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ISSN: 1179-1373 (Online) Journal homepage: www.tandfonline.com/journals/dhiv20

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To cite this article: Shrikala Acharya, Vijaykumar Karanjkar, Mohit Goyal, Prashant Vinay Deshpande, Anonymous, Maninder Singh Setia, Dhirubhai Rathod, Priya Kannan, Ashish Krishna, Anupam Khungar Pathni, Amol Palkar, Amit Harshana & Anonymous (2025) Prevalence of Hypertension and Its Associated Factors Among Adult People Living with HIV/AIDS at Anti-Retroviral Treatment (ART) Centers in Mumbai, India, HIV/AIDS - Research and Palliative Care, , 105-119, DOI: 10.2147/HIV.S499508

To link to this article: https://doi.org/10.2147/HIV.S499508

Published online: 02 Jun 2025.

HIV/AIDS - Research and Palliative Care

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ORIGINAL RESEARCH

Prevalence of Hypertension and Its Associated Factors Among Adult People Living with HIV/AIDS at Anti-Retroviral Treatment (ART) Centers in Mumbai, India

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Background: Globally, non-communicable diseases (NCDs), including hypertension, are the leading cause of mortality. People Living with HIV (PLHIV) on antiretroviral therapy (ART) have a higher prevalence of hypertension, risk of cardiovascular events, and all-cause mortality than HIV-uninfected individuals. We describe the implementation of an integrated hypertension screening initiative in a routine program setting and assessed the prevalence of hypertension and its associated factors among PLHIV accessing services at ART centers in Mumbai, India.

Methods: From November 2021 to October 2022, we implemented hypertension screening across 21 ART centers in Mumbai, India. An expert committee developed a clinical protocol for hypertension management among PLHIVs aged ≥18 years, and ART center staff were trained on hypertension screening and management. We measured the prevalence of hypertension and determined the relationship between hypertension and various factors using univariable and multivariable modified poisson regression.

Results: We screened 92% (36,098/39,402) of eligible adult PLHIV for hypertension; 23.8% (8,604/36,098) had hypertension (56.7% were newly identified, and 43.3% known cases), factors such as age ≥60 years, male gender, being overweight or obese were significantly associated with hypertension ($p<0.05$). The HIV-related factors such as CD4 cell count of 200 cells/mm^3 or higher, suppressed viral load (<1000 copies/mL), and longer duration of ART were also significantly associated with hypertension.

Conclusion: About one in every four PLHIV enrolled in the Mumbai ART program was hypertensive, reflecting hypertension prevalence in the general population. The findings highlight the increasing concern of NCDs among PLHIV, driven by longer life expectancies due to effective ART. This underscores the need for healthcare systems to evolve and adopt comprehensive and integrated care models that address HIV and non-communicable diseases. Integration of hypertension screening into routine HIV care can accelerate the early identification and management of hypertension.

Keywords: hypertension, HIV/AIDS, integrated screening, prevalence, India

Introduction

Globally, in 2022, 39 million people were estimated to be living with HIV, with nearly 1.3 million projected annual new infections.[1] The introduction of antiretroviral therapy (ART) has transitioned HIV into a manageable chronic condition, resulting in longer survival of people living with HIV (PLHIV). The longer survival increases the risk of developing age-related conditions, such as non-communicable diseases (NCDs), eg, hypertension, diabetes mellitus, chronic respiratory diseases, and cancers.[2,3] According to UNAIDS (2020), 8.1 million PLHIV globally are aged 50 or older, and this number is expected to continue rising.[4]

Received: 6 October 2024
Accepted: 25 January 2025
Published: 3 June 2025

The number of people with hypertension globally in 2019 was over 1 billion, which has doubled since 1990.[5] Forty-one million deaths are attributed to NCDs annually, and 77% of all NCD deaths occur in low- and middle-income countries.[6]

India has an estimated 2.4 million PLHIV, with an adult prevalence rate of 0.20% (2023).[7] India's National AIDS Control Program (NACP) witnessed a 42% reduction in new infections and a 77% decrease in AIDS-related mortality between 2010 and 2022, attributed to increased access to life-saving ART and person-centric care initiatives by NACP.[8] India is also witnessing an increasing prevalence of NCDs, including hypertension, diabetes, obesity, and dyslipidemia.[9] Annually, 6.5 million people in India are estimated to die from NCDs, with 1 in 4 Indians dying from an NCD before the age of 70 years.[10] Studies from India indicate hypertension prevalence of 35.5% (33.8–37.3), particularly prominent among South Asians worldwide.[9] There is also an observed increase in myocardial infarction (MI) and coronary artery disease (CAD) leading to MI, particularly among people younger than 40 years of age in India.[11]

The burden of cardiovascular disease (CVD) is significantly higher among PLHIV compared to the general population. PLHIV have a two-fold increased risk of developing CVD, with acute myocardial infarction (AMI) being the most common presentation.[12] Notably, PLHIV are 1.5 to 2 times more likely to experience AMI than HIV-uninfected individuals.[12] Projections suggest that by 2030, 27% of individuals with HIV will have three or more non-communicable diseases (NCDs), compared to 19% in HIV-uninfected populations.[13] A sharp increase in the prevalence of CVD, diabetes, and malignancies will primarily drive this rising burden of NCDs. Furthermore, models predict that by 2030, 78% of PLHIV will be diagnosed with CVD.[13] In the context of PLHIV, the synergistic effects of HIV-associated inflammation, immune activation, and antiretroviral therapy further amplify the cardiovascular risks posed by hypertension, underscoring its pivotal role in the development and progression of CVD.[14]

Screening for NCDs, particularly hypertension HTN, is crucial as early detection can prevent severe health complications. If left unmanaged, HTN can lead to life-threatening conditions like heart disease, stroke, and kidney failure, severely impacting an individual's quality of life and productivity. At the community level, untreated HTN contributes to rising healthcare costs and places a strain on healthcare systems. On a national scale, it hampers economic growth due to reduced workforce productivity and increased medical expenditures. Proactive screening and management are essential to mitigate these consequences and promote overall health and well-being.

A global meta-analysis reported a hypertension prevalence of 25% among PLHIV, with rates rising significantly with age —from 18.6% in individuals under 40 years to 40.3% in those over 50 years—indicating a clear age-related trend.[15] Hypertension prevalence also varied by antiretroviral therapy (ART) status, with higher rates observed in ART-experienced individuals (34.7%) compared to those who were ART-naïve (12.7%).[15] While some studies have explored the prevalence of hypertension among PLHIV in India, reporting rates between 14.3% and 15.8%.[16,17] However, these were limited by small sample sizes, single-center designs, or a lack of focus on programmatic integration of screening and care. This highlights the need for a broader understanding of the burden of hypertension among adult PLHIV within a programmatic framework. India's National Guidelines recommend integrated NCD care for PLHIV attending ART centers; however, there are no standard operating procedures for implementation in the routine program context.[18] We describe the implementation of an integrated hypertension screening initiative in a routine program setting and assess the prevalence of hypertension and its associated factors among adult PLHIV accessing routine care at ART centers in Mumbai, India.

Methods

This is a cross-sectional analysis of hypertension screening among 36,098 adult PLHIV accessing ART from 21 publicly funded ART centers in Mumbai, India, from November 01, 2021, to October 31, 2022.

Study Site

The Mumbai Districts AIDS Control Society (MDACS) provides HIV-related comprehensive care, support, and treatment services to PLHIV in Mumbai through ART centers in Mumbai, India. Of the 21 ART centers included in this analysis, nine were situated in tertiary care centers; nine were in secondary, and three were in primary healthcare centers. Each ART center is supported by a multidisciplinary healthcare team comprising a trained physician, nurse, licensed pharmacist, counselor, data manager, and care coordinator working collaboratively to provide comprehensive care. In addition to delivering healthcare services, the ART team documents vital information of registered PLHIV such as socio-

demographic details (age, gender, educational status, etc)., anthropometric and biochemical measurements, and the patient's disease and treatment history during routine pill pick-up visits. The collected data is stored in a centralized data management system directly under the supervision of MDACS.

Study Population and Procedures

From November 2021 to October 2022, 40,300 PLHIV were registered for care across these 21 ART centers. All registered PLHIV were eligible for hypertension screening; for the current analysis; however, we excluded children and adolescents living with HIV (<18 years of age) and pregnant or postnatal (six months post-delivery) women from hypertension screening. Of the 39,085 eligible adult PLHIV, 2,987 did not complete the hypertension screening. Thus, 36,098 PLHIV successfully underwent the hypertension screening process (Figure 1).

Screening of Hypertension in PLHIV

We drafted standard operating procedures for screening all eligible PLHIV for hypertension during routine visits to ART centers. We trained the staff of 21 ART centers for blood pressure (BP) measurement and reporting. The PLHIV were screened by the trained nurse during their visit to the ART centers using a validated and standardized digital BP instrument provided to all the implementing ARTCs under the project.

PLHIV who reported a prior diagnosis of hypertension were classified as a "known case of hypertension." We recorded their blood pressure and current antihypertensive treatment. For those not classified as "known cases of hypertension" only the blood pressure (BP) was measured. If the first BP reading was elevated (≥140/90 mm/Hg), the measurement was repeated after a 15–20-minute interval. The lower of the two BP readings was recorded in the participant's clinic visit booklet and treatment card per national guidelines.[18] PLHIV with elevated BP readings on the first contact had a second BP reading measured during the next scheduled pill-pick-up visit that routinely occurs after 30 days. A diagnosis of hypertension was made if there were two consistently high readings (≥140 SBP or ≥90 DBP) on two separate occasions and were classified as "new cases of hypertension." However, for those PLHIV with a first-day reading ≥160 mm/Hg systolic or ≥100 mm/Hg diastolic, hypertension was diagnosed during the first measurement itself, and these PLHIV were referred to a specialist after initial management. Those with first-day measurements of >180/110 were referred to a specialist immediately after initial management. All PLHIV, whether previously known or a new case

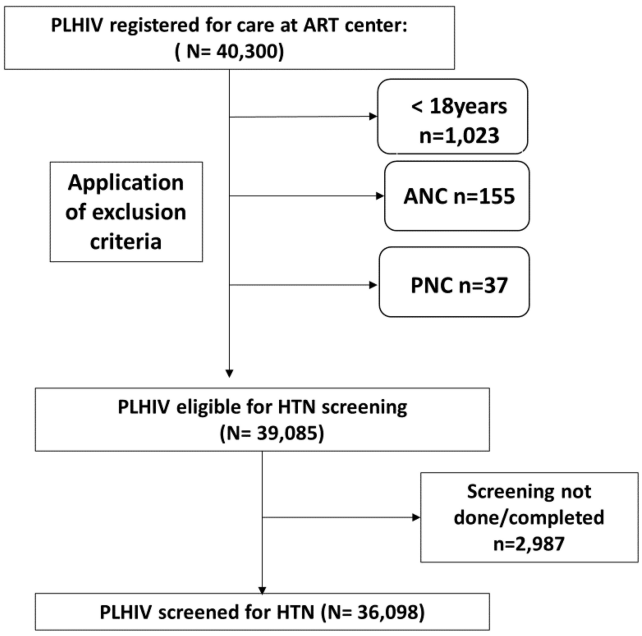

Figure 1 Flow chart depicting the enrolment of adult PLHIV at 21 ART centers in Mumbai, India, 2022.

https://doi.org/10.2147/HIV.S499508

Box 1 Operational Definitions used[20]

Operational Definitions

Type of case:

- **Known case**:
  - PLHIV who self-reported prior diagnosis with hypertension or has received hypertension treatment within the last 12 months.
- **New case**:
  - PLHIV who was not previously diagnosed or treated for hypertension and presented with SBP ≥140 mm/Hg or DBP ≥90 mm/Hg on two separate visits.

    OR
  - PLHIV with the first day reading ≥160 mm/Hg systolic or ≥100 diastolic, diagnosed as having hypertension during the first measurement itself.

Grade of hypertension:

- **Grade −1 hypertension**: Systolic blood pressure (SBP) between 140 and 159 mm/Hg and/or diastolic blood pressure (DBP) in the range of 90–99 mm/Hg
- **Grade-2 hypertension**: SBP between 160 and 179 mm/Hg and/or DBP in the range of 100–109 mm/Hg
- **Grade-3 hypertension**: SBP was ≥180 mm/Hg and/or DBP ≥110 mm/Hg.

of hypertension, were subsequently categorized into Grades 1, 2, or 3 as per the operational guidelines of non-communicable diseases in India.[19,20] The operational case definitions and grades of hypertension are shown in Box 1.

PLHIV with grade 1 hypertension were counseled on lifestyle modifications for diet, weight reduction, and physical activity by the ART center counselor using a pre-designed visual aid. The patient flow at the ART center was streamlined to ensure that the BP screening was conducted before the participant visited the medical officer. We have described the selection process and participant flow in Figure 2. The counselor and care coordinator provided education on the prevention and complications of hypertension to the PLHIV. In addition, educational posters on lifestyle modification were displayed across all ART centers.

Data Collection and Management

The sampling frame encompassed all eligible PLHIV enrolled and receiving care at the 21 ART centers from November 01, 2021, to October 31, 2022. As part of the national AIDS control program, these patients are managed by a comprehensive

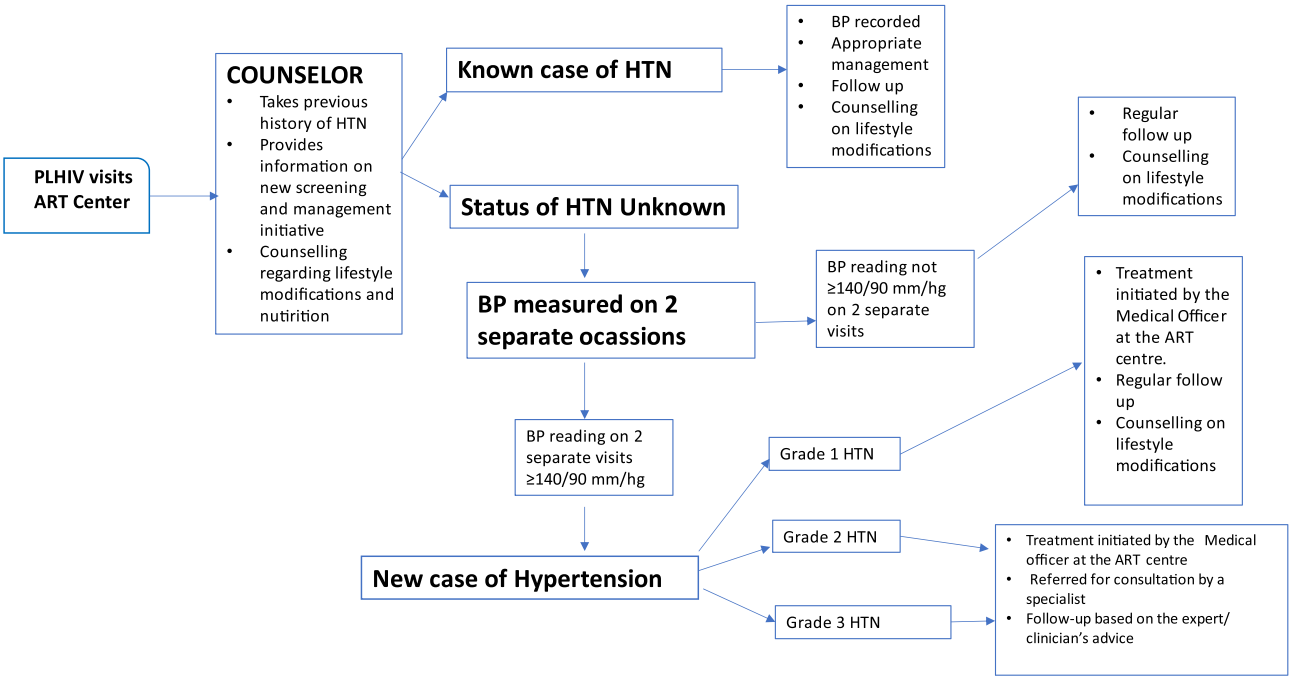

Figure 2 Patient flow for HTN diagnosis and management at ART centers, Mumbai, India, 2022.

ART team. For purpose of this analysis, BP measurements and its treatment medications for people diagnosed with hypertension was documented at the ART center in a separate register. The other variables such as demographic details (age, gender, education), ART regimen, date of diagnosis, duration of ART, CD4 count, most recent viral load count (if available), anthropometric measurement (height, weight) were extracted from the central database managed by the MDACS. The body mass index (BMI) was categorized according to the Indian Council for Medical Research (ICMR) guidelines into the following categories: underweight: <18.5 kg/m^2, normal: 18.5–22.9 kg/m^2, overweight: 23–24.9 kg/m^2, and obesity: ≥25 kg/m^2.[21]

Data Analysis

The data collected were entered in a coded form in Microsoft Excel (Version MSO (16.0.10383.20027)) spreadsheet. The data were analysed using a licensed version of the IBM Statistical Package for Social Sciences (SPSS Version 23.0). All the variables were analysed using descriptive statistics; categorical data were expressed in either frequency or proportions, and continuous data were described using median and inter-quartile range (IQR). All proportions were reported with corresponding 95% confidence intervals (CI).

To assess hypertension prevalence, categorical data were converted into percentages, and PLHIV with hypertension were categorized as known or new, with their respective frequencies. The relationship between hypertension and independent variables such as socio-demographic characteristics (age, gender, educational status), BMI, ART regimen, duration since HIV diagnosis, duration on ART, viral load (VL) count, and CD4 count was investigated using chi-square and Fisher's exact tests. To assess the impact of ART and duration of HIV infection on hypertension prevalence, chi-square tests for trend were employed, considering known risk factors such as age, gender, and body mass index (BMI). Univariable and multivariable modified Poisson regression models with robust variance were used to test the factors associated with hypertension, a p-value less than 0.05 was considered statistically significant. We also estimated prevalence ratios and attributable fractions.

Ethical Considerations

The protocol was approved by the Ethics Committee of Mumbai Districts AIDS Control Society (Ref: MDACS/Proposal/003/2021 dated 11th October 2021). The eligible participants were thoroughly briefed about the project's purpose and the screening process in a language they understood. Written informed consent was obtained from each participant, and their personal information was anonymized to ensure confidentiality. The data related to hypertension were collected during the screening process, and other variables were extracted from electronic data records. However, for analysis, all the collected data were anonymised to maintain confidentiality.

Results

The mean (SD) age of the 36,098 PLHIV included in our analysis was 45.7 (11.0) years. Fifty-six percent of the study population were males, 43% were females, and 1% were male-to-female transgendered people/hijras (TS/TGH). The mean (SD) ages of males, females, and TS/TGH were 46.5 (11.4), 44.6 (10.4), and 39.2 (11.2) years, respectively. Most PLHIV had completed secondary school (32.8%) or primary school (18.8%); only 10.9% had completed college education. The median (IQR) time since HIV diagnosis was 8.0 (4.0, 12.0) years and the median (IQR) time on ART was 6.0 (3.0, 10.0) years. At the time of hypertension screening, the majority (92.0%) were on an INSTI (Dolutegravir) based regimen. The majority had a CD4 count of ≥ 200 cells/mm3 (94.8%) and a suppressed viral load (<1000 copies/mL) (96.9%) at the time of screening (Table 1).

The overall prevalence of hypertension among PLHIV accessing routine care was 23.8% (8,604/36,098) (95% CI: 23.4%–24.3%). Of these 8,604 PLHIV, 43.3% (3,728/8,604) were known cases of hypertension, while 56.7% (4,876/8,604) were newly identified with hypertension. Among those with known hypertension, 1,279 (34.3%) had controlled blood pressure at the time of screening. Among all PLHIV with hypertension, 39% (3,364/8,604) were categorized as Grade-1, 30% (2,583/8,604) as Grade-2, 16% (1,378/8,604) as Grade-3 hypertension, and the rest had their BP readings under control.

Table 1 Demographic and Clinical Characteristics of PLHIV by Hypertension Status (N=36,098) at ART Centers, Mumbai, India, 2022

Variable	Total[#] (N=36,098) n (%)[§]	Hypertension=No (n=27,494)[§§]	Hypertension=Yes (n=8,604)[§§]			p-Value[a] [Known vs New]	p-Value[b] [HTN vs No HTN]
			All n (%)	Known (n=3,728)	New (n=4,876)		
1. Age Group (in years)						**<0.01****	**<0.01****
18–29	3,083 (8.5)	2,960 (96.0)	123 (4.0)	18 (0.6)	105 (3.4)		
30–44	12,541 (34.8)	10,741 (85.7)	1,800 (14.3)	568 (4.5)	1,232 (9.8)		
45–59	16,967 (47.0)	11,741 (69.2)	5,226 (30.8)	2,311 (13.6)	2,915 (17.2)		
60 and above	3,507 (9.7)	2,052 (58.5)	1,455(41.5)	831 (23.7)	624 (17.8)		
2. Gender						**<0.01****	**<0.01****
Female	15,493 (42.9)	12,656 (81.7)	28,37(18.3)	1,424 (9.2)	1,413 (9.1)		
Male	20,357(56.4)	14,632 (71.9)	57,25(28.1)	2,283 (11.2)	3,442 (16.9)		
TS/TGH	248 (0.7)	206 (83.1)	42(16.9)	21 (8.5)	21 (8.5)		
3. Educational status						**0.03**	**<0.01****
Illiterate	5,560 (15.4)	4,413 (79.4)	11,47(20.6)	520 (9.3)	627 (11.3)		
Primary School	6,793 (18.8)	5,337 (78.6)	1,456(21.4)	635 (9.3)	821 (12.1)		
Secondary School	11,839 (32.8)	9.012 (76.1)	2,827(23.9)	1,199 (10.1)	1,628 (13.7)		
College & above	3,938 (10.9)	3,088 (78.4)	850(21.6)	334 (8.5)	516 (13.1)		
Did not respond	7,968 (22.1)	5644 (70.8)	2324(29.2)	1040 (13.1)	1284 (16.1)		
4. BMI kg/m^2						**<0.01****	**<0.01****
Underweight ≤18.49	3042 (8.4)	2,663 (87.5)	379 (12.5)	154 (5.1)	225 (7.4)		
Normal (18.5–22.9)	7,741 (21.5)	6,276 (81.1)	1,465(18.9)	577 (7.5)	888 (11.5)		
Overweight (23–24.9)	3,942 (10.9)	2,985 (75.7)	957(24.3)	417 (10.6)	540 (13.7)		
Obesity ≥ 25	9,014 (25.0)	6,134 (68.1)	2,880(31.9)	1,292 (14.3)	1,588 (17.6)		
Missing	12,359 (34.2)	9,436 (76.4)	2,923(23.6)	1,288 (10.4)	1,635 (13.2)		
5. CD4 cell count (cells/mm3)						**0**.2	**<0.01****
< 200	1,855 (5.2)	1,582 (85.3)	273(14.7)	107 (5.8)	166 (8.9)		
≥200	34,128 (94.8)	25,824 (75.7)	8,304(24.3)	3,609 (10.6)	4,695 (13.8)		
6. Viral Load (VL) (copies/mL)						**0**.1	**<0.01****
VL ≥1000	1,040 (3.1)	903 (86.8)	137(13.2)	50 (4.8)	87 (8.4)		
VL < 1000	32,446 (96.9)	24,435 (75.3)	8,011(24.7)	3,446 (10.6)	4,565 (14.1)		
7. Duration of ART (in years)						**<0.01****	**<0.01****
≤3	11,048 (30.6)	9,045 (81.9)	2,003(18.1)	814 (7.4)	1,189 (10.8)		
4–6	8246 (22.8)	6,354 (77.1)	1,892(22.9)	753 (9.1)	1,139 (13.8)		
7–9	7416 (20.5)	5,397 (72.8)	2,019(27.2)	853 (11.5)	1,166 (15.7)		
≥10	9385 (26.0)	6,698 (71.4)	2,687(28.6)	1,306 (13.9)	1,381 (14.7)		

(*Continued*)

Table 1 (Continued).

Variable	Total# (N=36,098) n (%)§	Hypertension=No (n=27,494)§§	Hypertension=Yes (n=8,604)§§				p-Value[b] [HTN vs No HTN]
			All n (%)	Known (n=3,728)	New (n=4,876)	p-Value[a] [Known vs New]	
8. ART Regimen						**<0.01****	**<0.01****
NRTI + INSTI	33,198 (92.0)	25,345 (76.3)	7,853(23.7)	3,379 (10.2)	4,474 (13.5)		
NRTI + NNRT	567 (1.6)	415 (73.2)	152(26.8)	86 (15.2)	66 (11.6)		
PI Based	2,304 (6.4)	1,717 (74.5)	587(25.5)	255 (11.1)	332 (14.4)		
9. HIV Disease Duration (years)						**<0.01****	**<0.01****
1) ≤5	12,023 (33.3)	9,805 (81.6)	2,218(18.4)	857 (7.1)	1,361 (11.3)		
2) 6 to 10	8,700 (24.1)	6,767(77.8)	1,933(22.2)	801 (9.2)	1,132 (13.0)		
3) ≥11	11,452 (31.7)	8,378 (73.2)	3,074(26.8)	1,450 (12.7)	1,624 (14.1)		
4) Missing	3,923(10.9)	2,544(64.8)	1,379(35.1)	620 (15.8)	759(19.3)		

Notes: # For some variables, the total N varies due to missing values. p-value[a] for comparison amongst PLHIV with hypertension; new hypertension vs known hypertension with significant differences across groups. p-value[b] given is for comparison amongst PLHIV with hypertension (yes) with no hypertension (no).** significant difference across the groups at p-value<0.05. §- Column percentages. §§- Row percentage.

Abbreviations: NRTI, Nucleoside Reverse Transcriptase Inhibitors; INSTI, Integrase Strand Transfer Inhibitor; NNRTI, Non-Nucleoside Reverse Transcriptase Inhibitors; PI, Protease Inhibitor.

Among PLHIV accessing routine care, the prevalence of known hypertensives was 10.3% (95% CI: 10.0%, 10.6%), and of newly diagnosed hypertensives, 13.5% (95% CI: 13.2%–13.9%). We identified more new cases of hypertension compared to known cases (prevalence ratio [PR]: 1.31, 95% CI: 1.26–1.36). We estimate that about 23.5% (95% CI: 20.4%–26.5%) of additionally identified cases (new cases) can be attributed to routine hypertension screening and monitoring in this population. However, the identification of new hypertension cases was not similar across all sub-groups. For instance, the prevalence of new cases was significantly higher in the younger age group (18–29 years) (PR: 6.0, 95% CI: 3.63–9.62). The prevalence of new cases compared with known cases of hypertension gradually decreased with an increase in age. In those who were ≥60 years and older, we identified fewer new cases of hypertension compared with known cases (PR: 0.70, 95% CI: 0.62–0.78). Though more new hypertension cases than known cases were identified in males, no such finding was seen in females or the TS/TGH population (Figure 3).

In our analysis, factors such as age, gender, and BMI were significantly associated with a higher prevalence of hypertension among PLHIV. Hypertension was significantly associated with increasing age ($p<0.01$), with the highest prevalence observed among PLHIV aged 60 years and above (41.5%), while the lowest prevalence was in the 18–29 years age group (4.0%). Hypertension prevalence was significantly higher in males (28.1%) compared to females (18.3%) and TS/TGH (16.9%) ($p<0.01$). Additionally, PLHIV who were either overweight (24.3%) or obese (31.9%) had significantly higher hypertension prevalence compared to those with normal BMI (18.9%) and underweight (12.5%) ($p<0.01$).

HIV-related factors, such as higher CD4 count (≥200 cells/mm^3), viral load <1,000 copies/mL, duration of ART treatment, and time since HIV diagnosis were significantly associated with an increased prevalence of hypertension (Table 1).

In the multivariate modified Poisson regression model, after adjusting for all parameters, we observed that hypertension prevalence was significantly higher among those aged ≥60 years (aRR: 9.4, 95% CI: 7.7–11.6) compared to the reference group (18–29-year-old; $p<0.01$). The risk ratio was also significantly higher among those aged 45–59 years and 30–44 years compared to those 18–29 years (Table 2). The other factors associated with higher prevalence of hypertension were male gender (aRR: 1.4, 95% CI: 1.3–1.4, $p<0.01$), education (secondary or higher), being overweight (aRR: 1.3, 95% CI: 1.2–1.4, $p<0.01$) or obese (aRR: 1.6, 95% CI: 1.5–1.7; $p<0.01$) as compared to normal BMI, CD4 cell count of ≥200 cells/mm3 (aRR: 1.3, 95% CI: 1.1–1.5; $p<0.01$) as compared to CD4 cell count of <200 cells/mm3, suppressed

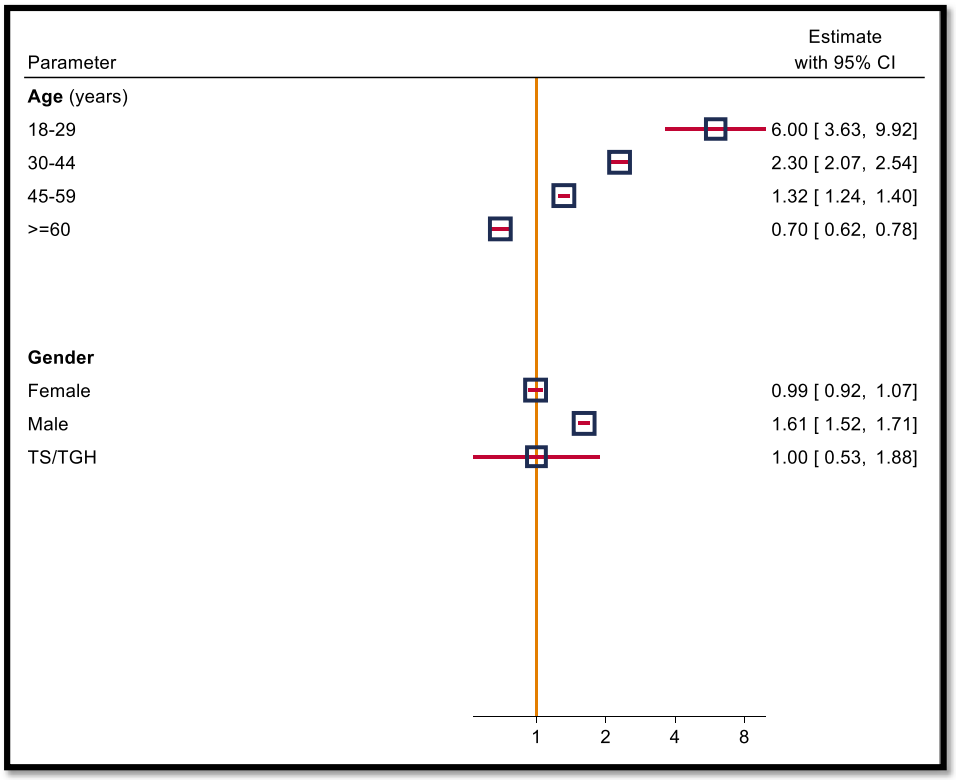

Figure 3 This figure shows the plot for prevalence estimates (and their 95% confidence intervals) to identify new cases of hypertension compared with old cases by age and gender at ART centers in Mumbai, India, 2022.

viral load (<1000 copies/mL) (aRR: 1.2, 95% CI: 1.1–1.6; p<0.01) as compared to unsuppressed viral load ≥1000 copies/mL, and longer duration of ART. There was no significant difference in prevalence of hypertension amongst those with HIV disease duration of 11 years or more when compared to those with five years or lesser (Table 2). We tested the interactions between ART duration with age and gender; none were statistically significant (p>0.05).

We analysed the cubic trend of hypertension prevalence by age and ART duration. Figure 3 illustrates that hypertension prevalence in the overall population increased with the increase in the duration of ART treatment. The

Table 2 Univariable and Multivariable Modified Poisson Regression Analysis for Factors Associated with Hypertension at ART Centers, Mumbai, India, 2022

	Univariable		Multivariable	
	RR [CI 95%]	**P Value**	**aRR [CI 95%]**	**P Value**
Age (in years)				
18–29	**Ref.**		**Ref.**	
30–44	3.6 [3.0–4.3]	<0.01*	**3.4 [2.8–4.2]**	< 0.01*
45–59	7.7 [6.5 −9.2]	<0.01*	**6.9 [5.7 −8.4]**	< 0.01*
≥60	10.4 [8.7–12.4]	<0.01*	**9.4[7.7–11.6]**	< 0.01*
Gender				
Female	**Ref.**		**Ref.**	
Male	1.5 [1.4–1.6]	<0.01 *	**1.4 [1.3–1.4]**	< 0.01*
TS/TGH	0.9 [0.7–1.2]	0.6	1.1[0.8–1.4]	0.7

(*Continued*)

 https://doi.org/10.2147/HIV.S499508

Table 2 (Continued).

	Univariable		Multivariable	
	RR [CI 95%]	**P Value**	**aRR [CI 95%]**	**P Value**
Education				
Illiterate	**Ref.**		**Ref.**	
Primary School	1.0 [0.9–1.1]	0.3	1.0 [0.9–1.1]	0.8
Secondary School	1.2 [1.1–1.2]	<0.01*	**1.1 [1.1–1.2]**	0.03*
College & above	1.0 [0.9–1.1]	0.3	**1.2 [1.1–1.3]**	<0.01*
Did not Respond	1.4 [1.3–1.5]	< 0.01*	**1.2 [1.1–1.3]**	<0.01*
BMI kg/m^2				
Underweight ≤18.49	0.7 [0.6–0.7]	<0.01*	**0.7 [0.6–0.8]**	<0.01*
Normal 18.5–22.9	**Ref.**		**Ref.**	
Overweight 23 −24.9	1.3 [1.2–1.4]	<0.01*	**1.3 [1.2–1.4]**	<0.01*
Obese ≥25	1.7 [1.6–1.8]	< 0.01*	**1.6 [1.5–1.7]**	< 0.01*
Missing	1.4 [1.3–1.5]	<0.01*	**1.3 [1.2–1.3]**	< 0.01*
CD4 cell count (cells/mm^3)				
1) < 200	**Ref.**		**Ref.**	
2) ≥ 200	1.7 [1.5–1.8]	<0.01*	**1.3[1.1–1.5]**	<0.01 *
Viral Load (copies/mL)				
1) Unsuppressed VL (≥1,000)	**Ref.**		**Ref.**	
2) Suppressed VL (<1,000)	1.9 [1.6–2.2]	<0.01*	**1.2 [1.1–1.6]**	<0.01*
Duration of ART (in years)				
≤3	**Ref.**		**Ref.**	
4–6	1.3 [1.2–1.3]	<0.01*	**1.1 [1.01–1.1]**	0.03*
7–9	1.5 [1.4–1.6]	<0.01*	**1.2 [1.1–1.3]**	<0.01*
≥10	1.6 [1.5–1.7]	<0.01*	**1.1 [1.1–1.2]**	<0.01*
ART regimen				
NRTI + INSTI	Ref.		**Ref.**	
NRTI + NNRT	1.1 [0.9–1.3]	0.07	1.2 [0.99–1.4]	0.06
PI Based	1.1 [1.0–1.2]	0.04	1.0 [0.9–1.1]	0.6
HIV Disease Duration (in years)				
1) ≤5	Ref.		**Ref.**	
2) 6 to 10	1.2[1.1–1.3]	<0.01*	**0.9[0.8–0.9]**	0.01
3) ≥11	1.5[1.4–1.5]	<0.01*	1.0[0.9–1.1]	0.18

Notes: *Significant at the level of p-value <0.05.
Abbreviations: NRTI, Nucleoside Reverse Transcriptase Inhibitors; INSTI, Integrase Strand Transfer Inhibitor; NNRTI, Non-Nucleoside Reverse Transcriptase Inhibitors; PI, Protease Inhibitors.

increase is less pronounced among age groups 18–29 and 30–44 years, with prevalence remaining relatively stable in younger PLHIV, but increases notably in age groups 45–59 and ≥60 years (Figure 4).

The prevalence of hypertension appears to increase with higher age groups and with longer durations of ART usage. The age and duration of ART medication seem to have a combined effect on the prevalence of hypertension in our population.

While formal trend analysis revealed no significant change in hypertension prevalence by ART duration in individuals aged 18–29 years (p=0.28), significant increasing trends were observed within the same ART duration for higher age

https://doi.org/10.2147/HIV.S499508

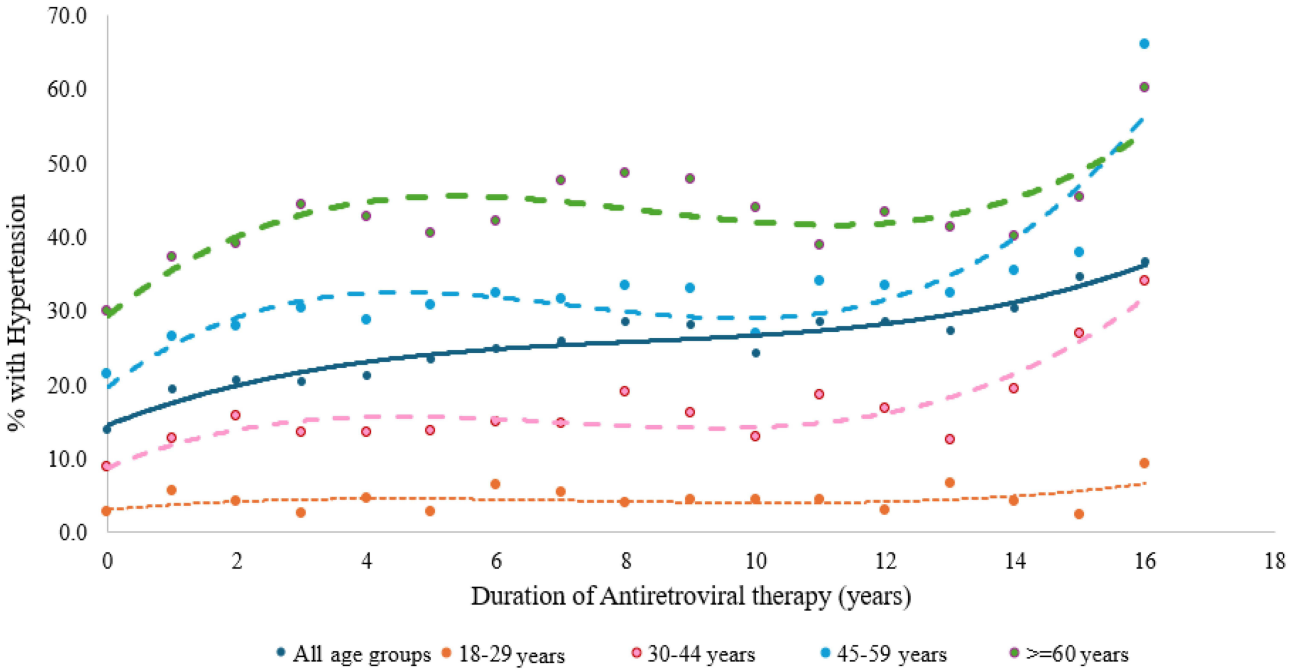

Figure 4 Trend of hypertension prevalence by duration of ART and age group (years), at ART centers, Mumbai, India, 2022.

groups and across the other age groups with higher ART duration. Similar increasing trends were also observed across BMI groups and gender (males and females) (Table 3).

Discussion

This is among the first studies conducted in a routine program setting from India to provide empirical evidence on the prevalence of hypertension and its associated factors among adult PLHIV in Mumbai, India. The overall prevalence of hypertension among 36,098 PLHIV receiving routine care in Mumbai across 21 ARTCs was 23.8%. This is comparable to the 25.3% prevalence reported by Geldsetzer et al in a nationally representative sample of 1.3 million adults in India by pooling data from two national health surveys in 2018.[22] Data from the National Family Health Survey-5 in India (2019–21) (n = 825,954) also reported a similar prevalence of 25.1% in the general population with a prevalence of 26.6% and 23.6% among males and females, respectively.[23]

With respect to resource-limited settings, the prevalence of 23.8% in our study is comparable to the prevalence rates of 24.9%, 22.0%, and 19.0% reported in prior studies among PLHIV in (Nigeria; 2022);[24] (Zambia; 2021)[25] and (Kenya; 2022).[26] Studies from South Africa that screened patients from an older age group (>50 years) demonstrated higher prevalence.[27] Our findings of associated factors for hypertension are consistent with known risk factors for hypertension, including age and male gender, aligning with previous studies conducted among PLHIV.[28–32]

We also observed an association between hypertension and a longer duration of ART exposure, high CD4 count, and viral suppression. However, a prior study from Cameroon with similar findings indicated that there is no independent relationship between CD4 cell count and hypertension after adjusting for important confounders such as BMI, age, sex, ART use, and duration of HIV infection.[33] This association between duration of ART and hypertension could be mediated directly through changes in endothelial function, or it could be due to longevity as well as age-associated comorbidities like ART-related changes in body composition and weight gain.[34,35] Our study did not show an association between the type of antiretroviral therapy (ART) regimen and hypertension. However, the wide-scale transition to dolutegravir-based regimens was only recently completed in 2021.[8] We do report an association between the duration of ART medication and being HIV positive for at least a decade, and the occurrence of hypertension.

Over half of those with hypertension were previously undiagnosed. This prevalence is slightly higher than the 42.6% reported among the general population in India by Boro et al and lower than the 72.1% reported by Amarchand et al in

Table 3 Chi-Square Test for Trend Analysis of HTN by Age, Gender, and BMI with Duration of ART (N=36,098) at ART Centers, Mumbai, India, 2022

Variable	Total (N=36098)	ART Duration_≤3 Years (N=11048)		ART Duration 4–6 Years (N=8246)		ART Duration 7–9 Years (N=7416)		ART Duration ≥10 Years (N=9385)		p-Value[b]
		Total (%)	HTN (%) n=2003	Total (%)	HTN (%) n=1892	Total (%)	HTN (%) n=2019)	Total (%)	HTN (%) n=2687)	
1. Age (Completed in years)										
18–29	3083 (8.5)	1730 (15.7)	62 (3.6)	694 (8.4)	31 (4.5)	297 (4.0)	14 (4.7)	362 (3.8)	16 (4.4)	0.28
30–44	12,541 (34.8)	4370 (39.6)	536 (12.3)	3202 (38.8)	447 (14.0)	2550 (34.4)	414 (16.2)	2419 (25.8)	403 (16.7)	**<0.01***
45–59	16,967 (47.0)	3922 (35.4)	1029 (26.2)	3561 (43.2)	1086 (30.5)	3844 (51.8)	1245 (32.4)	5638 (60.1)	1864 (33.1)	**<0.01***
60 and above	3507 (9.7)	1026 (9.3)	376 (36.6)	789 (9.6)	328 (41.6)	725 (9.8)	346 (47.7)	966 (10.3)	404 (41.8)	**<0.01***
p-value[a]			**<0.001***		**<0.001***		**<0.001***		**<0.001***	
2. Gender										
Female	15493 (42.9)	4379 (40.0)	640 (4.1)	3542 (43.0)	617 (17.4)	3284 (44.0)	654 (19.9)	4287 (46.0)	925 (21.6)	**<0.01***
Male	20357 (56.4)	6565 (59.0)	1347 (6.6)	4634 (56.0)	1262 (27.2)	4083 (55.0)	1355 (33.2)	5073 (54.0)	1759 (34.7)	**<0.01***
TS/TGH	248 (0.7)	104 (1.0)	16 (6.5)	70 (1.0)	13 (18.6)	49 (1.0)	10 (20.4)	25 (0.3)	3 (0.1)	0.89
3. BMI kg/m^2										
Underweight BMI≤ 18.49	3042 (8.4)	943 (9.0)	69 (7.3)	636 (14.6)	93 (8.0)	688 (9.0)	102 (14.8)	775 (8.0)	115 (14.8)	**<0.01***
Normal (18.5 and 22.9)	7741 (21.5)	2293 (21.0)	301 (13.1)	1700 (21.0)	273 (16.1)	1669 (22.0)	389 (23.3)	2077 (22.0)	500 (24.1)	**<0.01***
Overweight (23 and 24.99)	3942 (10.9)	1143 (10.0)	212 (18.5)	920 (11.0)	214 (23.3)	812 (11.0)	238 (29.3)	1067 (11.0)	293 (27.4)	**<0.01***
Obese BMI≥ 25	9014 (25)	2796 (25.0)	761 (27.2)	2174 (26.0)	686 (31.6)	1873 (25.0)	659 (35.2)	2171 (23.0)	774 (35.7)	**<0.01***
Missing	12359 (34.2)	3873 (35.0)	660 (17.0)	2816 (34.0)	626 (22.2)	2374 (32.0)	631 (26.6)	3295 (35.0)	1005 (30.5)	
p-value			**<0.001***		**<0.001***		**<0.001***		**<0.001***	

Notes: p-value[a] for comparison amongst categories within the variable, p-value[b] given is for comparison across different duration of ART medication. * significant difference across the groups at p-value<0.05.

https://doi.org/10.2147/HIV.S499508

the National Noncommunicable Disease Monitoring Survey.[36,37] The lower prevalence rates among newly diagnosed PLHIV in our study compared to the general population can be attributed to the frequent visits to ART centers and encounters with healthcare providers among PLHIV.

Screening initiatives can play a crucial role in identifying new cases and improving awareness, thereby facilitating better management and control of hypertension. Lifestyle interventions, such as promoting healthy diets, physical activity, weight control, smoking cessation, and substance abuse prevention, are essential components of hypertension prevention and management and can be integrated at ART centers.

Another finding was the higher prevalence of newly diagnosed hypertension among younger people living with HIV aged 18–29 years (105/123; 85.4%) compared to PLHIV aged 60 and above. (624/1455; 42.9%). Our finding is similar to those reported by Migisha et al (Uganda; 2021), who also found significantly higher undiagnosed hypertension cases among 13–25-year-old PLHIV.[38] This finding is noteworthy, considering that the national program for non-communicable diseases in India recommends opportunistic screening for NCDs to begin at the age of 30 and above.[19] Young PLHIV may face a heightened risk of developing hypertension depending on the age of diagnosis, ART regimen, and ART duration. Early recognition and management of hypertension among young PLHIV may prevent long-term consequences. Regular cardiovascular risk assessments, including blood pressure monitoring, lipid profiles, and glucose metabolism evaluation, may be incorporated into routine HIV care for young PLHIV.

Hypertension is a key risk factor for cardiovascular diseases and may lead to various renal, cardiac, and cerebrovascular complications. Diagnosing and treating hypertension early will prevent associated morbidity and mortality. Studies indicate that ART programs may serve as a powerful entry point for broader health improvements through increased NCD programmatic integration. PLHIV on ART are more likely to have received health care services for other chronic illnesses like hypertension.[39] In this regard, WHO calls for integrated people-centered health services, including NCD treatment.[40]

Introducing hypertension screening in a routine program setting through a standardized screening protocol was a feasible strategy that led to early diagnosis and treatment initiation among PLHIV across all ART centers in Mumbai, India. The existing patient flow at the clinics was followed with minimal additional human resources or infrastructure. Positioning routine HTN care in ART centers provides integrated care for the substantial number of PLHIV with hypertension.[41]

Limitations

Our analysis could not explore other risk factors associated with hypertension among PLHIV, including family history, sodium intake, alcohol use, and broader social determinants of health, which often intersect with disparities related to poverty and physical inactivity.[42,43] Due to the nature of the program data, some values were missing, particularly for BMI variable. To address this, we have included the proportion of missing data as an indicator for all variables. This approach allowed us to account for the gaps in the data and provided a more comprehensive analysis. Additionally, factors such as smoking, alcohol use, hepatitis infection, and substance use linked to cardiovascular disease could not be analysed due to the unavailability of data. Thus, we could not examine the possible effects of these factors on the prevalence of hypertension among PLHIV. Further, due to the cross-sectional analysis, temporality cannot be established.

Conclusion

Early detection and management of hypertension in PLHIV is important to reduce the risk of cardiovascular complications and prevent mortality. Nearly one-fourth of PLHIV on ART had hypertension. These findings indicate that PLHIV face a similar risk of hypertension when compared to the general population. This underscores the need for healthcare systems to evolve and adopt comprehensive and integrated care models that address HIV and non-communicable diseases. Initiation of early routine blood pressure monitoring and comprehensive cardiovascular risk assessments could be integrated into the routine program settings for PLHIV regardless of age and gender. Integrated delivery of ART and hypertension services is feasible for screening and managing PLHIV attending the ART centers.

Ethics Approval and Consent to Participate

The ethics committee of Mumbai Districts AIDS Control Society approved the participation (Ref: MDACS/Proposal/003/2021 dated 11th October 2021). The project was conducted in accordance with the principles and guidelines outlined in the Declaration of Helsinki.

Data Sharing Statement

There are ethical and legal restrictions on sharing the de-identified data set. As these data are related to PLHIV and contain sensitive information, there are restrictions as per the National law (HIV Prevention and Control Act, 2017). The ethics committee secretary, Dr. Shivkar, can be reached by Email at mdacsec@gmail.com for data requests.

Acknowledgments

The authors thank and acknowledge the invaluable contributions of the ART center staff and the participation of PLHIV community without whom this activity would not have been possible. We also thank and acknowledge the support and guidance from Care, Support & Treatment Division, National AIDS Control Organization (NACO), Government of India. The findings and conclusions in this publication are those of the authors and do not necessarily represent the official position of the funding agencies.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

Existing staff and infrastructure of the National AIDS Control Program was utilized. Additionally, this project has been supported by Resolve to Save Lives which is jointly supported by grants from Bloomberg Philanthropies, the Bill & Melinda Gates Foundation, and Gates Philanthropy Partners, funded with support from the Chan Zuckerberg Foundation.

Disclosure

Dr Anupam Pathni and Dr. Ashish Krishna report personal fees from Resolve to Save Lives, during the conduct of the study. The authors declare that they have no other financial or personal relationship(s) that may have inappropriately influenced them in writing this article.

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