Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Time to Blood Pressure Control and Its Determinant Factors among Hypertensive Patients at a Tertiary Teaching Hospital in Addis Ababa, Ethiopia: A Retrospective cohort study

Alazar Sitotaw

alazarsitotaw@gmail.com

Yekatit 12 Hospital Medical College

Samson Mulugeta

Yekatit 12 Hospital Medical College

Amdemeskel Mersha

Yekatit 12 Hospital Medical College

Yitagesu Getachew

Yekatit 12 Hospital Medical College

Getabalew Endazena

Yekatit 12 Hospital Medical College

Amanuel Zeleke

Yekatit 12 Hospital Medical College

Yoseph Abebe

Yekatit 12 Hospital Medical College

Kefyalew Dagne

Addis Ababa University

Gashaw Solela

Yekatit 12 Hospital Medical College

Abdurahim Wereka

Yekatit 12 Hospital Medical College

Gedion Masresha

Yekatit 12 Hospital Medical College

Bereket Tesfaye

Dilla University

Lulseged Teferi

Yekatit 12 Hospital Medical College

Getachew Wondafrash

Yekatit 12 Hospital Medical College

Mekoya Mengistu
Yekatit 12 Hospital Medical College
Tadesse Tibebu
Yekatit 12 Hospital Medical College
Mesfin Abiyu
Yekatit 12 Hospital Medical College
Balew Arega
Yekatit 12 Hospital Medical College

Research Article

Keywords: Hypertension, Time-to-control, Cox Regression, Ethiopia, Hospital Care

Posted Date: November 13th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10844734/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Abstract

Background

Hypertension, affecting over 1.28 billion adults globally, and being a major public health challenge in Ethiopia, with an adult prevalence of approximately 20%, is a major contributor to cardiovascular morbidity and mortality. Achieving timely blood pressure (BP) control is critical for reducing complications; however, evidence on the time to control and its determinants within Ethiopian hospital settings remain limited.

Objective

To assess the time required to achieve BP control and to identify factors associated with delayed control among hypertensive patients attending the medical outpatient department at Yekatit 12 Hospital Medical College in Addis Ababa, Ethiopia, from May 09, 2024 to December 09, 2025

Methods

A retrospective cohort study was conducted using 12 months of patient records. Adult hypertensive patients (≥ 18 years) with at least three follow-up visits were included. Time to BP control (< 140/90 mmHg) for all hypertensive patients and (< 130/80) for hypertensive patients with diabetes and/or CKD was analyzed using Kaplan-Meier estimation and Cox proportional hazards regression. For clinical interpretability, results are presented as Time Ratios (TR), where TR > 1 indicates a longer time to control. Adjusted TRs with 95% confidence intervals (CIs) are reported.

Results

A total of 502 participants were included in the cohort (response rate: 96.2%). By 12 months of follow-up, the cumulative incidence of blood pressure (BP) control was 72.3% (95% CI: 68.2–76.2%), with a median time to BP control of 5.3 months. In the final adjusted model, older age (aTR = 1.06 per year, 95% CI: 1.00–1.08, p = 0.006), higher baseline systolic BP (aTR = 1.10 per mmHg, 95% CI: 1.01–1.11, p < 0.001), and the presence of diabetes (aTR = 1.39, 95% CI: 1.10–1.72, p = 0.005) were independently associated with longer time to achieve BP control.

Conclusion

Although most patients achieved BP control within one year, the duration was significantly prolonged for older patients, those with higher initial systolic BP, and those with diabetes. These findings support the

need for risk-stratified management, including earlier treatment intensification and closer monitoring for high-risk groups to shorten the time to BP control.

Background

Hypertension (HTN), affecting over 1.28 billion adults globally, is a major contributor to cardiovascular morbidity and mortality (1). A pooled analysis of population-based studies from 1990 to 2019 reported substantial global improvements in hypertension awareness and treatment; however, effective BP control remains inadequate in many regions, especially in low- and middle-income countries (2).

In Ethiopia, HTN represents a growing public health burden, affecting nearly 20% of the adult population (3). The Federal Ministry of Health has incorporated non-communicable disease prevention and management into national health sector development strategies aimed at strengthening chronic care services and expanding access to treatment (4).

Despite the expansion of antihypertensive treatment strategies and clinical guidelines, blood pressure (BP) control remains inadequate worldwide (2). Evidence shows that less than half of individuals with hypertension receive treatment, and only a small proportion achieve adequate BP control (5). Large global burden analyses further demonstrate persistent gaps between treatment coverage and effective BP control, highlighting ongoing challenges related to treatment adherence, health system barriers, and socioeconomic disparities (6, 7).

A national systematic review and meta-analysis conducted in Ethiopia reported that a substantial proportion of hypertensive patients remain uncontrolled despite treatment, with considerable variability across healthcare settings (8), particularly in Tertiary Hospital settings where complex comorbidities and health system barriers often hinder optimal management. Recent national data indicate that only 49% of hypertensive individuals achieve guideline-recommended BP control (9).

Hospital-based data highlights a high burden of uncontrolled hypertension and its complications. For instance, studies at Jimma University Medical Center and other tertiary facilities report control rates as low as 42.8% (10), with frequent hospitalizations for stroke, heart failure, and hypertensive crises (11, 12), resulting in prolonged hospital stays, high treatment costs, and increased risk of premature mortality.

Several factors are associated with poor BP control in hospital settings, including delayed treatment intensification, medication non-adherence, lack of standardized follow-up, and the presence of comorbid conditions like diabetes and chronic kidney disease (CKD) (13, 14).

Implementation of the updated American College of Cardiology/American Heart Association (ACC/AHA) hypertension guidelines has increased the proportion of individuals classified as hypertensive, emphasizing the need for earlier and more intensive blood pressure management to improve cardiovascular risk reduction (15). However, in low-income settings such as Ethiopia, hypertension

detection, treatment coverage, and blood pressure control remain substantially limited due to health system constraints, low awareness, and barriers to long-term treatment adherence (16).

To date, no studies in Ethiopia have quantified time to BP control in hospital outpatient departments using retrospective cohort data. This gap limits our understanding of hypertension treatment trajectories under tertiary care. This study aims to fill that gap by conducting a hospital-based retrospective cohort study using EMR data at Yekatit 12 Hospital Medical College, one of Ethiopia's major urban tertiary centers. The study will provide critical insights into delays in BP control, determinants of poor control, and implications for improving quality care in hospital-based outpatient settings.

In Ethiopia, the burden of hypertension is increasing steadily. Studies estimate the prevalence of hypertension to range from 15% to over 30% among adults, depending on age and location (9). Yet timely control of BP remains poorly documented. Available data suggest that many patients remain uncontrolled for prolonged periods, significantly elevating their risk of stroke, myocardial infarction, kidney failure, and death (10, 11). Unfortunately, there are limited hospital-based studies that investigate how long it takes to control BP and what delays it in real-world clinical settings.

Uncontrolled hypertension is a leading cause of hospitalization and cardiovascular complications in tertiary hospitals in Ethiopia. According to national statistics, cardiovascular diseases now rank among the top causes of premature death in Ethiopia (17, 18). Stroke and heart failure, often secondary to long-standing uncontrolled BP, account for a large share of hospital admissions, particularly in medical wards and emergency departments (19, 20).

This study is significant as it bridges a major knowledge gap in the longitudinal care of hypertensive patients in Ethiopian hospitals. While most existing studies are cross-sectional and based in primary care settings, this research will assess the time to BP control over 12 months in a tertiary care environment, leveraging EMR data for precision. The findings help to identify the time to BP control, reveal patient and system-level factors affecting control in hospital settings, and provide baseline data for quality improvement initiatives, support the implementation of evidence-based hospital care protocols, and inform national hypertension strategies beyond primary care.

Methods and materials

Study setting, design, and periods

This study was conducted at Yekatit 12 Hospital Medical College, a tertiary teaching hospital located in Addis Ababa, Ethiopia. The hospital provides specialized outpatient and inpatient services, including a dedicated chronic care clinic for hypertension patients. The hospital also offers health education programs that emphasize lifestyle modifications and medication adherence for patients with established chronic disease including hypertension. Yekatit 12 hospital medical college is among the major referral hospitals in the capital and serves a large catchment population. EMRs are routinely used to document

patient histories, follow-up visits, laboratory results, and medication prescriptions. The study was conducted on hypertensive patients on follow-up at the medical outpatient department.

The study period covered follow-up data from May 09, 2024 to December 09, 2025, where data was collected from December 25, 2025 to January 15, 2026.

A retrospective dynamic (open) cohort study design was employed using data extracted from the hospital's electronic medical record system. The cohort included adult hypertensive patients who either initiated follow-up at the outpatient department or were already under follow-up with documented elevated blood pressure and subsequently met the eligibility criteria. Participants were observed for a 12-month period from cohort entry, and those with at least three recorded blood pressure measurements during follow-up were included in the analysis.

Population, sample size, and study variable

All adult hypertensive patients (aged ≥ 18 years) who attended follow-up care at the chronic illness clinic of Yekatit 12 Hospital Medical College between May 9, 2024, and December 9, 2025 were source population and;

All hypertensive patients who attended follow-up care at the chronic illness clinic of Yekatit 12 Hospital Medical College between May 9, 2024, and December 9, 2025, who met the inclusion criteria and whose data are complete in the EMR system were included in the analysis.

Adults (≥ 18 years) with a diagnosis of hypertension (SBP ≥ 140 mmHg or DBP ≥ 90 mmHg).

Patients who initiated and/or continued follow-up at Yekatit 12 Hospital during the study period.

And, those with at least three follow-up visits with BP measurements at approximately 3, 6, and 9/ 12 months were included.

Pregnancy or gestational hypertension and those with incomplete BP records at baseline or follow-up were excluded.

This study employed a retrospective cohort design, with time to BP control as the primary outcome. As such, the sample size was determined using a method appropriate for survival analysis, specifically the Schoenfeld formula for estimating sample size in Cox proportional hazards regression.

According to a previous study conducted at Jimma University Specialized Hospital, the proportion of hypertensive patients with uncontrolled BP was reported to be 59.5%, implying that 40.5% of patients achieved BP control during follow-up. This value (40.5%) was used as the event rate in the sample size calculation.

The following assumptions were made:

Proportion of patients who achieved BP control (event) = 0.405

- Level of significance (α) = 0.05
- Power = 80% (Zβ = 0.84)
- Anticipated hazard ratio = 1.5
- Z-value for 95% confidence interval = 1.96

Using the Schoenfeld formula:

$n = ((Z\alpha/2 + Z\beta)^2) \div ((\ln(HR))^2 \times p \times (1-p))$

Substituting the values:

$n = (1.96 + 0.84)^2 \div ((\ln(1.5))^2 \times 0.405 \times 0.595)$

$n \approx 7.84 \div 0.0395 \approx 199$

Thus, approximately 199 events (i.e., patients that would achieve BP control) were required.

To calculate the total sample size, the number of required events was divided by the event rate:

Total sample size = $199 \div 0.405 \approx 491$

Given that the total eligible hypertensive patient population in the hospital is 6066, a finite population correction (FPC) was applied using the formula:

$n_{adj} = (n \times N) \div (n + (N - 1))$

$n_{adj} = (491 \times 6066) \div (491 + 6065) \approx 454$

Adding a 15% contingency for incomplete or missing data:

Final sample size = 454 + (15% of 454) = 454 + 68 ≈ 522

Therefore, 522 hypertensive patient records were sampled, having approximately 502 complete records for final analysis (96.2% response rate).

All eligible patients who met the inclusion criteria and were recorded in the EMR database during the study period were reviewed. A random sampling approach was applied to select the number of study participants. The data was downloaded from EMR using MRNs of hypertensive patients in excel then, the participants were selected randomly using SPSS.

Data was extracted using a structured and pre-tested **data abstraction checklist**. This checklist was built based on the WHO PEN protocol and adapted to the hospital's EMR fields. It included:

Socio-demographics (Age, Sex, BMI, region);

Baseline clinical data (Systolic BP (SBP), Diastolic BP (DBP), Fasting blood sugar (FBS);

Medication history (antihypertensive, statins);

Lifestyle risk factors (History of alcohol consumption, tobacco, salt restriction, physical activity based on physician documentation);

Duration of hypertension

Comorbidities (Diabetes mellitus, CKD, Cardiac disease, HIV/AIDS, dyslipidemia)

BP follow-up outcomes at 3, 6, 9, and 12 months.

Data was collected by trained internal medicine General practitioners and residents under the supervision of the principal investigator. Data abstraction was performed using a secure Kobo Collect platform on tablets.

Dependent variables

The outcome of interest was Time to BP Control

Independent Variables

The **potential predictor variables** considered for time to BP control during the follow up period were categorized into five domains:

Socio-demographic Variables

Age, Sex, BMI

Baseline Clinical Data

SBP, DBP, BMI, Fasting Blood Glucose (FBS), and/or HgA1C, Primary Diagnosis (Type 1 Diabetes Mellitus (TIDM), Type 2 DM, duration of hypertension, dyslipidemia, CKD, Cardiac disease, HIV/AIDS

Behavioral Risk Factors

History of Alcohol consumption, Tobacco Use, adherence to physical activity, salt restriction based on physician documentation.

Medication List

Antihypertensive, Statin

Medication adherence

based on physician documentation

Data collection procedure and quality

A pretest was conducted on 5% of randomly selected EMRs to ensure checklist clarity and completeness. Data collectors were trained for one day prior to data collection to ensure a clear understanding of the procedures and tools, and daily quality checks was performed by the principal investigator to verify accuracy, completeness, and consistency.

Data analysis and statistics

Data were checked for consistency and completeness, coded, and analyzed using Stata version 27.1. Descriptive statistics, including means with standard deviations or medians with interquartile ranges, were used to summarize continuous variables, while frequencies and percentages were used for categorical variables.

Time to BP control was analyzed using survival analysis methods. The Kaplan–Meier method was used to estimate the cumulative probability of control over time and the median time to control. Cox proportional hazards regression was applied to identify factors associated with the time to BP control. For clinical interpretability, adjusted hazard ratios (aHR) were converted to adjusted time ration (aTR) using the formula aTR = 1/aHR, where aTR > 1 indicates longer time to control. Variables with a p-value < 0.05 in the final multivariable model were considered statistically significant predictors. Results are presented as aTR with 95% CIs.

Operational definitions

Controlled BP

BP < 140/90 mmHg in all ages of hypertensive patients, and < 130/80 in DM and CKD patients. The BP range outside the specified cut point for the specified population was considered uncontrolled hypertension [21].

Time to BP Control

The number of months from baseline/initial high BP records until the first visit at which the BP falls within the defined controlled range.

Physical activity

Categorized based on physician documentation in the EMR as physically active or physically inactive during follow-up visits.

Alcohol consumption

Categorized as alcohol user or non-user based on documentation in the EMR during follow-up.

- **Tobacco use**: Categorized as tobacco user or non-user based on documentation in the EMR during follow-up

Medication adherence

Determined based on physician documentation in the EMR. Patients documented as adherent to prescribed antihypertensive medications during follow-up were classified as adherent, while those documented as non-adherent were classified as non-adherent.

- **Salt restriction**: Classified as restricted or not, based on physician documentation in the EMR during follow-up.

Ethical considerations

Ethical clearance was obtained from Yekatit 12 Hospital Medical College Research and Ethics Review Board. As this was a retrospective study using anonymized EMR data, informed consent was waived. Data confidentiality has been strictly maintained; patient identifiers were not collected, and all electronic data has been stored securely with password protection.

Results

Presentation of Baseline Characteristics and Management Patterns

This study enrolled a cohort of 502 participants, representing a response rate of 96.2%. The population had a mean age of 57.1 years (SD ± 11.96), with 55.2% of participants aged between 46 and 65 years. A slight majority were female 280 (55.8%). Geographically, the cohort was predominantly from Addis Ababa 470 (93.6%). The mean BMI was 25.9 kg/m² (SD ± 4.44), with the largest proportion of participants classified as normal 218 (43.4%) or overweight 197 (39.2%) (30). Documented behavioral risk factors were low, with a history of smoking and alcohol consumption noted in only 12 (2.4%) and 22 (4.4%) of participants, respectively. The cohort exhibited a substantial burden of comorbidities, including diabetes mellitus 204 (40.6%), dyslipidemia 104 (20.7%), and cardiac disease 92 (18.3%) (Table 1).

Table 1
Baseline Demographic and Clinical Characteristics of HTN Patients at a Tertiary Hospital, Addis Ababa, Ethiopia (N = 502).

Characteristic	n	%
Sex		
Female	280	55.8
Male	222	44.2
Age (years)		
<45	92	18.3
46–65	277	55.2
>66	133	26.5
Region		
Addis Ababa	470	93.6
Amhara	5	1.0
Oromia	27	5.4
BMI (kg/m²)		
<18.5 (Underweight)	10	2.0
18.5–24.9 (Normal)	218	43.4
25.0–29.9 (Overweight)	197	39.2
≥30.0 (Obese)	77	15.3
Smoking History (Yes)	12	2.4
Alcohol Consumption History (Yes)	22	4.4
Diabetes Mellitus (Yes)	204	40.6
Dyslipidemia (Yes)	104	20.7
HIV/AIDS (Yes)	8	1.6
Cardiac Disease (Yes)	92	18.3
CKD (Yes)	28	5.6

Hypertension Treatment Patterns and Adherence

The majority of hypertensive patients presented with Stage 1, 326(64.9%) or Stage 2, 145(28.9%) disease, with most 345(68.7%) having a duration of 1–5 years. The mean BP was elevated at 155.3/84.6

mmHg, indicating suboptimal control. Metabolic parameters reflected a high comorbidity burden, including elevated FBS (122.9 ± 39.08 mg/dL), consistent with impaired fasting glucose, while the mean total cholesterol level (165.7 ± 43.4 mg/dL) was within the desirable range. Medication adherence 353(70.3%) was notably higher than adherence to physical activity 228(45.4%). Treatment was predominantly based on amlodipine 292(58.2%) and Enalapril 265(52.8%), and over half of the cohort 287(57.2%) indicated for statin and were on therapy (Table 2).

Table 2
Clinical Profile, Management, and Treatment of HTN Patients at Tertiary Hospital, Addis Ababa, Ethiopia (N = 502).

Characteristic	n	%
Hypertension Stage		
Stage 1	326	64.9
Stage 2	145	28.9
Hypertensive Urgency	26	5.2
Hypertensive Emergency	05	1.0
Duration of HTN		
≤ 1 year	71	14.1
1–5 years	345	68.7
> 5 years	36	7.2
Fasting blood glucose among DM (n = 181)		
<70mg/dl	27	13.2
70-130mg/dl	35	17.2
> 130mg/dl	119	58.3
Fasting blood glucose among non DM (n = 193)		
<100mg/dl	97	33.2
101-126mg/dl	74	25.3
>126mg/dl	22	7.5
Adherence		
Adherent to physical activity (Yes)	228	45.4
Medications (Adherent)	353	70.3
Salt Restriction (Adherent)	274	54.6
Use of Specific Antihypertensive Drug Classes		
Amlodipine	292	58.2
Enalapril	265	52.8
Hydrochlorothiazide	139	27.7
Losartan	76	15.1

Characteristic	n	%
Hypertension Stage		
Beta Blockers	44	8.8
Nifedipine	28	5.6
Spironolactone	19	3.8
Statin Indication at Baseline (Yes)	287	57.2
Mean score of clinical variables		
	n	**Mean (SD)**
Blood Pressure (n = 502)		
Systolic BP (mmHg)	502	155.25 (13.44)
Diastolic BP (mmHg)	502	84.62 (11.86)
Metabolic Parameters (n = 502)		
FBS (mg/dl)	375	122.93 (39.08)
Hemoglobin A1c (%)	145	7.40 (1.93)
LDL Cholesterol (mg/dL)	336	93.23 (36.28)
Total Cholesterol (mg/dL)	376	165.70 (43.42)

Cumulative Distribution of Time to BP Control

The data shows a clear trend of progressive increase in the measured outcome over time. The overall blood pressure control at the end of the 12-month follow-up was 72.3% (363/502) (95% CI: 68.2%–76.2%). The cumulative percentage rises steadily from 37.6% by month 3 to 72.3% by month 12. The most substantial increase occurs in the first six months, with growth slowing somewhat in the second half of the year, though it remains consistent. This pattern indicates an accumulating or time-dependent effect, with the majority of the outcome (over 70%) realized within the first year. Overall, 4.38% (22/502) of patients were lost to follow-up, with rates rising from 1.56% at 3 months to a peak of 17.78% at 9 months before declining to 4.73% at 12 months (Fig. 1).

Incidence of BP control

The Kaplan–Meier curve demonstrates a progressive increase in the incidence of blood pressure control over the follow-up period. This median indicates that half of the patient cohort experienced control BP within about 5.3 months of follow-up. At baseline, all participants had uncontrolled blood pressure. By approximately 3 months, about 38% of patients had achieved control, increasing to around 56% at 6 months and 64% at 9 months (Fig. 2).

Factors Associated with Time to BP Control

In univariate analysis, age, BMI, baseline systolic BP, baseline diastolic BP, and diabetes each showed a statistically significant association with time to BP control and were included in the multivariable model.

In the final adjusted model, older age, higher baseline systolic blood pressure, and the presence of diabetes remained independently associated with a longer time to achieve control. Specifically, each one-year increase in age was associated with a 6% longer time to control (adjusted TR = 1.06, 95% CI: 1.00–1.08, p = 0.006). Each 1 mmHg increase in baseline systolic blood pressure was associated with a 10% longer time to control (aTR = 1.10, 95% CI: 1.01–1.11, p < 0.001). Patients with diabetes required 39% longer time to achieve control compared to those without diabetes (aTR = 1.39, 95% CI: 1.10–1.72, p = 0.005).

Table 3
Univariate and multivariate Cox proportional analysis of factors associated with time to BP control, Addis Ababa, 2025.

Variables	Univariable Analysis				Multivariable Analysis			
	β (SE)	HR (95% CI)	TR (95% CI)	P-value	β (SE)	HR (95% CI)	TR (95% CI)	P-value
Age (Years)	-0.013 (0.004)	0.987 (0.979–0.995)	1.10 (1.01–1.11)	0.001	-0.012 (0.004)	0.988 (0.980–0.996)	1.06 (1.00–1.08)	0.006
BMI	-0.033 (0.012)	0.968 (0.945–0.991)	1.03 (1.01–1.05)	0.008	-0.024 (0.013)	0.976 (0.952–1.001)	1.04 (1.00–1.05)	0.056
Baseline SBP	-0.028 (0.005)	0.973 (0.963–0.982)	1.12 (1.02–1.18)	< 0.001	-0.024 (0.005)	0.976 (0.967–0.986)	1.10 (1.01–1.11)	< 0.001
Baseline DBP	-0.010 (0.004)	0.990 (0.982–0.998)	1.01 (1.00–1.02)	0.019	-0.006 (0.005)	0.994 (0.984–1.004)	1.01 (1.00–1.02)	0.258
Diabetes	-0.400 (0.110)	0.670 (0.540–0.832)	1.49 (1.20–1.85)	< 0.001	-0.323 (0.114)	0.724 (0.579–0.905)	1.39 (1.10–1.72)	0.005

Discussion

This retrospective cohort study evaluated the time required to achieve blood pressure control and its determinants among hypertensive patients at a Tertiary Hospital in Ethiopia. The primary findings indicate that 72.3% of patients attained control within 12 months of follow-up, with a median time to control being 5.3 months. Multivariable Cox proportional hazards regression identified older age, higher

baseline systolic blood pressure (SBP), and the presence of diabetes mellitus as independent clinical factors associated with a significantly longer time to achieve control.

The cumulative control rate of 72.3% at one year represents a favorable outcome compared to previously reported control rates in LMICs. Global data indicate that while control rates have improved over recent decades, they remain suboptimal, particularly in hospital settings where patients present with greater disease severity and comorbidity burdens (22–24). The rate observed in this cohort exceeds those documented in several prior Ethiopian studies, which have reported control rates ranging from approximately 22% to 43% in both hospital and primary care contexts (1, 10, 11, 14). This discrepancy may be attributable to several key distinctions. Firstly, this study specifically followed hypertensive patients during their inaugural year of treatment, capturing the early treatment response trajectory. In contrast, many earlier studies employed cross-sectional designs that assessed a heterogeneous mix of patients at various, often advanced, stages of chronic management, where therapeutic inertia and long-standing uncontrolled hypertension are more prevalent. Secondly, the study site's participation in structured, ministry-led hypertension management programs, with an emphasis on protocolized care and provider training, likely contributed to more consistent and effective treatment delivery. This aligns with literature underscoring that healthcare system organization, including reliable medication supply, standardized protocols, and continuity of care, is a critical determinant of hypertension outcomes in resource-limited settings (22, 23).

The median time to control of 5.3 months provides a valuable metric for understanding the pace of treatment effectiveness. This finding situates the cohort's experience meaningfully within the global continuum. It is markedly shorter than the 9.2 months reported in a Nigerian study (3) and is comparable to, though slightly faster than, the 6.42 months found in a similar Ethiopian hospital-based study (1). However, it remains longer than the 3.4 months documented in a high-income setting utilizing integrated electronic health records (9, 25). This gradient, from high-income settings to LMICs, highlights a persistent care gap. It reflects disparities in fundamental health system infrastructures, such as the frequency and ease of follow-up visits, patient navigational support, and perhaps the timeliness of treatment intensification, which collectively influence the speed of achieving therapeutic targets (24).

The association between older age and delayed control is robustly supported by both local and international literature (10). The physiological rationale is multifold: age-related increase in arterial stiffness reduces vascular compliance, potentially blunting the response to certain antihypertensive agents. Furthermore, older patients frequently have a higher burden of comorbidities, which complicates pharmacotherapy due to polypharmacy, drug-disease interactions, and a heightened risk of adverse effects, often necessitating a slower, more cautious titration of therapy.

The powerful and independent role of diabetes mellitus in prolonging the time to control is a critical finding, consistent with studies from other African regions, such as Kenya, where diabetes significantly increased the odds of poor control (14). The pathophysiological synergy between hypertension and diabetes, mediated through mechanisms like endothelial dysfunction, chronic inflammation, and renal

sodium handling, creates a therapeutic challenge. Management often requires more complex drug regimens (*e.g.*, prioritizing RAAS inhibitors) and stricter target goals, which can extend the period needed to find an effective and tolerated treatment combination.

The finding that higher baseline SBP is an independent predictor of longer time to control is clinically intuitive, but importantly, quantified in this model. It confirms that the initial severity of hypertension is a principal driver of management complexity. Patients presenting with markedly elevated SBP likely require a more aggressive initial approach, possibly including early combination therapy, to overcome their heightened vascular resistance and achieve control within a reasonable time-frame. This observation argues against therapeutic inertia and supports guideline recommendations for timely treatment intensification in patients with higher-grade hypertension.

This study has several notable strengths. First, the application of a time-to-event (survival) analytical framework allowed for a dynamic assessment of the process of achieving BP control. This approach is superior to cross-sectional analysis, as it accounts for the timing of the event and appropriately handles censored data, providing clinically meaningful estimates of cumulative incidence and median time to control. Second, the relatively long follow-up period of 12 months enhanced the reliability of identifying factors associated with both timely and delayed control. Third, the study directly addresses a recognized evidence gap by employing a retrospective cohort design with electronic medical record data from a hospital setting in Ethiopia, offering longitudinal insights that are scarce in the existing literature.

Several limitations must also be acknowledged. First, the single-center, facility-based design may limit the generalizability of findings to community or primary care settings and other geographical regions. Second, the retrospective reliance on routine clinical data introduces the potential for measurement bias and unmeasured confounding. Key determinants such as detailed medication adherence, socioeconomic status, health literacy, and specific reasons for clinical decisions (*e.g.*, delays in treatment intensification) were not captured. Third, the definition of control was based on clinic BP measurements, which are subject to variability and may not reflect out-of-office control. Finally, while the model adjusted for major clinical confounders, residual confounding from other unmeasured patient and provider-level factors cannot be excluded.

Conclusion

In this hospital-based cohort, approximately three-fourths of hypertensive patients achieved BP control within 12 months of follow-up, with a median time to control of 5.3 months. This demonstrates that effective control is achievable with structured management. However, the time to control was significantly longer for older patients, those who had a higher baseline SBP, or those who had diabetes mellitus. These findings highlight the need for a risk-stratified approach to hypertension management to accelerate control in high-risk subgroups and reduce cumulative cardiovascular risk exposure.

Patients identified in this study as having delayed BP control (such as those with older age, higher baseline SBP, or diabetes) should receive closer follow-up and timely treatment intensification in routine

clinical practice. Health facilities should consider implementing structured risk-based monitoring approaches to reduce prolonged uncontrolled blood pressure and prevent complications.

Interventions should focus on supporting patients to maintain recommended lifestyle behaviors through education, counseling, and digital reminders. Tailored strategies targeting both medication and lifestyle adherence, especially for high-risk groups such as older adults, patients with high baseline BP, and those with diabetes may help reduce the time to achieve BP control.

Strengthening patient education and employing digital tools for appointment and medication reminders to address adherence, a key factor influencing time to control are vital.

In addition, conducting Prospective and Mixed-Methods Studies that prospectively collects detailed data on adherence, socioeconomic barriers, and clinical decision-making to better understand the determinants of delay in BP control, is recommended.

Abbreviations

AIDS
Acuired Immnuno deficiency Syndrome
AHRs
Adjusted hazard ratios
Anti-DM
Antidiabetic
aTR
adjusted Time Ratio
BMI
Body Mass Index
BP
Blood pressure
CIs
Confidence intervals
CKD
Chronic Kidney Diseases
CVD
Cardiovascular disease
DBP
Diastolic Blood Pressure
EMR
Electronic Medical Record
FBS
Fasting Blood Glucose

FPC
Finite population correction
HER
Electronic health record
HIV
Human immune virus
HTN
Hypertension
LMICs
Low- and middle-income countries
MICE
Multiple imputation by chained equations
MoH
Ministry of Health
MRN
Medical record number
SBP
Systolic Blood pressure
T2DM
Type 2 Diabetes Mellitus
TIDM
Type 1 Diabetes Mellitus
WHO
World Health Organization
Y12HMC
Yekatit 12 Hospital Medical College

Declarations

Ethical considerations and consent participation:

This study was approved by the ethical committee of Yekatit-12 Hospital Medical College and was conducted according to the declaration.

Consent for publication:

Not applicable

Competing interests

The authors declare that they have no competing interests.

Funding:

No funding organization was involved in this study.

Author Contribution

AS involved in conceptualization, data curation, formal analysis, writing of original manuscript draft, reviewing, editing and validation; SM participated in data curation, methodology, analysis, validation; AM: methodology, analysis, and writing of original draft, YG: data curation, analysis, writing of original draft and validation; GE: data curation, analysis, writing of original draft, supervision of the study and validation; AZ: analysis, writing of original draft and validation; YA: data curation, methodology and analysis; KD: analysis, writing of original draft and validation; GS: data curation, methodology, analysis and writing up of original manuscript draft; AW: data curation, methodology, analysis and writing up of original manuscript draft; GM: data curation, methodology and writing up of original manuscript draft; BT: data curation, and methodology; LT: data curation, and methodology; GW: analysis, writing of original draft and validation; MM: analysis, writing of original draft and validation; TT: data curation, and methodology; MA: data curation, and methodology; BA: conceptualization, data curation, formal analysis, supervision of overall study, writing, reviewing, editing of the manuscript and validation.

Acknowledgement

I am grateful to Yekatit 12 Hospital Medical College, Department of Internal Medicine and Research, and Publications Office, for making the necessary arrangements to conduct this valuable clinical research. Furthermore, I express my gratitude to all my advisors and colleagues for their unreserved professional support and technical guidance in developing this research project.

Availability of data and materials:

Supporting data is available with the corresponding author and it will be accessible upon reasonable request.

References

1. World Health Organization. Hypertension fact sheet, Geneva WHO. 2023 [cited 2025 Jun 19]. Available from: https://www.who.int/news-room/fact-sheets/detail/hypertension. 2025.
2. Zhou B, Carrillo-Larco RM, Danaei G, Riley LM, Paciorek CJ, Stevens GA, et al. Worldwide trends in hypertension prevalence and progress in treatment and control from 1990 to 2019: a pooled analysis of 1201 population-representative studies with 104 million participants. lancet. 2021;398(10304):957–80.

3. Ethiopian Public Health Institute (EPHI). ETHIOPIA STEPS REPORT ON RISK FACTORS FOR CHRONIC NON-COMMUNICABLE DISEASES AND PREVALENCE OF SELECTED NCDs. 2016.
4. FMoH. Health Sector Development Programme IV (HSDP-IV). Addis Ababa. 2010.
5. Organization WH. Global report on hypertension: the race against a silent killer. World Health Organization; 2023.
6. Murray CJ, Aravkin AY, Zheng P, Abbafati C, Abbas KM, Abbasi-Kangevari M, et al. Global burden of 87 risk factors in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. lancet. 2020;396(10258):1223–49.
7. Mills KT, Stefanescu A, He J. The global epidemiology of hypertension. Nat Rev Nephrol. 2020;16(4):223–37.
8. Amare F, Hagos B, Sisay M, Molla B. Uncontrolled hypertension in Ethiopia: a systematic review and meta-analysis of institution-based observational studies. BMC Cardiovasc Disord. 2020;20(1):129.
9. Gobezie MY, Hassen M, Tesfaye NA, Solomon T, Demessie MB, Fentie Wendie T, et al. Prevalence of uncontrolled hypertension and contributing factors in Ethiopia: a systematic review and meta-analysis. Front Cardiovasc Med. 2024;11:1335823.
10. Kebede B, Chelkeba L, Dessie B. Rate of blood pressure control and its determinants among adult hypertensive patients at Jimma University Medical Center, Ethiopia: Prospective cohort study. SAGE open Med. 2021;9:20503121211006000.
11. Márquez DF, Rodríguez-Sánchez E, de la Morena JS, Ruilope LM, Ruiz-Hurtado G. Hypertension mediated kidney and cardiovascular damage and risk stratification: Redefining concepts. nefrologia. 2022;42(5):519–30.
12. Masenga SK, Kirabo A. Hypertensive heart disease: risk factors, complications and mechanisms. Front Cardiovasc Med. 2023;10:1205475.
13. Ojangba T, Boamah S, Miao Y, Guo X, Fen Y, Agboyibor C, et al. Comprehensive effects of lifestyle reform, adherence, and related factors on hypertension control: A review. J Clin Hypertens. 2023;25(6):509–20.
14. Laar AK, Adler AJ, Kotoh AM, Legido-Quigley H, Lange IL, Perel P, et al. Health system challenges to hypertension and related non-communicable diseases prevention and treatment: perspectives from Ghanaian stakeholders. BMC Health Serv Res. 2019;19(1):693.
15. Flack JM, Adekola B. Blood pressure and the new ACC/AHA hypertension guidelines. Trends Cardiovasc Med. 2020;30(3):160–4.
16. Ataklte F, Erqou S, Kaptoge S, Taye B, Echouffo-Tcheugui JB, Kengne AP. Burden of undiagnosed hypertension in sub-saharan Africa: a systematic review and meta-analysis. Hypertension. 2015;65(2):291–8.
17. Ali S, Misganaw A, Worku A, Destaw Z, Negash L, Bekele A, et al. The burden of cardiovascular diseases in Ethiopia from 1990 to 2017: evidence from the Global Burden of Disease Study. Int Health. 2021;13(4):318–26.

18. Abate TW, Zeleke B, Genanew A, Abate BW. The burden of stroke and modifiable risk factors in Ethiopia: A systemic review and meta-analysis. PLoS ONE. 2021;16(11):e0259244.
19. Berhe DF, Taxis K, Haaijer-Ruskamp FM, Mulugeta A, Mengistu YT, Mol PG. Hypertension treatment practices and its determinants among ambulatory patients: retrospective cohort study in Ethiopia. BMJ open. 2017;7(8):e015743.
20. Ethiopian Public Health Institute (EPHI). Ethiopia Demographic and Health Survey. Addis Ababa: Central Statistical Agency; 2014.
21. Sorato MM, Davari M, Kebriaeezadeh A, Sarrafzadegan N, Shibru T, Fatemi B. Reasons for poor blood pressure control in eastern sub-Saharan Africa: looking into 4P's (primary care, professional, patient, and public health policy) for improving blood pressure control: a scoping review. BMC Cardiovasc Disord. 2021;21(1):123.
22. Ataro BA, Mulatu G, Mengistu D. Compliance with guidelines of hypertension management, and associated factors among the health practitioners. INQUIRY: J Health Care Organ Provis Financing. 2023;60:00469580231216400.
23. FMoH. National training manual on screening and comprehensive management of hypertension. Ethiopia: Addis Ababa; 2023.
24. World Health Organization. The WHO STEPwise approach to NCD risk factor surveillance: Q-by-Q guide v.3.2. Geneva: WHO; 2017.
25. Choudhry NK, Kronish IM, Vongpatanasin W, Ferdinand KC, Pavlik VN, Egan BM, et al. Medication adherence and blood pressure control: a scientific statement from the American Heart Association. Hypertension. 2022;79(1):e1–14.
26. Xu W, Goldberg SI, Shubina M, Turchin A. Optimal systolic blood pressure target, time to intensification, and time to follow-up in treatment of hypertension: population based retrospective cohort study. BMJ. 2015;350.
27. Abegaz TM, Shehab A, Gebreyohannes EA, Bhagavathula AS, Elnour AA. Nonadherence to antihypertensive drugs: a systematic review and meta-analysis. Medicine. 2017;96(4):e5641.
28. Weldegebreal F. Time to blood pressure control among patients on treatment at Jimma University. BMC Cardiovasc Disord; 2020.
29. Armstrong C. JNC 8 guidelines for the management of hypertension in adults. Am Family Phys. 2014;90(7):503–4.
30. Weir CB, Jan A. BMI classification percentile and cut off points. 2019.

Figures

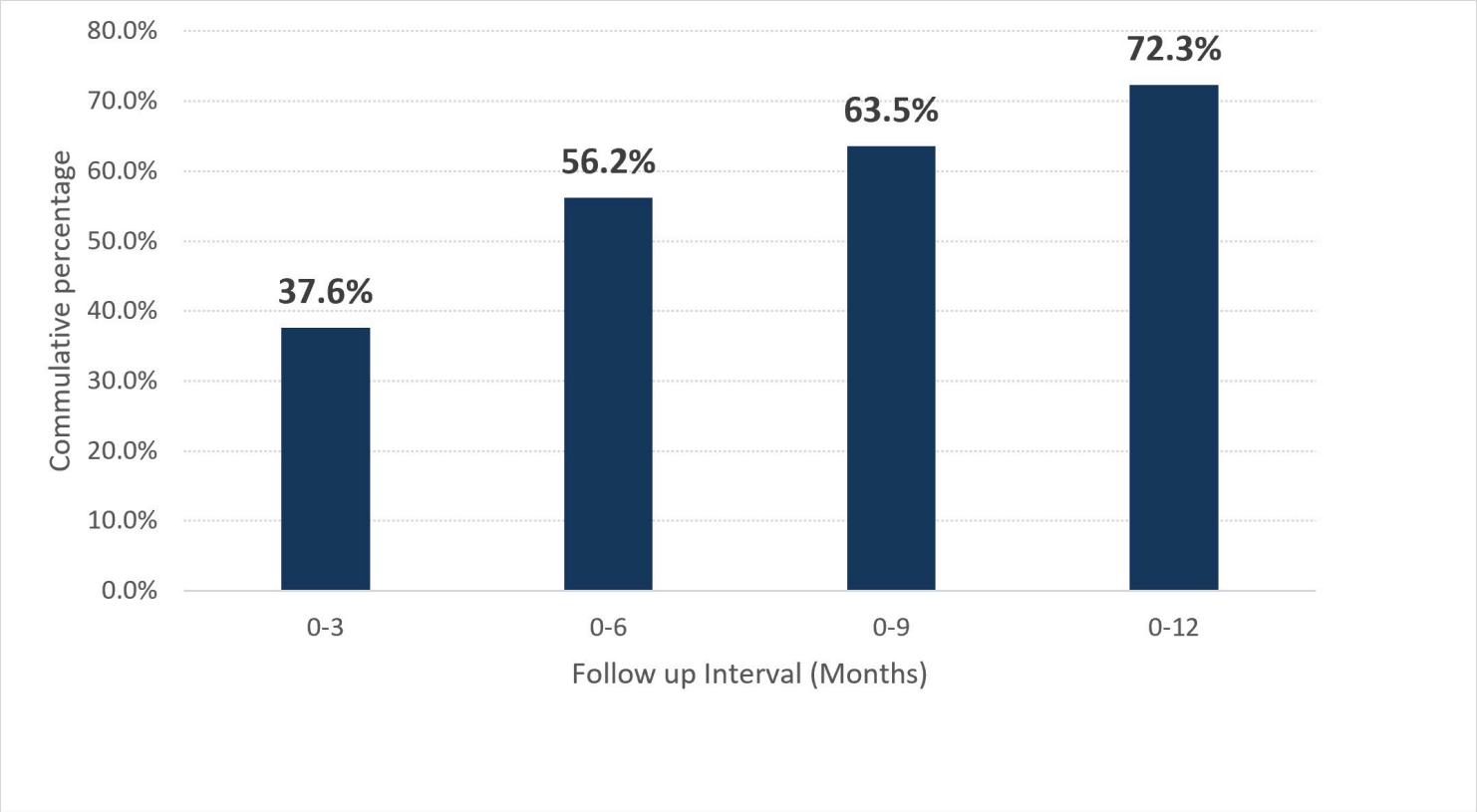


Figure 1

Cumulative Achievement over Time among HTN Patients at a Tertiary Hospital, Addis Ababa, Ethiopia.

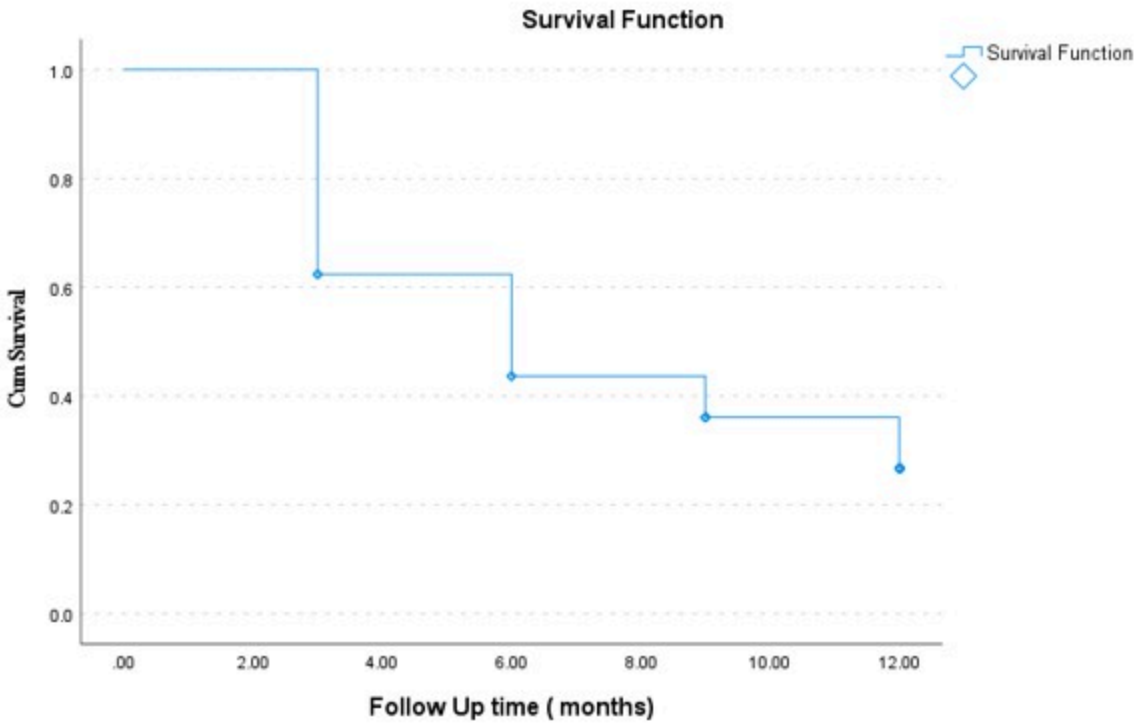


Figure 2

Kaplan-Meier Curve of Cumulative BP Control over 12-Month Follow-up among Hypertensive Patients at Tertiary Hospital, Addis Ababa, Ethiopia.