BMC Cardiovascular Disorders

RESEARCH

Open Access

Incidence of hypertension and factors associated with blood pressure control among older adults living with HIV in Western Kenya: a retrospective cohort study

Jepchirchir Kiplagat[1,2*], Richard Mugo[1], Beverly Musick[3], Ann Mwangi[1,4], Constantin T. Yiannoutsos[1,5] and Kara Wools-Kaloustian[1,6]

Abstract

Background People living with HIV are living longer due to expanded access to antiretroviral treatment (ART). As they age, their risk of hypertension is greater due to HIV-immune activation and long-term use of some antiretrovirals. Screening and treatment of hypertension and monitoring hypertension control are key strategies for averting morbidity and mortality from cardiovascular disease and improving the health outcomes of older adults living with HIV (OALWH). We sought to estimate the incidence of hypertension and determine the proportion of blood pressure control among OALWH in western Kenya.

Methods We analyzed deidentified clinical data for OALWH (≥ 50 years) attending a large HIV care and treatment program in western Kenya, between January 1, 2016, and August 24, 2021. Hypertension was defined by two consecutive blood pressure (BP) readings with systolic BP (SBP) ≥ 140 and diastolic BP (DBP) ≥ 90, a clinical diagnosis of hypertension, or the use of hypertension medication. Screening and monitoring were defined as having BP measurements in individuals without or with hypertension, respectively. Descriptive statistics and logistic regression assessed baseline characteristics and factors associated with hypertension. Linear mixed models estimated the rates of screening, monitoring, BP control, and sex differences.

Results Of 6216 eligible OALWH, 52.5% were female and 23.0% were hypertensive at baseline. Baseline factors associated with hypertension included, age, body mass index, sex, prior ART exposure and having health insurance. On follow up, 91.1% (95% CI, 90.8%-91.4%) of non-hypertensive individuals were screened. The incidence of hypertension was 84 cases per 1000-person years. Of individuals with hypertension, 91.2% (95% CI, 90.9%-91.5%) were monitored and 47.9% (95% CI, 46.6%, 49.1%) achieved BP control. No gender differences were identified in BP screening, monitoring, or control rates.

Conclusion The high incidence of hypertension with less than half of those with hypertension achieving controlled BP, reveals a significant gap between detection and effective management. This highlights the needs not only in

*Correspondence:
Jepchirchir Kiplagat
chiri2809@gmail.com

Full list of author information is available at the end of the article

the continuity of hypertension screening but also the need for strengthened hypertension management within HIV programs.

Keywords Older adults, HIV, Hypertension, Integration, Unmet needs

Background

Worldwide scale-up of antiretroviral treatment (ART) has transformed the course of HIV infection leading to increased life expectancy in people living with HIV (PLHIV) [1]. In 2021, about 7.5 million older adults, aged ≥ 50 years, were living with HIV globally [2, 3], and more than half of this population resided in sub-Saharan Africa. As PLHIV live longer, they are at an increased risk of developing non-communicable diseases (NCDs) when compared to people without HIV [4, 5]. HIV-induced immune activation, as well as dyslipidemia associated with long-term use of some antiretrovirals, contribute to increased cardiovascular risks among PLHIV [6, 7] with hypertension being the most common cardiovascular risk factor for older adults living with HIV (OALWH). The prevalence of hypertension in PLHIV ranges from 18% to 67% [8–12] and some studies have reported that over half of OALWH on ART have hypertension [13, 14]. Routine screening for hypertension in OALWH is therefore necessary for early identification of those with hypertension and at risk of cardiovascular events.

Hypertension is the leading modifiable risk factor for cardiovascular events such as myocardial infarction, and heart failure [15–17] accounting for more than 15 million annual deaths globally [18]. Among PLWH, the risk of hypertension is disproportionately high, with regional disparities evident. PLHIV in sub-Saharan Africa face up to 1.5 times higher risk of developing hypertension compared to PLHIV in Australia, America or Europe [19]. Because hypertension is a core driver of cardiovascular diseases, its prevention is particularly critical among OALWH who face an elevated burden due to aging and long-term use of antiretroviral therapy.

To mitigate these risks, routine screening for early diagnosis, timely treatment initiation, and continuous monitoring are essential. Prompt detection and effective management of hypertensive complications are crucial, particularly for individuals with long-term antiretroviral therapy (ART) experience [20]. Such proactive approaches can reduce the risk of complications, improve quality of life, and promote healthy aging. In recognition of this need, the WHO recommends integrating hypertension screening and treatment into HIV care for adults on ART [21]. However, despite these recommendations, evidence remains limited on how hypertension screening and monitoring are being implemented within HIV care programs in sub-Saharan Africa, particularly for OALWH. Few studies have quantified the extent of unmet needs in hypertension care among this population, and data from large, real-world cohorts remain scarce. This knowledge gap constrains the ability of programs to design responsive, integrated models of care.

To address this, we analyzed the electronic medical records of a cohort of PLHIV from the Academic Model Providing Access to Healthcare (AMPATH) to evaluate hypertension screening and blood pressure monitoring practices, estimate hypertension incidence, and determine proportions of blood pressure control among OALWH.

Methods

Study design and setting

This was a retrospective analysis of clinical de-identified data (data that has been stripped of personal details like names, addresses, or ID numbers so that it cannot be traced back to an individual) from the electronic medical records of individuals living with HIV who received HIV care services within AMPATH at Moi Teaching and Referral Hospital (MTRH) clinics in Eldoret, Kenya.

AMPATH is a partnership between Moi University, MTRH and a consortium of North American Universities led by Indiana University School of Medicine [22]. Established in 2001, AMPATH has grown to be one of Africa's most comprehensive HIV treatment and prevention programs. AMPATH has enrolled over 200,000 people living with HIV with more than 120,000 individuals currently on ART in over 500 Kenya Ministry of Health (MOH) facilities spread throughout the western part of Kenya. The AMPATH facility in Eldoret is located at MTRH and has five comprehensive care clinics, including three adult clinics. Each adult clinic serves more than 250 patients daily. AMPATH at MTRH has provided HIV care services for over 45,000 people living with HIV since inception – about 33% of whom are aged ≥ 50 years. Clinical care protocols follow the Kenya National AIDS and STI control Programme [23] and WHO guidelines [24] that have recommended treatment for all individuals testing positive for HIV since July 2016. These protocols include routine viral load monitoring annually with more frequent monitoring for patients who are not suppressed. Per protocol, blood pressure (BP) is measured in all patients reporting for a clinic visit, and those diagnosed with hypertension are initiated on antihypertensive medication and a lifestyle modification plan.

In partnership with the Kenya Ministry of Health, AMPATH launched a Chronic Disease Management (CDM) program in 2011 to deliver care for non-communicable diseases such as hypertension and diabetes

in western Kenya. Since then, the program has enrolled over 60,000 patients. PLHIV do not pay fees to receive HIV and TB medications, as well as viral load monitoring tests and BP measurements. However, patients incur out-of-pocket expenses for medications for hypertension and other chronic conditions. While some patients who were registered under national hospital insurance fund (NHIF) could access the medications, consistent supply in most facilities is often a challenge. To ensure reliable access to chronic disease medicines, AMPATH established revolving fund pharmacy (RFP) [25, 26], as a backup supply chain to support the CDM program by ensuring consistent access to medications for patients.

Study population

All electronic medical records for patients ≥ 50 years of age that had at least one HIV clinical encounter between January 1, 2016 and August 24, 2021 were included in this analysis. Baseline was defined as the first visit on or after age 50 (Fig. 1). Participants were categorized at baseline based on the presence or absence of hypertension. Those with hypertension subsequently assessed for monitoring of hypertension (presence of blood pressure measurement) and BP control. Those without hypertension at baseline were assessed for screening for hypertension (presence of blood pressure measurement) during subsequent clinic visits. Those who were diagnosed with hypertension during follow-up transitioned into the hypertensive cohort and were then assessed for monitoring of hypertension and for BP control.

Data sources

Data was abstracted from the AMPATH medical records system (AMRS) [27, 28]. AMPATH routinely collects clinical data from people living with HIV at each encounter or clinical visit. The facility is equipped with an electronic tablet-based decision support interface called "point-of-care" that allows health care providers to enter health information which is uploaded into a secure electronic database called AMRS. Prior to roll out of the POC system in 2020, healthcare providers completed standardized clinical encounter forms (paper forms) and collected information on patients' demographic, clinical, and treatment information at each encounter. The data assistants entered the data from the clinical encounter forms into the AMRS. To verify the entered data (quality control), a random sample of 10% of the forms entered was reviewed. From AMRS, we obtained de-identified electronic data for the cohort that met the inclusion criteria and used the data in this analysis. Data accessed and abstraction occurred from December 7–21, 2021.

Variables and endpoint definitions

An encounter was defined as a clinical visit where a BP measurement was supposed to be taken as part of routine care and captured in the system. Differentiated service delivery (DSD) models such a fast-track ART refills are implemented at AMPATH. In these models, patients have minimal interactions with clinician and are therefore not recorded as having a clinical encounter. Hypertension was defined by two consecutive BP measurements with a systolic BP (SBP) ≥ 140 mmHg and a diastolic BP (DBP) ≥ 90 mmHg recorded at two separate clinic visits; or a clinical diagnosis of hypertension; or documentation of having received hypertension medication. Baseline was defined as the first visit at or after age 50. Screening was defined as a recorded BP measurement in individuals without hypertension during each visit. Monitoring was defined as a recorded BP measurements in individuals with hypertension at each visit. Lastly, among participants with hypertension, BP control was defined as the proportion of documented BP readings of < 140/90mmHg over the follow-up period, based on serial clinic measurements.

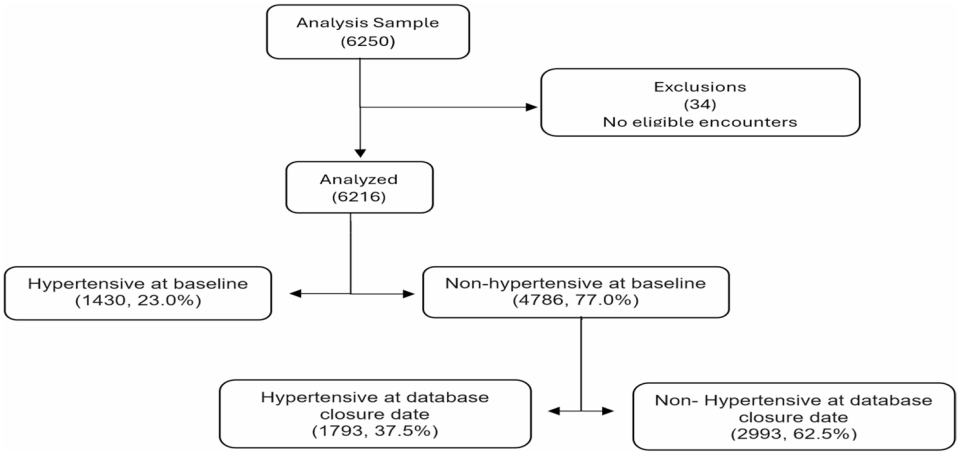

Fig. 1 CONSORT flow diagram for eligibility into analysis cohort

The main analysis was conducted in three stages. In the first stage of analysis, the outcome was defined as having hypertension at baseline. Participant's baseline factors explored for their association, included demographic variables such as sex and age. Additional variables of interest included WHO clinical stage, enrollment in the National Hospital Insurance Fund (NHIF), and body mass index (BMI) categories: underweight (BMI < 18.5), normal weight (18.5 ≤ BMI ≤ 24.9), pre-obese (24.9 < BMI ≤ 29.9), and obese (BMI > 29.9). Other variables included the duration (in years) on antiretroviral therapy (ART), the duration (in years) in the AMPATH HIV care program, and the class of ART regimen, all measured at baseline.

In the second analysis, we assessed the baseline factors associated with the incidence of hypertension after baseline. The outcome was analyzed using an event-time framework, where the event was defined as the development of hypertension among patients who were free of the condition at baseline. The time-to-event variable was calculated as the duration between enrollment in the AMPATH care program and the date of hypertension diagnosis, as previously defined. Although ART exposure(regimens) may change over time, modeling it as a time-varying variable would require careful handling of time-dependent confounding, since treatment initiation or modification during follow-up could be influenced by clinical factors (e.g., comorbidities or evolving cardiovascular risk) that are also associated with hypertension. In the absence of methods specifically designed to address time-dependent confounding (e.g., marginal structural models), inclusion of time-updated ART exposure could introduce bias. Therefore, we focused on baseline ART status to evaluate its prognostic association with incident hypertension.

Lastly, to estimate the proportions of individuals who were screened, monitored, and achieved BP control, we defined the respective outcomes as binary indicators. As some individuals had multiple visits over the 5-year period, these binary outcomes were evaluated across all visits for each participant, allowing for a comprehensive assessment of screening (for those without hypertension at baseline), and monitoring, and BP control (for those who had or developed hypertension at baseline or on follow up) across time.

Statistical methods

Analyses were performed using R version 4.2.3 (R Core Team, 2023) and RStudio integrated development environment (version 4.4.3; Posit team, 2025). Descriptive statistics (counts, percentages, medians, and interquartile ranges (IQRs)) were used to summarize baseline patient characteristics. We compared continuous data using t-tests and categorical data using Fisher's exact test. For categories with fewer than 5 observations, we applied Fisher's exact test with Monte Carlo simulations to generate the p value for the testing independence between individuals with and without hypertension at baseline. In the first analysis a multivariate logistic regression model was used to investigate significant baseline factors that were associated with hypertension. All baseline variables adjusted for in this stage have been previously mentioned.

In the second analysis, we defined person-years as time in years from baseline until the development of hypertension. If the endpoint of hypertension was not observed during the 5-year period, follow-up time was right censored at each patient's last encounter date. Incidence of hypertension was calculated as the total number of new hypertension cases divided by the total number of person-years. Event time analysis was conducted using cox proportional hazards models where all baseline factors were adjusted for. The hazard ratios (HR) and corresponding 95% confidence limits (95% CL) were reported.

Lastly, to estimate the proportions and 95% confidence intervals for screening, monitoring, and BP control, we used generalized logistic mixed models. These models accounted for the repeated measures within individuals by incorporating a random intercept for each individual. This approach allowed us to handle the correlation between multiple visits for the same individual over time. To account for potential confounders, we adjusted for sex, age and time in care in the analysis, as these factors are known to be associated with hypertension and may influence the likelihood of screening, monitoring, and BP control.

We handled missing data by employing the following techniques and definitions: The BMI closest to the baseline date within 180 days prior and 30 days post was used; NHIF values closest to the baseline date within one year prior to the baseline date were used; ART class at baseline was defined using the complete regimen closest to the baseline visit date. WHO clinical stage for HIV at baseline was defined as the maximum value, where available, at or prior to the baseline date, otherwise the first value after baseline, but within four months was used.

Results

Participant characteristics at baseline

Records of 6250 patients were extracted and 34 patients without a single routine clinic visit were excluded, resulting in a 6216 patient records that were analyzed (Fig. 1).

More than half (52.5%) of the participants were female, 5.8% were 61 years or older. Nearly a quarter (23%) of the participants were identified as hypertensive before or at their first visit on or after age 50 years (Table 1). Median age at entry into the cohort was 50.2 (IQR: 50.1,52.3) years, with those 50 years of age being overrepresented

Table 1 Participants' baseline characteristics

	Total (*N* = 6216)	No Hypertension (*N* = 4786)	With Hypertension (*N* = 1430)	*p* value
Sex				0.673[1]
Female	3276 (52.7%)	2515 (52.5%)	761 (53.2%)	
Male	2940 (47.3%)	2271 (47.5%)	669 (46.8%)	
Age				< 0.001[2]
Median	50.2	50.4	50.1	
Q1, Q3	50.1, 52.3	50.1, 54.0	50.1, 50.2	
Min-Max	50.0–88.3	50.0–88.3	50.0–70.8	
Age Group (Years)				< 0.001[3]
50	4250 (68.4%)	2883 (60.2%)	1367 (95.6%)	
51–60	1605 (25.8%)	1547 (32.3%)	58 (4.1%)	
61–70	299 (4.8%)	294 (6.1%)	5 (0.4%)	
71 +	62 (1.0%)	62 (1.3%)	0 (0.0%)	
Years in Care program**				< 0.001[2]
Median	6.4	5.2	8.5	
Q1, Q3	2.5, 10.0	1.4, 9.2	5.4, 11.4	
Min-Max	0.0003–18.7	0.0003–18.7	0.008–18.1	
ART Exposure				< 0.001[1]
No Prior ART Exposure	2259 (36.3%)	2174 (45.4%)	85 (5.9%)	
Prior ART Exposure	3957 (63.7%)	2612 (54.6%)	1345 (94.1%)	
Years on ART***				< 0.001[2]
Median	6.4	5.6	7.8	
Q1, Q3	3.3, 9.7	2.8, 9.0	4.6, 10.8	
Min – Max	0.003–20.0	0.003–20.0	0.06–18.0	
ART class				< 0.001[3]
NNRTI	2886 (73.0%)	1962(75.2%)	924 (68.6%)	
Integrase inhibitor	669(16.90%)	378 (14.5%)	291 (21.6%)	
Protease Inhibitor	400 (10.1%)	270 (10.3%)	130 (9.7%)	
Missing	2	2	0	
Body Mass Index				< 0.001[3]
<18.5	884 (15.3%)	815 (18.5%)	69 (5.1%)	
18.5–24.9	3141 (54.5%)	2497 (56.6%)	644 (47.4%)	
25-29.9	1240 (21.5%)	797 (18.1%)	443 (32.6%)	
≥29.9	501 (8.7%)	299 (6.8%)	202 (14.9%)	
Missing	450	378	72	
WHO stage				0.013[1]
Stage (1,2)	2299 (41.5%)	1752 (42.4%)	547 (38.8%)	
Stage (3,4)	3242 (58.5%)	2379 (57.6%)	863 (61.2%)	
Missing	675	655	20	
Have National Health Insurance Fund				0.001[1]
No	1989(54.7%)	1470 (59.3%)	519 (44.9%)	
Yes	1647 (45.3%)	1010 (40.7%)	637 (55.1%)	
Missing	2580	2306	274	

[1]Fisher's Exact Test for Count Data. [2]Fisher's Exact Test for Count Data with simulated p-value (Based on 2000 replicates). [3]Kruskal-Wallis rank sum test. ** Calculated among those that joined AMPATH care program before baseline date (*n* = 4728). *** Calculated among those that had prior ART exposure

in this cohort (68.4%). Most participants (63.7%) had prior experience using HIV treatment. The median duration on ART was 6.4 years (IQR: 3.3,9.7) with the majority (73.0%) being on non-nucleoside reverse transcriptase inhibitors (NNRTI) -based regimen. At baseline, 58.5% of OALWH were categorized as being in advanced stages of HIV (WHO stage 3 and 4).

Factors associated with hypertension at baseline

In a bivariate analysis (Table 1), age group, prior ART exposure and ART class were significantly associated with hypertension at baseline. The median duration on ART was significantly less at 5.6 years (IQR: 2.8,9.0) for those without hypertension than for those with hypertension at 7.8 years (IQR: 4.6,10.8). A higher proportion of those without hypertension were on regimens that contained an NNRTI at baseline (75.2%), compared to those

with hypertension (68.6%). A significantly higher proportion of those with hypertension had of BMI ≥ 29.9 (14.9% vs. 6.8%) or BMI 25–29.9 (32.6% vs. 18.1%) compared to those without hypertension. More than half of those with hypertension were enrolled in NHIF compared to those without hypertension (55.1% vs. 40.7%). There were no sex differences between those with and without hypertension at baseline (p value 0.673).

In the multivariate logistic regression (Table 2), males exhibited a higher risk of having hypertension at baseline, with an adjusted odds ratio (aOR) of 1.71 (95% CI: 1.44–2.03) when compared to females. Participants with a BMI of ≥ 30 and those with BMI of 25-29.9 had a higher risk of having hypertension at baseline than participants with BMI of 18-24.9, with aOR of 3.03 (95% CI: 2.31–3.98) and 2.02 (95% CI: 1.67–2.45), respectively. Underweight participants (BMI < 18.5) had a lower risk of hypertension, with an aOR of 0.52 (95% CI: 0.38–0.79).

Table 2 Multiple logistic analysis of factors associated with hypertension at baseline

Baseline factors	Levels	Univariate analysis		Multivariable analysis	
		OR (95% CI)	*P* value	aOR* (95% CI)	*P* value
Sex	Female	-		-	
	Male	0.97 (0.86–1.10)	0.657	1.71 (1.44–2.03)	0.001
Difference in Years from Entry Age 50	[0.0,33.3]**	0.55 (0.51–0.60)	0.001	0.84 (0.75–0.92)	0.001
BMI group	18.5-<25	-		-	
	< 18.5	0.33 (0.25–0.42)	0.001	0.52 (0.38–0.79)	0.001
	25-<30	2.16 (1.86–2.49)	0.001	2.02 (1.67–2.45)	0.001
	>=30	2.62 (2.15–3.19)	0.001	3.03 (2.31–3.98)	0.001
WHO	Stage (1,2)	-		-	
	Stage (3,4)	1.16 (1.03–1.32)	0.001	0.93(0.78–1.10)	0.378
Have National health insurance Fund	No	-		-	
	Yes	1.79 (1.55–2.06)	0.001	1.23 (1.05–1.45)	0.012
ART Class	Not Started	-		-	
	NNRTI	12.06 (9.63–15.28)	0.001	2.06 (1.38–3.13)	0.001
	Integrase inhibitor	19.71 (15.18–25.82)	0.001	2.18 (1.37–3.51)	0.001
	Protease Inhibitor	12.33 (9.14–16.71)	0.001	1.52 (0.93–2.52)	0.100
Duration in AMPATH Care program in Years.	[0.0,18.7]**	1.22 (1.20–1.23)	0.001	1.11 (1.06–1.15)	0.001
Duration on ART in Years	[0.0,20.0]**	1.20 (1.19–1.22)	0.001	1.01 (0.97–1.05)	0.590

aOR Adjusted odds ratio

*All adjusted factors reported as in the table

- Reference category

**Minimum, Maximum

There was no difference in the risk of hypertension in those in WHO HIV stage 1 or 2 when compared with those in WHO HIV stage 3 or 4, with aOR of 0.93 (95% CI: 0.78–1.10). Having NHIF was associated with a higher risk of hypertension with aOR 1.23 (95% CI:1.05–1.45) compared to those without NHIF. OALWH who were on ART (NNRTI and integrase inhibitors) had a higher risk of hypertension compared to those who had not started ART, NNRTI 2.06 (95% CI: 1.38–3.13), integrase inhibitors 2.18 (95% CI: 1.37–3.51) and protease inhibitors 1.52 (95% CI: 0.93–2.52). Longer duration in AMPATH care program was associated with higher risks of hypertension.

We then compared ART-experienced individuals to ART-naïve participants and found that ART exposure was significantly associated with higher odds of hypertension after adjustment (aOR ≈ 2.1) (Supplemental Table 1). In a secondary analysis restricted to ART-experienced participants, using NNRTI-based regimens as the reference, differences between ART classes were largely attenuated, with minimal heterogeneity observed across regimens (Supplement Table 2) suggesting that the observed association is driven primarily by ART exposure itself rather than specific regimen differences.

Blood pressure screening and incidence of hypertension

Among the 4786 participants without HTN at baseline, BP screening was completed in 91.1% (95% CI, 90.8% – 91.4%) of clinical encounters that OALWH had within the program. After controlling for age, there was no statistically significant difference in screening rates between males and females.

During the follow-up period, 1,793 participants (37.5%) developed hypertension. This resulted in an incidence rate of 84.0 cases per 1,000 person-years (95% CI, 80.1–87.9). All baseline factors considered (Table 3) were significantly associated with incident hypertension based on bivariate analysis.

The multivariate cox regression model (Table 4; Fig. 2) showed that, when compared to healthy weight (BMI of 18.5–24.9), having a BMI of 25-29.9 or > 29.9 was associated with a significantly increased hazard of hypertension, with aHRs of 1.58 (95%CI: 1.39–1.79) and 2.18 (95% CI: 1.83–2.59), respectively. However, a BMI of < 18.5 was associated with a lower hazard of hypertension, aHRs 0.66 (95% CI: 0.58–0.77). Being a male was

Table 3 Factors associated with incidence of hypertension

	Total (*N* = 4786)	No HTN (*N* = 2993)	With HTN (*N* = 1793)	p value
Male				0.0031
Male	2271 (47.5%)	1370 (45.8%)	901 (50.3%)	
Female	2515 (52.5%)	1623 (54.2%)	892 (49.7%)	
Age				< 0.001[2]
Median	50.36	50.234	51.242	
Q1,Q3	50.097, 54.039	50.089, 52.402	50.116, 55.838	
MinMax	50.001–88.279	50.001–85.196	50.001–88.279	
BMI Group				< 0.001[3]
18.5–24.9	2497 (56.6%)	1565 (57.4%)	932 (55.4%)	
<18.5	815 (18.5%)	576 (21.1%)	239 (14.2%)	
25-29.9	797 (18.1%)	445 (16.3%)	352 (20.9%)	
>29.9	299 (6.8%)	141 (5.2%)	158 (9.4%)	
Missing	378	266	112	
ART Class				< 0.001[3]
Not Started ART	2176 (45.5%)	1089 (36.4%)	1087 (60.6%)	
NNRTI	1962 (41.0%)	1347 (45.0%)	615 (34.3%)	
Integrase inhibitors	378 (7.9%)	344 (11.5%)	34 (1.9%)	
Protease Inhibitor Based	270 (5.6%)	213 (7.1%)	57 (3.2%)	
Time in Program years**				< 0.001[2]
Median	1.755	4.066	0.038	
Q1,Q3	0.000, 7.246	0.000, 8.994	0.000, 3.362	
MinMax	0.000–18.702	0.000–18.702	0.000–15.398	
Time on ART years***				< 0.001[2]
Median	0.825	2.856	0	
Q1,Q3	0.000, 6.203	0.000, 7.693	0.000, 2.820	
MinMax	0.000–20.008	0.000–20.008	0.000–16.701	

[2]Fisher's Exact Test for Count Data with simulated p-value (Based on 2000 replicates). [3]Kruskal-Wallis rank sum test. ** Calculated among those that joined AMPATH care program before baseline date (*n* = 4728). *** Calculated among those that had prior ART exposure

associated with a lower hazard of developing hypertension, aHR 0.85 (95% CI: 0.77–0.94) when compared to female. We also note that 60.6% of incident hypertension cases occurred among individuals who were ART-naïve at baseline; however, this reflects the distribution of ART status at cohort entry, where the majority of participants had not yet initiated ART. Crude proportions of cases do not directly reflect relative risk, as the Cox proportional hazards model accounts for the size of the population at risk in each exposure group. In adjusted analyses individuals on ART (NNRTI, integrase inhibitor or protease inhibiter-based) did not have an increased hazard of hypertension compared to patients who had not initiated ART at baseline. This observation was further explored in a supplementary analysis restricted to participants who were ART-naïve at baseline to examine predictors of incident hypertension within this subgroup (Supplement Table 1 and Supplement Table 2). The findings were

Table 4 Adjusted hazards rates of hypertension from cox proportional regression model

Baseline factors	Levels	aHR*
Gender	Female	-
	Male	0.85 (0.77–0.94)
Age in years	[50.0–88.3]**	1.03 (1.02–1.04)
BMI group	18.5–24.9	-
	< 18.5	0.66 (0.58–0.77)
	25-29.9	1.58 (1.39–1.79)
	> 29.9	2.18 (1.83–2.59)
ART class	Not Started ART	-
	NNRTI	0.88 (0.75–1.02)
	Integrase inhibitors	0.67 (0.43–1.03)
	Protease Inhibitor	0.82 (0.59–1.15)
Time in AMPATH Program(yrs)	[0.0 -18.7]**	0.89 (0.86–0.92)
Time on ART (yrs)	[0.0–20]**	1.05 (1.01–1.09)

*aHR** Adjusted hazards rate

*All adjusted factors all reported as in the table

-Reference category

**Minimum, Maximum

broadly consistent with the main analysis. Longer duration on ART treatment was associated with an increased hazard, aHR 1.05 (95% CI: 1.01–1.09).

Blood pressure monitoring and control

Among the 3,223 participants with hypertension in the cohort—comprising those with hypertension at baseline and those who developed it during follow-up—BP monitoring was performed during 91.2% (95% CI: 90.9–91.5%) of all routine clinical visits. The probability of being monitored for BP control was not influenced by sex. However, less than half of the clinical visits for individuals with hypertension, 47.9% (95% CI: 46.6–49.1%), indicated BP control. Sex was also not associated with BP control, with similar rates observed in males (45.5%; 95% CI: 43.7–47.3%) and females (47.9%; 95% CI: 46.2–49.8%). BP control rates were higher among individuals aged 50–60 years compared to those aged ≥ 61 years. Sensitivity analyses incorporating follow-up time and the age–time interaction showed that the effect of time in care on BP control differed by age group (interaction $p < 0.01$). Despite this, the overall pattern of age-group differences remained, indicating that older patients consistently had lower BP control (Fig. 3).

Discussion

In this cohort of OALWH, more than one third of participants (37.5%) developed hypertension during follow up, corresponding to an incident rate of 84.0 cases per 1,000 person-years. This incidence reflects the substantial burden of hypertension comorbidity in aging people with HIV. Although few longitudinal studies in sub–Saharan Africa report incidence of hypertension among OALWH, existing evidence shows a high burden (more than 50%)

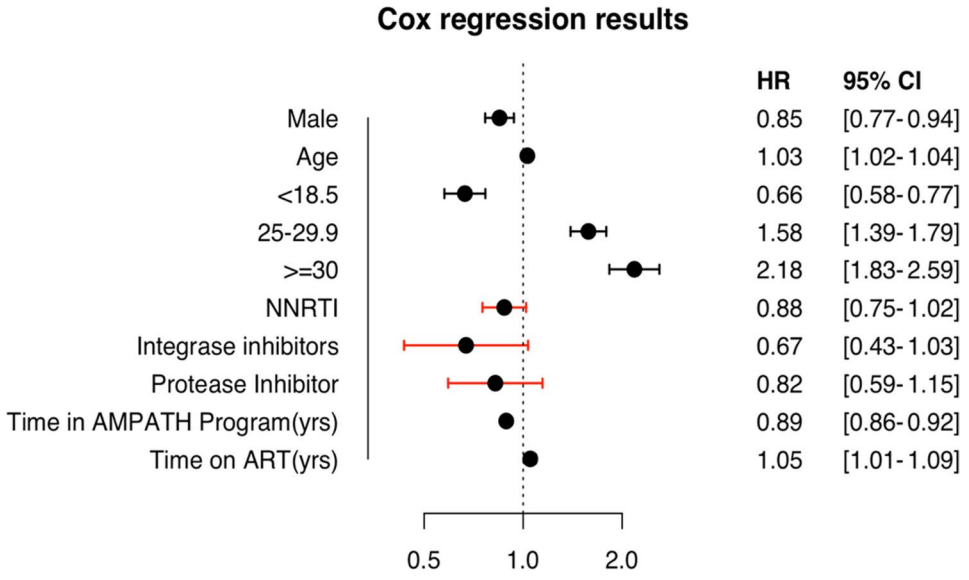

Fig. 2 Forest plot of adjusted baseline risk factors for developing hypertension

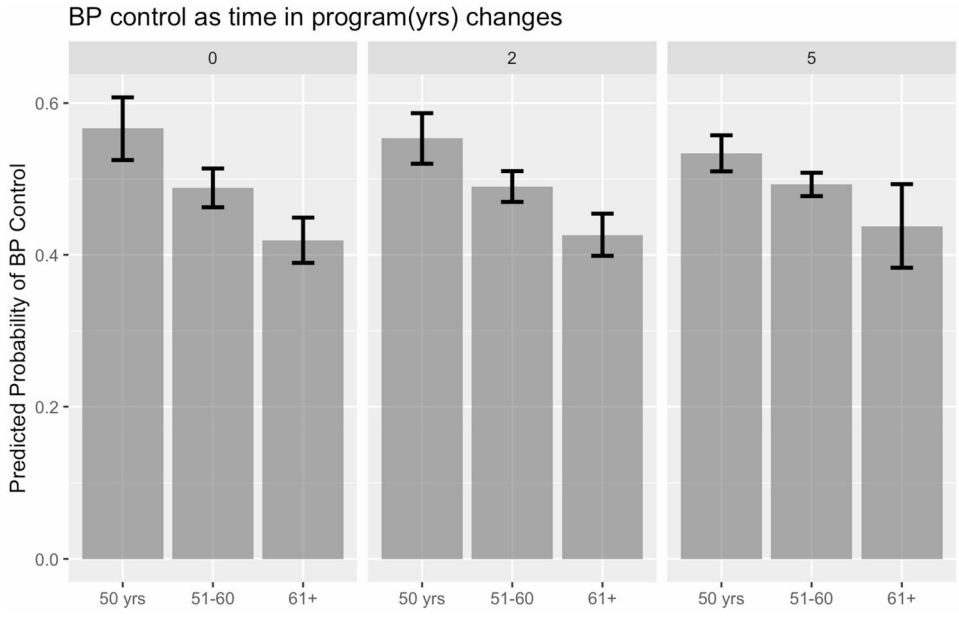

Fig. 3 Blood pressure control among age groups over time in care

of hypertension in this age group [29]. Our observed rate suggests that approximately 8 out of 100 OALWH develop hypertension annually, highlighting the dynamic and ongoing risks of hypertension in this vulnerable population. These findings have important implications for HIV programs transitioning towards integrated chronic disease care. It emphasizes the need for proactive risk stratification as a strategy for cardiovascular risk reduction.

The increased risk of prevalent hypertension observed among males as well as individuals who were pre-obese and obese at baseline aligns with existing literature [30, 31]. These findings align with risk factors for hypertension, particularly the higher susceptibility among younger males compared to females, and the strong association between excess weight and hypertension risk. Notably, some of the men in our cohort who had hypertension at baseline were likely diagnosed before their 50th birthday, suggesting a higher burden among younger males. Although data on hormonal profiles or other biological markers are not collected during clinic visits, our findings are consistent with existing literature indicating that sex-related biological mechanisms, including potential protective hormonal influences in pre-menopausal women,

may contribute to lower hypertension risk among younger women [32]. In addition, gender-related behavioral and lifestyle factors such as higher prevalence of smoking and alcohol use, delayed health seeking behaviors among younger men could plausibly increase their cardiovascular risks [33]. Given the absence of direct biological and behavioral measurements in our study, these explanations remain speculative and warrant further investigation in future studies incorporating such data.

During follow up period, we observed a higher incidence of hypertension among older women compared to men. This finding is consistent with prior literature documenting that women at their menopausal stage have a higher risk of hypertension attributed to hormonal changes and high BMI at older age [34]. Although we did not measure hormonal markers in our study, the observed patterns may reflect age-related biological changes associated with declining estrogen levels, which have been linked to increased vascular stiffness and elevated BP [35, 36]. These results highlight the need for targeted interventions, including regular screening and tailored management strategies for younger men, older women and individuals with elevated body mass index. Despite documented evidence of increased hypertension risk with protease inhibitor (PI)-based ART regimens [8], our study only found a borderline association. This lack of statistical significance may reflect attenuation of the effect due to covariates adjusted for in the model, as well as the relatively small number of individuals receiving PI-based regimens in our cohort.

Our study found that less than half of our participants achieved BP control, consistent with other studies in sub-Saharan Africa which found BP control rates ranging between 2% and 46% [37–40]. There are documented challenges to patients achieving BP control that include poor medication adherence - due to lack of finances to purchase prescribed medication or medication side effects, inadequate lifestyle modification, and other underlying medical conditions [10, 38, 39, 41, 42]. Although AMPATH has established access to subsidized anti-hypertensive medications through the revolving fund pharmacy (RFP), the observed suboptimal uncontrolled BPs may be a reflection of financial burden in purchasing antihypertensive medications potentially affecting adherence. The RFP ensures consistent access to hypertension medications and maintains stocks by charging a nominal fee and use the revenue to restock the supply [25, 26]. Efforts to integrate HIV and hypertension care as recommended by WHO [21] therefore, must prioritize continuous access to affordable anti-hypertensive medication and clinical management of underlying conditions in OALWH to enhance BP control. We observed that participants with hypertension were more likely to be enrolled in NHIF compared to those without. This may reflect on the role of insurance coverage in facilitating access to hypertension medication. Advocating for enrolment of OALWH and hypertension in health insurance schemes may facilitate access to free/more affordable medication for hypertension resulting in improved adherence and subsequently better HTN control [43].

A key strength to this study is its ability to estimate hypertension incidence in a large population of OALWH within an HIV care and treatment program, AMPATH in western Kenya. Most existing studies focus on prevalence rather than longitudinal incidence rate. However, one of the limitations was the missing data, which has the potential to create biases in our analyses, despite our efforts in mitigating these. For example, the diagnosis of hypertension was limited to having two consecutive elevated blood pressure recording where there was no indication of hypertension diagnosis or documentation of an anti-hypertensive agent. This could have led to an underestimation of hypertension prevalence in our population in two ways: first, those individuals who may have continued controlled BPs would have been excluded and second, those who had elevated BP in visit 1, but normal in visit 2, and elevated again in visit 3 were also excluded. For WHO staging at baseline, we used the maximum WHO stage value at or prior to the baseline date, otherwise the first value after baseline within four months, but we still had some missing data on this variable. Data on wealth and socioeconomic indices are not routinely collected during clinical visits. This information would have provided context on the financial capacities of study population, towards them being able to afford antihypertensive medications. However, enrolment in NHIF served as a proxy indicator of financial protection for healthcare costs. In addition, data on anti-hypertensive medication were frequently missing from the AMRS database. We could not consistently determine if someone with a diagnosis of hypertension had been placed on antihypertensive medication nor can we assess the appropriateness of the medication and dosage. Although AMRS is designed to capture care for hypertension and other non-communicable diseases, most clinicians inconsistently use this module resulting in incomplete capture of data on medications and other treatment for chronic diseases. Causal association between ART exposure and hypertension needs to be explored further, as the data analysed in this paper may reflect confounding by indication or duration in care. Our findings should therefore be interpreted with caution and may not be generalizable to the wider programs implementing HIV care delivery in Kenya.

Conclusion

The high rate of BP screening and monitoring among OALWH in the AMPATH Program documented by our study, reflects a commendable commitment to

comprehensive healthcare. However, the finding that less than half of those diagnosed with hypertension achieved BP control underscores a critical gap in hypertension management. This warrants further inquiry into the underlying reasons for the disconnect between screening and control including provider-related factors such as the frequency of monitoring and completeness of data capture. Identifying these reasons are essential in informing appropriate strategies and interventions in order to optimize hypertension outcomes and reduce cardiovascular risks in this vulnerable population.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12872-026-05804-x.

Supplementary Material 1.

Acknowledgements
We gratefully acknowledge the support from East Africa IeDEA for their assistance in facilitating data extraction and analysis for this manuscript.

Authors' contributions
JK and KWK conceptualized the idea, RN and BM abstracted, cleaned and performed data analysis. AM, and CTY provided review of analysis codes. All authors provided critical inputs on all drafts and approved the final version of the manuscript.

Funding
This research reported in this publication was supported by the Fogarty International Center of the National Institutes of Health under grant #D43TW009345, awarded to the Northern Pacific Global Health (NPGH) Fellows Program. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health or NPGH program.

Data availability
Data for this study was obtained from East Africa IeDEA data, specific to the AMPATH Program. Data and software codes are available upon submitting the request to East African IeDEA [https://www.iedea.org/resources/multiregional-research-sops-templates/](https:/www.iedea.org/resources/multiregional-research-sops-templates).

Declarations

Ethics approval and consent to participate
The study received ethics approval from Moi Teaching and Referral Hospital/Moi University Institutional Research Ethics Committee (FAN:0003889) and was exempted from review from the Indiana University institutional review board (Protocol #11922) and University of Washington IRB (STUDY 00013910). In addition, a research permit was obtained from Kenya's National Council for Science Technology and Innovation (NACOSTI/P/21/11258) before initiating the study. Written consent from patients was waived as these were routinely collected data of public health significance and all data were de-identified prior to transmission to the investigators for analysis.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Author details
[1]Academic Model Providing Access to Healthcare, Eldoret, Kenya
[2]School of Public Health, Department of Epidemiology and Medical Statistics, Moi University, Eldoret, Kenya
[3]School of Medicine, Department of Biostatistics and Health Data Science, Indiana University, Indianapolis, USA
[4]School of Science and Aerospace Studies, Department of Mathematics, Physics and Computing Eldoret, Moi University, Eldoret, Kenya
[5]Graduate School of Public Health, City University of New York, New York, USA
[6]School of Medicine, Department of Medicine, Division of Infectious Diseases, Indiana University, Indianapolis, USA

Received: 30 September 2025 / Accepted: 26 March 2026
Published online: 30 March 2026

References

1. UNAIDS. The gap report. In. Geneva: UNAIDS; 2014.
2. UNAIDS. UNAIDS data 2019. In. Geneva. Switzerland: UNAIDS; 2019.
3. Definition of an older or. elderly person: proposed working definition of an older person in Africa for the MDS Project http://www.who.int/healthinfo/survey/ageingdefnolder/en/index.html.
4. Patel P, Rose CE, Collins PY, Nuche-Berenguer B, Sahasrabuddhe VV, Peprah E, Vorkoper S, Pastakia SD, Rausch D, Levitt NS. Noncommunicable diseases among HIV-infected persons in low-income and middle-income countries: a systematic review and meta-analysis. AIDS. 2018;32(Suppl 1):S5.
5. Kansiime S, Mwesigire D, Mugerwa H. Prevalence of non-communicable diseases among HIV positive patients on antiretroviral therapy at joint clinical research centre, Lubowa, Uganda. PLoS ONE. 2019;14(8):e0221022.
6. Masenga SK, Elijovich F, Koethe JR, Hamooya BM, Heimburger DC, Munsaka SM, Laffer CL, Kirabo A. Hypertension and metabolic syndrome in persons with HIV. Curr Hypertens Rep. 2020;22:1–8.
7. Pangmekeh PJ, Awolu MM, Gustave S, Gladys T, Cumber SN. Association between highly active antiretroviral therapy (HAART) and hypertension in persons living with HIV/AIDS at the Bamenda regional hospital, Cameroon. Pan Afr Med J. 2019: 33.
8. Lubega G, Mayanja B, Lutaakome J, Abaasa A, Thomson R, Lindan C. Prevalence and factors associated with hypertension among people living with HIV/AIDS on antiretroviral therapy in Uganda. Pan Afr Med J 2021: 38.
9. Parikh NI, Gerschenson M, Bennett K, Gangcuangco LMM, Lopez MS, Mehta NN, Playford MP, Nakamoto BK, Seto TB, Chow DC. Lipoprotein concentration, particle number, size and cholesterol efflux capacity are associated with mitochondrial oxidative stress and function in an HIV positive cohort. Atherosclerosis. 2015;239(1):50–4.
10. Okyere J, Ayebeng C, Owusu BA, Dickson KS. Prevalence and factors associated with hypertension among older people living with HIV in South Africa. BMC Public Health. 2022;22(1):1684.
11. Musekwa R, Hamooya BM, Koethe JR, Nzala S, Masenga SK. Prevalence and correlates of hypertension in HIV-positive adults from the Livingstone Central Hospital, Zambia. Pan Afr Med J. 2021;39:237.
12. Tsuro U, Oladimeji KE, Pulido-Estrada GA, Apalata TR. Risk Factors Attributable to Hypertension among HIV-Infected Patients on Antiretroviral Therapy in Selected Rural Districts of the Eastern Cape Province, South Africa. Int J Environ Res Public Health. 2022; 19(18).
13. Xu Y, Chen X, Wang K. Global prevalence of hypertension among people living with HIV: a systematic review and meta-analysis. J Am Soc Hypertens. 2017;11(8):530–40.
14. Dakum P, Kayode GA, Abimiku A, Avong YK, Okuma J, Onyemata E, Ali T, Adekanmbi V, Uthman O. Prevalence of hypertension among patients aged 50 and older living with human immunodeficiency virus. Med (Baltim). 2019;98(15):e15024.
15. Niiranen TJ, Kalesan B, Hamburg NM, Benjamin EJ, Mitchell GF, Vasan RS. Relative contributions of arterial stiffness and hypertension to cardiovascular disease: the Framingham Heart Study. J Am Heart Association. 2016;5(11):e004271.
16. Bloomfield GS, Hogan JW, Keter A, Sang E, Carter EJ, Velazquez EJ, Kimaiyo S. Hypertension and obesity as cardiovascular risk factors among HIV seropositive patients in Western Kenya. PLoS ONE. 2011;6(7):e22288.
17. Bloomfield GS, Hogan JW, Keter A, Holland TL, Sang E, Kimaiyo S, Velazquez EJ. Blood pressure level impacts risk of death among HIV seropositive adults in Kenya: a retrospective analysis of electronic health records. BMC Infect Dis. 2014;14(1):284.

18. World Health Organization. Noncommunicable diseases progress monitor 2022: 2022.
19. Feinstein MJ, Hsue PY, Benjamin LA, Bloomfield GS, Currier JS, Freiberg MS, Grinspoon SK, Levin J, Longenecker CT, Post WS. Characteristics, prevention, and management of cardiovascular disease in people living with HIV: a scientific statement from the American Heart Association. Circulation. 2019;140(2):e98–124.
20. Nozaki I, Shobugawa Y, Sasaki Y, Takagi D, Nagamine Y, Zin PE, Bo TZ, Nyunt TW, Oo MZ, Lwin KT, et al. Unmet needs for hypertension diagnosis among older adults in Myanmar: secondary analysis of a multistage sampling study. Health Res Policy Syst. 2022;20(1):114.
21. World Health Organization. Updated recommendations on service delivery for the treatment and care of people living with HIV. 2021.
22. Academic Model Providing Access to Healthcare. https://www.ampathkenya.org/.
23. National AIDS, STI Control Program. & : Guidelines on Use of Antiretroviral Drugs for Treating and Preventing HIV Infection in Kenya – 2018 Edition In., 2018 edn; 2018.
24. WHO. Consolidated guidelines on the use of antiretroviral drugs for treating and preventing HIV infection: recommendations for a public health approach. World Health Organization; 2016.
25. Manji I, Manyara SM, Jakait B, Ogallo W, Hagedorn IC, Lukas S, Kosgei EJ, Pastakia SD. The Revolving Fund Pharmacy Model: backing up the Ministry of Health supply chain in western Kenya. Int J Pharm Pract. 2016;24(5):358–66.
26. Tran DN, Manji I, Njuguna B, Kamano J, Laktabai J, Tonui E, Vedanthan R, Pastakia S. Solving the problem of access to cardiovascular medicines: revolving fund pharmacy models in rural western Kenya. BMJ Global Health. 2020;5(11):e003116.
27. Mamlin BW, Biondich PG. AMPATH Medical Record System (AMRS): collaborating toward an EMR for developing countries. *AMIA Annual Symposium proceedings / AMIA Symposium* 2005:490–494.
28. Siika AM, Rotich JK, Simiyu CJ, Kigotho EM, Smith FE, Sidle JE, Wools-Kaloustian K, Kimaiyo SN, Nyandiko WM, Hannan TJ, et al. An electronic medical record system for ambulatory care of HIV-infected patients in Kenya. Int J Med Informatics. 2005;74(5):345–55.
29. Global burden of. 288 causes of death and life expectancy decomposition in 204 countries and territories and 811 subnational locations, 1990–2021: a systematic analysis for the Global Burden of Disease Study 2021. Lancet. 2024;403(10440):2100–32.
30. Mbuthia GW, Magutah K, McGarvey ST. The prevalence and associated factors of hypertension among HIV patients. Int J Hypertens. 2021;2021:1–8.
31. Njelekela M, Muhihi A, Aveika A, Spiegelman D, Hawkins C, Armstrong C, Liu E, Okuma J, Chalamila G, Kaaya S. Prevalence of hypertension and its associated risk factors among 34,111 HAART naïve HIV-infected adults in Dar es Salaam, Tanzania. *International journal of hypertension* 2016: 2016.
32. Sabbatini AR, Kararigas G. Estrogen-related mechanisms in sex differences of hypertension and target organ damage. Biol Sex Differ. 2020;11(1):31.
33. Nagao T, Nogawa K, Sakata K, Morimoto H, Morita K, Watanabe Y, Suwazono Y. Effects of Alcohol Consumption and Smoking on the Onset of Hypertension in a Long-Term Longitudinal Study in a Male Workers' Cohort. *Int J Environ Res Public Health.* 2021; 18(22).
34. Kim KI. Hypertension in Older Women: The Biggest Challenge for Cardiovascular Health in an Aged Society. Korean Circ J. 2022;52(5):393–4.
35. Raj A, Chakole S, Agrawal S, Gupta A, Khekade H, Prasad R, Lohakare T, Wanjari M. The Impact of Menopause on Cardiovascular Aging: A Comprehensive Review of Androgen Influences. Cureus. 2023;15(8):e43569.
36. Samargandy S, Matthews KA, Brooks MM, Barinas-Mitchell E, Magnani JW, Thurston RC, El Khoudary SR. Trajectories of Blood Pressure in Midlife Women: Does Menopause Matter? Circ Res. 2022;130(3):312–22.
37. Dzudie A, Hoover D, Kim HY, Ajeh R, Adedimeji A, Shi Q, Pefura Yone W, Nsame Nforniwe D, Thompson Njie K, Pascal Kengne A, et al. Hypertension among people living with HIV/AIDS in Cameroon: A cross-sectional analysis from Central Africa International Epidemiology Databases to Evaluate AIDS. PLoS ONE. 2021;16(7):e0253742.
38. Muddu M, Tusubira AK, Sharma SK, Akiteng AR, Ssinabulya I, Schwartz JI. Integrated hypertension and HIV care cascades in an HIV treatment program in Eastern Uganda: a retrospective cohort study. J Acquir Immune Defic Syndr. 2019;81(5):552.
39. Jackson I, Okonta J, Ukwe C. HIV-and hypertension-related knowledge and medication adherence in HIV seropositive persons with hypertension. J Public Health. 2022;44(1):e79–87.
40. Kwarisiima D, Atukunda M, Owaraganise A, Chamie G, Clark T, Kabami J, Jain V, Byonanebye D, Mwangwa F, Balzer LB. Hypertension control in integrated HIV and chronic disease clinics in Uganda in the SEARCH study. BMC Public Health. 2019;19(1):511.
41. Holt E, Joyce C, Dornelles A, Morisky D, Webber LS, Muntner P, Krousel-Wood M. Sex differences in barriers to antihypertensive medication adherence: findings from the cohort study of medication adherence among older adults. J Am Geriatr Soc. 2013;61(4):558–64.
42. Vedanthan R, Lee DJ, Kamano JH, Herasme OI, Kiptoo P, Tulienge D, Kimaiyo S, Balasubramanian H, Fuster V. Hypertension management in rural western Kenya: a needs-based health workforce estimation model. Hum Resour Health. 2019;17(1):1–9.
43. Maritim B, Koon AD, Kimaina A, Lagat C, Riungu E, Laktabai J, Ruhl LJ, Kibiwot M, Scanlon ML, Goudge J. It is like an umbrella covering you, yet it does not protect you from the rain: a mixed methods study of insurance affordability, coverage, and financial protection in rural western Kenya. Int J Equity Health. 2023;22(1):27.

Publisher's Note