not comply with NLEM pricing. Among the Angiotensin Receptor Blockers (ARBs) available in the hospital pharmacy, losartan (25 mg and 50 mg) and telmisartan (20 mg and 40 mg) were evaluated for cost variation. Losartan 25 mg showed a cost difference of ₹9.5, with a cost ratio of 1.56 and a percentage cost variation of 56.54%, while losartan 50 mg demonstrated a cost difference of ₹18, a cost ratio of 1.56, and a percentage cost variation of 56.60%, indicating substantial inter-brand price variation at both doses. (Table 1). Telmisartan 20 mg demonstrated a cost difference of ₹5.3, a cost ratio of 1.15, and a percentage cost variation of 15.58%. Telmisartan 40 mg showed a cost difference of ₹3, with a cost ratio of 1.04 and a percentage cost variation of 4.54%. Telmisartan exhibits minimal variation, remaining close to NLEM (₹2.9–₹3.3 above NLEM price). (Table 5).

Table 1: Cost variation analysis of single drug formulations from drug class ACEIS and ARBS of antihypertensive drugs.

Group	Generic name	Price/packet (10)	Cost difference	Cost ratio	% cost variation
ACEIs	Enalapril (2.5)	24.5	1.3	1.05	5.6
	Enalapril (2.5)	23.2			
	Enalapril (5)	41.4	2	1.05	5.07
	Enalapril (5)	39.4			
	Ramipril (2.5)	54.7	1.6	1.03	3.01
	Ramipril (2.5)	53.1			
	Ramipril (5)	91.6	8.3	1.09	9.96
	Ramipril (5)	83.3			
ARBs	Losartan (25)	16.8	9.5	1.56	56.54
	Losartan (25)	26.3			
	Losartan (50)	31.8	18	1.56	56.60
	Losartan (50)	49.8			
	Telmisartan (20)	34	5.3	1.15	15.58
	Telmisartan (20)	39.3			
	Telmisartan (40)	66	3	1.04	4.54
	Telmisartan (40)	69			

Table 2: Cost variation analysis of single drug (beta blockers) formulations of antihypertensive drugs.

Group	Generic name	Price/packet (10)	Cost difference	Cost ratio	% cost variation
Beta blockers	Propranolol (10)	14	0.1	1	0.71
	Propranolol (10)	13.9			
	Propranolol (20)	34.1	11.5	1.5	50.88
	Propranolol (20)	22.6			
	Propranolol (40)	36	1.6	1.04	4.65
	Propranolol (40)	34.4			
	Metoprolol (25)	18.9	9.8	1.51	51.85
	Metoprolol (25)	28.7			
	Carvedilol (12.5)	91.5	25.3	1.38	38.21
	Carvedilol (12.5)	66.2			
	Atenolol (50)	11.2	2.7	1.24	24.1
	Atenolol (50)	13.9			
	Nebivolol (5)	191.2	11.9	1.06	6.63
	Nebivolol (5)	179.3			
	Labetalol (100)	129	28	1.21	21.7
	Labetalol (100)	157			

Among the β-blockers available in the hospital pharmacy, propranolol, metoprolol, carvedilol, atenolol, nebivolol, and labetalol were evaluated for cost variation. Propranolol 10 mg showed minimal price variation with a cost difference of ₹0.1, a cost ratio of 1.00, and a percentage cost variation of 0.71%. However, propranolol 20 mg demonstrated a markedly higher cost difference of ₹11.5, a cost ratio of 1.50, and 50.88% cost variation,

while propranolol 40 mg showed relatively low variation with a cost difference of ₹1.6, a cost ratio of 1.04, and 4.65% cost variation. Metoprolol 25 mg exhibited substantial inter-brand variation with a cost difference of ₹9.8, a cost ratio of 1.51, and 51.85% cost variation. Carvedilol 12.5 mg showed a cost difference of ₹25.3, a cost ratio of 1.38, and 38.21% cost variation (Table 2). Atenolol 50 mg demonstrated a cost difference of ₹2.7, with a cost ratio of 1.24 and 24.10% cost variation, whereas nebivolol 5 mg showed the relatively low variation with a cost difference of ₹11.9, a cost ratio of 1.06, and the 6.63% cost variation. Atenolol shows price stability and is compliant with NLEM limits, as its price is actually below the ceiling (by ₹3.9) (Table 5). Labetalol 100 mg exhibited a cost difference of ₹28, a cost ratio of 1.21, and 21.70% cost variation. Among the Calcium Channel Blockers (CCBs) available in the hospital pharmacy, amlodipine (2.5 mg and 5 mg), verapamil (40 mg), and diltiazem (30 mg) were evaluated for cost variation. Amlodipine 2.5 mg showed a cost difference of ₹1.5, with a cost ratio of 1.08 and a percentage cost variation of 8.1%, indicating low inter-brand price variation. In contrast, amlodipine 5 mg demonstrated a markedly higher cost difference of ₹8.6, a cost ratio of 1.96, and a percentage cost variation of 96.62%, reflecting substantial inter-brand cost variation. Verapamil 40 mg exhibited minimal price variation with a cost difference of ₹0.5, a cost ratio of 1.06, and a percentage cost variation of 6.41%. Similarly, diltiazem 30 mg showed a cost difference of ₹0.6, a cost ratio of 1.02, and a percentage cost variation of 2.14%, indicating relatively uniform pricing among available brands. (Table 3).

Table 3: Cost variation analysis of single drug (CCBS) formulations of antihypertensive drugs.

Group	Generic name	Price/packet (10)	Cost difference	Cost ratio	% cost variation
CCBs	Amlodipine (2.5)	20	1.5	1.08	8.1
	Amlodipine (2.5)	18.5			
	Amlodipine (5)	8.9	8.6	1.96	96.62
	Amlodipine (5)	17.5			
	Verapamil (40)	7.8	0.5	1.06	6.41
	Verapamil (40)	8.3			
	Diltiazem (30)	28.6	0.6	1.02	2.14
	Diltiazem (30)	28			

Table 4: Cost variation analysis of single drug (diuretics and α2 agonists) formulations of antihypertensive drugs.

Group	Generic name	Price/packet (10)	Cost difference	Cost ratio	% cost variation
Diuretics	Frusemide (40)	10.1	4.6	1.83	83.63
	Frusemide (40)	5.5			
	Spironolactone (25)	23.3	9.4	1.67	67.62
	Spironolactone (25)	13.9			
α2 agonists	Clonidine (100)	30	0.8	1.02	2.73
	Clonidine (100)	29.2			
	Clonidine (150)	48	11	1.22	22.91
	Clonidine (150)	59			

Table 5: Comparison of cost of essential antihypertensives (as per NLEM) with the drugs available in hospital pharmacy.

Drug	Dose	NLEM price/10 tablets	Maximum cost	Cost difference
Amlodipine	5	26	17.5	8.5
Atenolol	50	17.8	13.9	3.9
Enalapril	2.5	19.3	24.5	5.2
	5	32	41.4	9.4
Ramipril	2.5	47.2	54.7	7.5
Telmisartan	20	36.4	39.3	2.9
	40	65.7	69	3.3

Among the Diuretics available in the hospital pharmacy, frusemide 40 mg and spironolactone 25 mg were evaluated for cost variation. Frusemide 40 mg showed a marked inter-brand price variation. The cost difference between available brands was ₹4.6, with a cost ratio of 1.83 and a percentage cost variation of 83.63%, indicating substantial variation in pricing despite identical dose and pack size. Similarly, spironolactone 25 mg demonstrated

considerable cost variation, with a cost difference of ₹9.4, a cost ratio of 1.67, and a percentage cost variation of 67.62% (Table 4). Among the α_2 agonists available in the hospital pharmacy, clonidine (100 mcg and 150 mcg) was evaluated for cost variation. Clonidine 100 mcg showed minimal inter-brand price variation, with a cost difference of ₹0.8, a cost ratio of 1.02, and a percentage cost variation of 2.73%, indicating relatively uniform pricing among available brands. In contrast, clonidine 150 mcg demonstrated a higher degree of cost variation, with a cost difference of ₹11, a cost ratio of 1.22, and a percentage cost variation of 22.91%, reflecting notable inter-brand price disparity at the higher dose (Table 4).

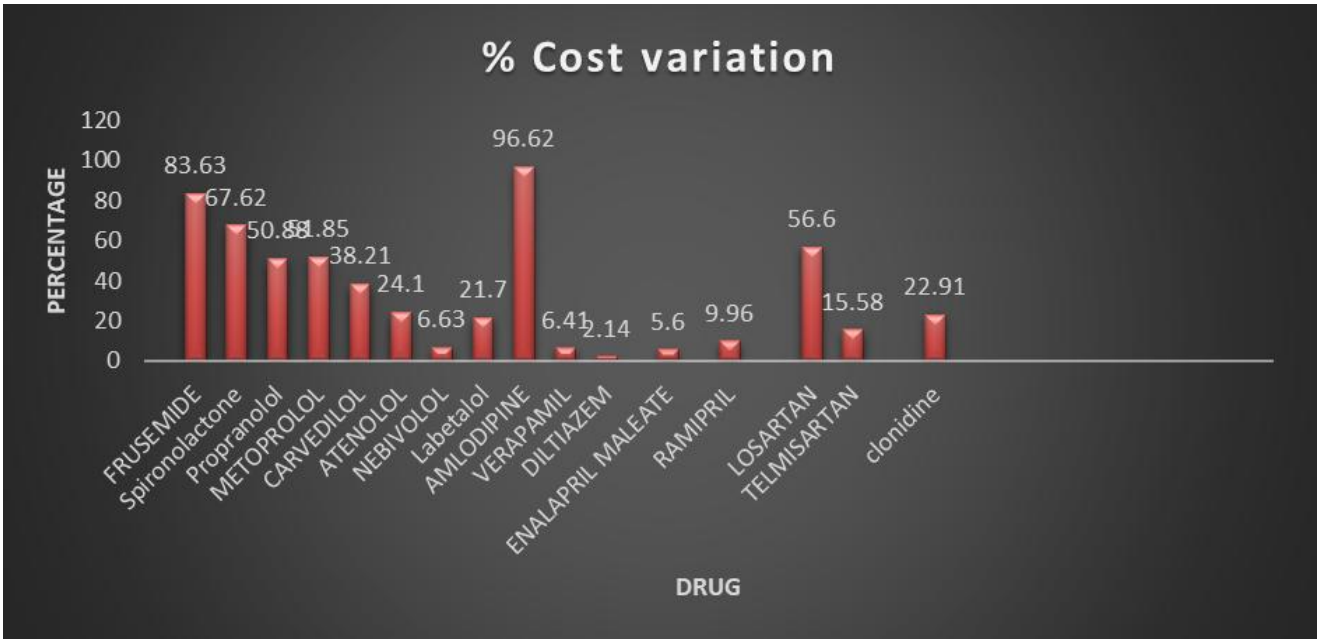

Figure 1: Percentage cost variation among antihypertensive drugs.

In the present analysis, the prices of amlodipine and atenolol were found to be within the NLEM ceiling limits. Although amlodipine showed the maximum percentage cost variation**,** the prices of even the costliest brands did not exceed the NLEM ceiling. In contrast, enalapril, ramipril, and telmisartan demonstrated relatively modest price differences. However, their maximum market prices were observed to be marginally above the NLEM ceiling levels.[7] (Table 5).

DISCUSSION

Hypertension is one of the most prevalent chronic non-communicable diseases worldwide and requires lifelong pharmacotherapy in a majority of patients. A wide range of antihypertensive drug classes including Angiotensin-Converting Enzyme inhibitors (ACE inhibitors), Angiotensin Receptor Blockers (ARBs), β-blockers, Calcium Channel Blockers (CCBs), Diuretics, and Centrally Acting α_2 agonists are commonly prescribed either as monotherapy or in combination. As clinical efficacy within the same drug class is often comparable, drug cost becomes a crucial determinant of medication adherence and overall treatment success.

Pharmacoeconomics plays an essential role in rational drug therapy by evaluating the cost and outcomes of pharmaceutical products. Among its various methods, cost-minimisation analysis (CMA) is particularly applicable when therapeutic equivalence is established, as is frequently the case with antihypertensive agents. CMA helps identify the least costly alternative among equally effective drugs, thereby supporting evidence-based, affordable prescribing and optimizing healthcare resource utilization.[8]

In the present study, ACE inhibitors demonstrated minimal inter-brand price variation (~10%), reflecting a mature and relatively well-regulated market supported by long-standing availability and widespread generic competition. These findings are comparable to those of Beck RK et al, who reported only moderate price variation for ramipril (~54%), indicating greater price stability of ACE inhibitors compared with other antihypertensive classes.[9] In contrast, earlier reports by Kamath L et al showed substantially higher variation for ramipril 10 mg (478.39%), suggesting that pricing stability for ACE inhibitors may have improved over time, likely due to strengthened regulatory oversight and market maturation.[10] This predictable pricing makes ACE inhibitors particularly suitable for long-term therapy in resource-limited settings.

Conversely, ARBs exhibited notable inter-brand price variability in the present study, with losartan showing approximately 57% variation. Similar and more pronounced variability has been reported previously, with Kamath L et al documenting very high variation for telmisartan 40 mg (542.22%) and Beck RK et al reporting substantial ARB price variation (~283%). Given the widespread use of ARBs for their favourable tolerability and reno protective benefits, such persistent pricing inconsistencies despite therapeutic equivalence are clinically significant and may adversely affect long-term patient adherence.

Amlodipine exhibited the highest price variation (96.62%) among all drugs analysed. As a commonly prescribed first-line antihypertensive, this wide cost disparity likely due to numerous branded formulations has important implications for adherence and treatment affordability. This finding is consistent with multiple Indian studies. Kamath L et al (2015) and Arya N et al (2019) reported extremely high variations exceeding 1000% for amlodipine, while Beck RK et al observed a variation of 460%.[11] Collectively, these studies, including ours, underscore that amlodipine remains one of the most variably priced antihypertensive agents despite its widespread first-line use.

β-blockers showed variable price differences depending on the drug and dose. While propranolol 10 mg and nebivolol showed minimal variation, metoprolol, carvedilol, and labetalol demonstrated substantial inter-brand cost differences (~52%). Atenolol 50 mg remained within NLEM ceiling prices, reflecting effective price regulation. In contrast, Beck RK et al reported extreme variation with atenolol 12.5 mg (880%), emphasizing that β-blockers are particularly susceptible to market-driven pricing differences that may affect affordability in long-term therapy. A similar study by Anand V. Karve et al (2014) and Limaye D et al. (2017) also reported significant price variations among different brands of the same antihypertensive drugs, highlighting the persistent issue of inter-brand cost disparities in the Indian pharmaceutical market.[12-13] Previous studies have reported that significant price variation among drug brands can affect medication adherence and patient outcomes, as higher costs may lead to switching or discontinuation of therapy.[14-15] Although inter-brand price variation was observed in the present study, it was lower than that reported earlier. Notably, the prices of amlodipine and atenolol remained within NLEM ceiling limits, highlighting the importance of selecting cost-effective antihypertensive brands to improve adherence and reduce financial burden.

Limitations

This study considered only antihypertensive brands available in the hospital pharmacy; therefore, the observed price variation may not reflect the full range of inter-brand differences in the open market, limiting the generalizability of the findings beyond the study setting.

CONCLUSION

The present cost-minimisation analysis reveals inter-brand price variation among commonly prescribed antihypertensive drugs despite therapeutic equivalence within drug classes. Relatively lower price variation was observed among ACE inhibitors, while ARBs and other antihypertensive agents showed moderate variability. A limited number of essential medicines were priced above the recommended ceiling levels. Overall, the findings support the importance of cost-conscious prescribing and adherence to price regulation policies to promote affordable antihypertensive therapy and improve long-term treatment adherence and cardiovascular outcomes.

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