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REVIEW

# Hypertension in Sub-Saharan Africa: Burden, Barriers and Priorities for Improving Treatment Outcomes

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**ABSTRACT:** The burden of hypertension is rising rapidly in sub-Saharan Africa (SSA), posing significant health challenges and economic costs that hinder national development. Despite being well-studied in clinical medicine, the detection, treatment, and control of hypertension in SSA remain inadequate. This is due to barriers across the care continuum, including individual-, provider-, and system-level obstacles within the health system. A critical issue is the lack of contextualized mechanistic research to understand the mechanisms, phenotypes, and treatment responses in native SSA populations. Current treatment approaches are often based on data from diaspora Africans, particularly African Americans. Consequently, most guidelines do not recommend angiotensin system drugs as first-line agents for Black patients, a stance that should be reconsidered given some evidence of their effectiveness in native SSA populations. Addressing these barriers requires a comprehensive, multisectoral strategy that includes both preventative and clinical measures at the population and individual levels. Preventative approaches should encompass health and nutrition education, improving food supply quality, and implementing comprehensive transportation and environmental policies. In addition, strategies should be developed to increase the detection of undiagnosed cases through enhanced screening and treatment access to those not receiving care, and revisit current treatment approaches to ensure that they are more tailored to the specific populations and settings. In conclusion, innovative strategies are needed to identify and overcome barriers to hypertension diagnosis and management. A coordinated, multisectoral approach that includes a contextualized mechanistic research agenda, as well as task shifting and task sharing, will help prevent and reduce hypertension in SSA.

**Key Words:** Africa South of the Sahara ■ cardiovascular diseases ■ hypertension ■ myocardial ischemia ■ renin-angiotensin system

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Hypertension affects over 1.39 billion people globally, >75% of whom (1.04 billion people) live in low- and middle-income countries.[1,2] It is the leading underlying cause of death worldwide, causing an estimated 10 million annual deaths.[3] Hypertension is generally present in all countries and societies though its prevalence varies significantly. These differences are primarily driven by the lifestyle and environmental factors unique to each population.[4] The prevalence of hypertension is expected to continue rising due to population aging, increasing sedentary lifestyles, rising obesity rates, and the adoption of unhealthy diets. This trend is likely to escalate the burden of cardiovascular diseases, including stroke, ischemic heart disease, and heart failure, as well as chronic kidney diseases, vision loss, and sexual dysfunction.[5]

While the age-standardized prevalence of hypertension decreased by 2.6% in high-income countries between 2000 and 2010, it increased by 7.7% in low- and middle-income countries.[6] Furthermore, of 8.5 million deaths attributable to hypertension in 2015, 88% occurred in low- and middle-income countries.[7] Sub-Saharan Africa (SSA) bears the greatest burden compared with other low- and middle-income regions.[8] There has been a steady increase in the burden of hypertension

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## Nonstandard Abbreviations and Acronyms

| | |
|---|---|
| **AT1** | angiotensin II receptor type 1 |
| **CREOLE** | Comparison of Three Combination Therapies in Lowering Blood Pressure in Black Africans |
| **ENaC** | epithelial sodium channel |
| **ET1** | endothelin-1 |
| **NOAAH** | Newer versus Older Antihypertensive Agents in African Hypertensive Patients |
| **PA** | primary aldosteronism |
| **RAS** | renin-angiotensin system |
| **SABHA** | South African Burden of Hypertension Assessment |
| **SSA** | sub-Saharan Africa |

in the region, which has increased from 54.6 million in 1990 to 92.3 million in 2000 (70% rise) and 130.2 million in 2010 (41% increase from 2000). It is projected to further affect 216.8 million (66% from 2010) by the year 2030 if appropriate measures are not taken.[9] Already in the region, hypertension imposes significant direct and indirect economic costs to patients, their families, and national economies.[10–12] In SSA, hypertension was linked to more than half a million deaths and 10 million years of life lost in 2010 alone. The risk of stroke on the continent also increased by nearly 50% between 1990 and 2015.[13] In addition to stroke, the burden of coronary heart disease and heart failure has also risen markedly in recent decades, significantly contributing to morbidity and mortality in the region.[14,15]

In this review, we examine the burden of hypertension among African populations in comparison to other groups, explore the key barriers to effective hypertension care in SSA, and discuss potential strategies to address the hypertension burden across the continent.

## RACIAL AND GEOGRAPHIC DISPARITIES

Studies on hypertension have frequently compared Black and non-Black populations, highlighting racial differences and associated health outcomes. It is, however, crucial to note that most of these studies did not include native African populations. Such comparative studies are typically conducted in biracial or multiracial societies, which are uncommon in most parts of SSA.

In the United States, Black populations face a higher risk of hypertension and consistently exhibit elevated blood pressure levels compared with their White counterparts at all ages. Black boys and girls aged 8 to 17 years were found to have 2.9 and 1.6 mm Hg higher systolic blood pressure, respectively, compared with age-matched White boys and girls.[16] In addition, Black populations experience significantly worse outcomes, including earlier onset of stroke, a 2-fold higher stroke mortality rate, and a 5-fold greater incidence of end-stage renal disease.[17]

The risk of hypertension and its related outcomes is not homogeneous among African-origin populations. A study by Cooper et al[18] in 7 populations of West African origin describes a consistent gradient in the prevalence of hypertension rising from 10% to 15% in Africa to 20% to 25% in the Caribbean and to 33% in the United States. The Research on Obesity and Diabetes among African Migrants (RODAM) study compared hypertension prevalence, awareness, and control among Ghanaians (all born in Ghana), including those living in Ghana and various European cities. The study found differences in outcomes, with better results in those living in Europe.[19] These findings suggest that the causes contributing to the racial and geographic disparities (among Black populations) are multifactorial, including genetic, lifestyle, and environmental factors, as well as access to quality health care.[20]

## GENETIC FACTORS AND ENVIRONMENTAL INFLUENCES

Hypertension in SSA is influenced by a complex interplay of genetic factors and environmental influences. Understanding this interaction is critical for developing effective prevention and treatment strategies tailored to the region. SSA is one of the most genetically diverse regions globally.[21] Variants in candidate genes such as *ACE*, *AGT*, and *NOS3* have been associated with hypertension in African populations.[22] In addition, some populations of African origin carry genetic variants that increase salt sensitivity. For example, variants in the *SLC4A5* gene, which regulates sodium transport, have been linked to salt-sensitive hypertension.[23] Furthermore, the *APOL1* gene, which is more prevalent in populations of African origin, is associated with kidney disease and may contribute to hypertension-related complications. However, it is important to note that genetic predisposition alone is rarely sufficient to cause hypertension or increase its risk without environmental triggers such as dietary and lifestyle factors, socioeconomic conditions, and psychosocial stress. This highlights the importance of addressing these environmental factors to effectively prevent and manage hypertension in SSA.

## ROLE OF RACE IN ANTIHYPERTENSIVE THERAPY

Although hypertension is one of the most extensively studied diseases in clinical medicine, much of our current understanding of its etiological drivers, resultant phenotypes, and treatment approaches in native Black Africans is derived from studies in diaspora Africans,

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particularly African Americans.[18,24] Extrapolating these findings to native Africans may not be justified. This is due to differences in cardiovascular risk profiles, socioeconomic status, and responses to antihypertensive treatment between African Americans and other Black populations, especially native Africans.[25] Critically, studies on drug responses in hypertension are lacking in SSA. We are aware of only 2 multicountry studies conducted exclusively on sub-Saharan African populations. These are the NOAAH trial[26] (Newer versus Older Antihypertensive Agents in African Hypertensive Patients) and the CREOLE clinical trials (Comparison of Three Combination Therapies in Lowering Blood Pressure in Black Africans).[27] The NOAAH trial found a combination of amlodipine/valsartan to be more effective at controlling systolic blood pressure compared with bisoprolol/hydrochlorothiazide in native Africans. In the CREOLE study, amlodipine plus either hydrochlorothiazide or perindopril was found to be more effective than perindopril plus hydrochlorothiazide at lowering blood pressure at 6 months.

The appropriateness of using the Black race to guide the choice of initial antihypertensive therapy, therefore, warrants careful consideration. While practice guidelines[28,29] favor calcium-channel blockers and diuretics for Black adults with hypertension, these are typically recommended as part of combination therapy with a renin-angiotensin system (RAS) blocker rather than as monotherapy. Importantly, race-specific differences in average blood pressure responses do not reliably predict individual responses to single-drug therapy, as the BP response distributions overlap significantly between Black and White adults.[30] Therefore, there is no clear advantage to using race as a determinant for selecting single-drug therapy in patients for whom monotherapy is otherwise appropriate.

The Kaiser Permanente's Gardena Medical Offices in the United States implemented a comprehensive hypertension control program to address racial disparities in blood pressure management. The program that included a patient population that was 65% Black utilized a team-based approach, culturally tailored communication, physician-led initiatives to reduce therapeutic inertia, and adherence to evidence-based guidelines.[31] A race-agnostic therapeutic algorithm was also introduced to guide treatment decisions. The program initially aimed to close the racial gap in blood pressure control (<140/90 mm Hg), which stood at 6.3% (76.6% control in Black patients versus 82.9% in others). Over several years, blood pressure control rates among Black patients improved to 81.4%, reducing the disparity to 2.8%. This demonstrated that high blood pressure control rates and reduced racial disparities can be achieved without race-specific prescribing, particularly when combined with intensive, guideline-aligned care and efforts to avoid therapeutic inertia.

### Lifestyle Approaches in Hypertension

As hypertension care moves away from race-based prescribing, race-informed approaches are increasingly focusing on dietary and lifestyle changes. Practice guidelines[28,29] highlight nonpharmacological strategies, such as weight loss, increased physical activity, limited alcohol intake, and dietary modifications (eg, reduced sodium, increased potassium, and adoption of a DASH-like diet). While these strategies benefit adults of all races, evidence suggests they may be particularly effective for Black patients, who often experience greater blood pressure reductions from dietary interventions.

Black adults tend to consume higher levels of sodium and lower levels of potassium compared with their White counterparts,[32] which exacerbates hypertension risks. Increasing potassium intake, especially in the context of high sodium consumption, can significantly lower blood pressure and reduce salt sensitivity. The Dietary Approaches to Stop Hypertension (DASH) diet, rich in fruits, vegetables, low-fat dairy, whole grains, and lean proteins, has been shown to produce twice the blood pressure–lowering effect in Black adults compared with White adults.[33]

Physical activity also plays a critical role in hypertension management. While beneficial for all races, Black adults are less likely to engage in moderate-to-vigorous physical activity, increasing their risk of hypertension.[34] Encouraging increased physical activity in Black patients is likely to yield significant health benefits.

Lifestyle factors such as unhealthy diet and physical inactivity are strongly linked to obesity, which, in turn, is a major risk factor for hypertension in SSA. Findings from the H3Africa (Human Hereditary and Health in Africa) CHAIR (Cardiovascular H3Africa Innovation Resource) study, involving 30 044 participants across 13 African countries, demonstrated a consistent association between obesity and elevated rates of hypertension.[35] This aligns with numerous other studies on the continent,[36,37] further emphasizing the critical role of obesity in the region's hypertension burden. Race-informed dietary and lifestyle interventions, particularly those emphasizing potassium-rich diets and increased physical activity, should, therefore, be prioritized for Black adults with hypertension to achieve better health outcomes.

## THE HIGHER BURDEN OF HYPERTENSION IN BLACK POPULATIONS

Several theories have been advanced to explain possible reasons behind the higher burden of hypertension among African-origin populations. However, it must be emphasized that these theories are mostly based on diaspora Africans and may not be applicable, at least universally, to native sub-Saharan Africans. Some of the theories are highlighted in the following.

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## Primary Aldosteronism Is Common in Black Populations

Primary aldosteronism (PA) is a common cause of secondary hypertension, characterized by excessive aldosterone production leading to sodium retention, hypokalemia, and increased blood pressure. It is an independent risk factor for cardiovascular, renal, and metabolic diseases, whose early detection and targeted therapy could prevent complications in many patients with hypertension.[38] It has been previously underdiagnosed, especially in Black populations, but emerging evidence suggests that its prevalence may be higher than previously thought. In a prospective study of 88 consecutive patients referred to a specialist clinic for resistant hypertension, PA was present in 20% of patients, and the prevalence was similar between Black (23%) and White (18%).[39] These data are supported by data from the SABHA study (South African Burden of Hypertension Assessment), where a high prevalence of PA was identified in Black men in South Africa.[40] The genetics of PA in Black patients with hypertension is complex and differs in some important ways from other populations. A study by Nanba et al[41] found that somatic CACNA1D (Calcium Voltage-Gated Channel Subunit Alpha1 D) mutations were the most prevalent genetic alteration in Black patients with aldosterone-producing adenomas, followed by KCNJ5 mutations. This contrasts with European and East Asian populations, where KCNJ5 mutations are more common. Black individuals may also have a higher prevalence of bilateral adrenal hyperplasia, a subtype of PA, which may have a distinct genetic basis compared with unilateral aldosterone-producing adenomas. This may have important implications for their management, as medical therapy instead of surgery is preferred in those with bilateral adrenal hyperplasia.[42]

## Higher Salt Sensitivity and Salt Retention in Black Patients With Hypertension

Salt sensitivity plays a crucial role in the development of hypertension, especially among Black patients, in whom it is more pronounced compared with White individuals. Studies consistently show that Black individuals exhibit higher rates of salt sensitivity. For example, a crossover trial comparing ethnic differences in salt sensitivity found that hypertensive Black women experienced a greater increase in mean arterial pressure (12.6 versus 8.2 mm Hg) following high-salt intake, indicating a heightened sensitivity to sodium-induced blood pressure elevation.[43] In addition, a study in Nigeria demonstrated that pressure responses to acute salt loading were significantly higher in hypertensive (60.7%) compared with normotensive individuals (52.0%).[44] Several factors including genetic, epigenetic, environmental/social determinants, and diet have been implicated in renal, neural, and vascular mechanisms leading to salt-sensitive hypertension in Black patients.[45] A leading hypothesis for the increased salt sensitivity is through mutations in the ENaC (epithelial sodium channel),[46] which regulates sodium reabsorption in renal tubules. Furthermore, Black individuals, particularly women, exhibit increased oxidative stress and inflammation, which can impair endothelial function and exacerbate blood pressure elevation in response to salt intake.[47]

## Liddle Phenotype Tends To Be Higher in Black Populations

Liddle syndrome is a rare, monogenic form of hypertension characterized by excessive sodium reabsorption, hypokalemia, and low levels of renin and aldosterone despite elevated blood pressure levels. Although initially described in White populations, recent studies have highlighted a higher prevalence in individuals of African descent. In a study in South Africa, Black individuals were found to have significantly lower renin and aldosterone levels compared with their White counterparts, suggesting a genetic predisposition to sodium retention. Studies in South Africa have identified specific mutations in the *SCNN1B* gene, which encodes the β-subunit of ENaC, associated with Liddle syndrome.[42] The p.Arg563Gln (R563Q) mutation was found in 5.9% of hypertensive Black South Africans compared with 1.7% in normotensive individuals, suggesting a strong association with hypertension in this group.[48] This mutation was, however, notably absent in West African populations.

A recent study investigating hypertension in 3 African nations (Nigeria, Kenya, and South Africa) analyzed candidate genes linked to the Liddle phenotype in 14 individuals. The researchers identified 4 nonsynonymous variants in the *GRK4* gene (*R65L*, *A116T*, *A142V*, and *V486A*), with each patient carrying at least one. Notably, 3 of these variants had been previously linked to hypertension. The *SCNN1B* gene revealed 3 nonsynonymous variants (*R206Q*, *G442V*, and *R563Q*), 2 of which were previously known, with one associated with hypertension. The *NPPA* gene showed a novel nonsynonymous variant (*V32M*), while no variants were found in *NEDD4L*. Finally, the *UMOD* gene presented 3 nonsynonymous variants: *D25G*, *L180V*, and *T585I*.[49]

## HIV-Associated Hypertension

HIV remains a significant public health challenge in SSA, particularly in Eastern Africa and Southern Africa. The intersection of HIV and hypertension warrants greater attention, as their co-occurrence poses unique challenges for health care systems and patient outcomes. The mechanisms of hypertension in people living with HIV are complex and multifactorial. With effective antiretroviral therapy, people living with HIV are living longer, increasing the prevalence of age-related hypertension.[50] Some factors are HIV specific, and others are related to the effect of the antiretroviral therapy. During the asymptomatic phase, CD4+ cells

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decline, leading to gut dysbiosis and bacterial translocation, which exacerbate inflammation. This triggers inflammatory cytokines (eg, interleukin [IL]-17 and IL-6) and T-cell infiltration into organs such as the kidneys and liver, activating the RAS.[51] RAS that can also be activated by drugs, particularly by protease inhibitors, increases blood pressure through vasoconstriction, sodium retention, and aldosterone release.[52] In addition, ART-induced lipodystrophy and adipocyte proliferation promote macrophage infiltration, adipokine release, and insulin resistance, further impairing nitric oxide production, thereby leading to vasoconstriction and elevation of blood pressure.[53]

Chronic HIV infection begins with dendritic cells in the gastric-associated lymphoid tissue, which activate CD4+T cells. These, in turn, stimulate CD8+T cells, leading to arterial stiffness. Activated arterial endothelial cells promote the expression of adhesion molecules (intercellular Adhesion molecule [ICAM], vascular cell adhesion molecule [VCAM], and Platelet-derived growth factors [PDGF]) facilitating leukocyte adhesion to arterial walls and contributing to atherosclerosis.[54] Advanced infection involves HIV-1 glycoprotein 120 (gp120) increasing ET1 (endothelin-1) and reducing nitric oxide, causing vasoconstriction.[55] Furthermore, antiretrovital therapy (ART) and lifestyle changes in HIV-infected patients, such as central obesity, smoking, physical inactivity, and excessive alcohol intake also influence nitric oxide levels.[54]

## BARRIERS TO HYPERTENSION MANAGEMENT

The barriers to effective hypertension management in SSA are multiple and complex. Besides the health system barriers, there is also a lack of contextualized mechanistic research (Figure 1). Although there are concerns and growing calls to move away from race-based prescribing, this does not negate the need for further research to understand hypertension mechanisms, phenotypes, and drug responses in SSA, which are crucial to improving outcomes.

### Health System Barriers

To significantly reduce hypertension-related burden, there is a need to strengthen the entire hypertension care cascade from awareness (through screening and diagnosis) to treatment (including risk stratification and appropriate initiation of treatment) and ultimately to long-term control (which includes regular monitoring, ensuring medication adherence, and timely referral for specialist care if required).[56] The health system barriers to improving hypertension care occur at various levels impeding effective hypertension prevention, diagnosis, and management. These barriers are briefly discussed in the following.

#### *Individual-Level Barriers*

A major challenge often arises from the asymptomatic nature of hypertension. Many individuals are unaware of their hypertensive status until serious complications such as heart failure, stroke, or kidney disease occur. This lack of awareness is exacerbated by low health literacy, competing priorities such as income-generating activities or family obligations. In some settings, traditional health beliefs or spiritual interpretations of illness lead individuals to delay or avoid seeking care, instead turning to traditional healers or home remedies.[57–60] These

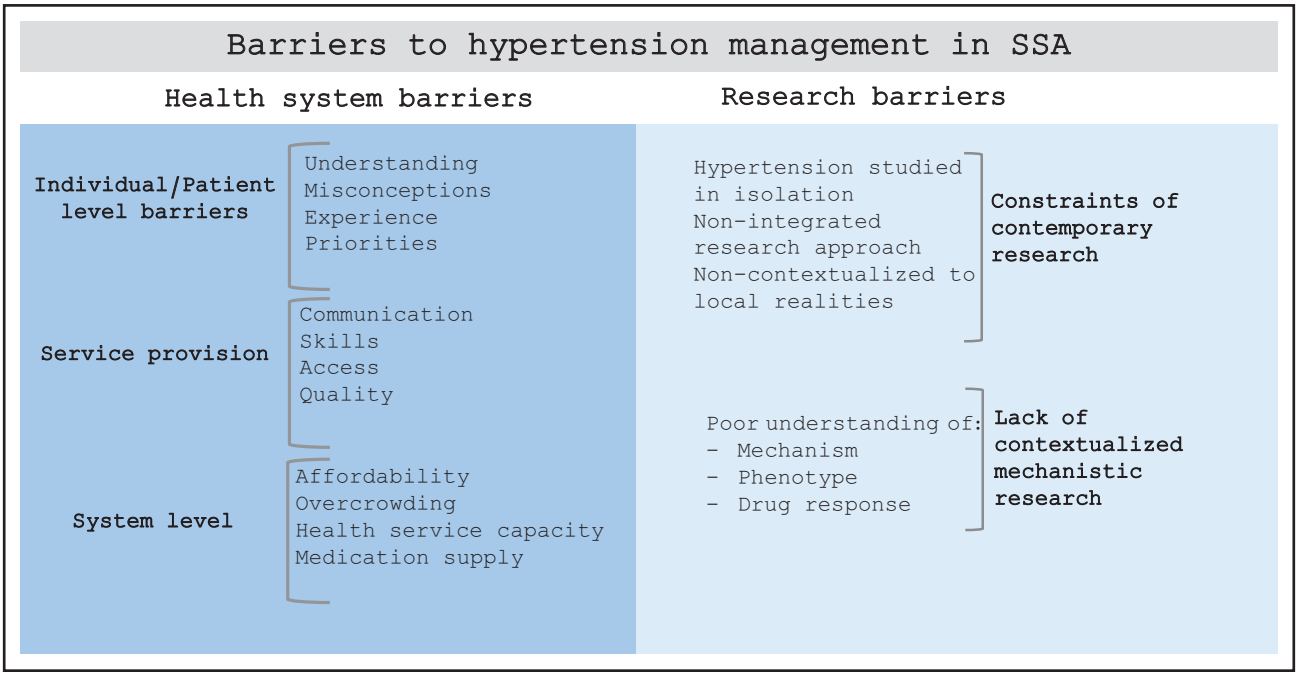


**Figure 1. Barriers to hypertension management in sub-Saharan Africa (SSA).**

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barriers are compounded by misconceptions about the cause of hypertension and the potential benefits of drug treatment. These perceptions highlight the need for community-based health education campaigns that not only raise awareness but also tackle prevailing myths and misconceptions.

### *Provider-Level Barriers*

One of the major challenges is the lack of adequately trained health care personnel, particularly in primary care and rural settings. Many health workers in SSA lack the training to accurately diagnose, risk-stratify, and manage hypertension according to current guidelines. Communication between health care workers and their patients is often sub-optimal. This, among others, leads to poor patient engagement with the health care system. In addition, some health facilities frequently lack sufficient basic resources, such as calibrated blood pressure machines, or laboratory services required for proper diagnosis, assessment, and monitoring.[60]

### *System-Level Barriers*

Several structural issues hamper the delivery of consistent, high-quality hypertension care. Access to health services is unevenly distributed, with rural and periurban populations facing difficulties due to long travel distances, poor transport infrastructure, and a shortage of health facilities. Overcrowding in urban public health clinics often results in long waiting times and short consultation durations, further deterring patients from seeking care unless symptoms are severe. In addition, health facilities across the continent frequently face limited, inconsistent, or insufficient supplies of antihypertensive medications. Even when treatment is available, it is often unaffordable, exacerbated by inadequate coverage from national health insurance schemes. Addressing these challenges requires urgent attention to the underinvestment in health care service capacity.[61]

## Research Barriers

### *Constraints of Contemporary Research Approaches*

There has been a lot of research on hypertension globally and, to some extent, in SSA. In the region especially, the current research approaches have 3 major limitations.

First, much of the research conducted to address noncommunicable diseases focuses on individual cardiovascular risk factors. However, hypertension rarely exists in isolation; it often coexists with other conditions such as diabetes, obesity, and dyslipidemia. This narrow research approach also overlooks the international consensus for an overall CVD risk assessment, which considers multiple cardiometabolic risk factors to guide risk evaluation and management.[62] Cardiovascular risk stratification in SSA requires tools and approaches that are simple, affordable, and tailored to low-income settings. The steps to developing such tools are, however, beyond the scope of this review. A few considerations are, nevertheless, worth mentioning. As the region often faces challenges such as limited health care infrastructure and a lack of diagnostic resources, easily measurable tools such as age, sex, blood pressure, and smoking status should be used to develop such tools. An example of this is the nonlaboratory-based World Health Organization (WHO)/International Society of Hypertension (ISH) Risk Prediction models.[63] Although useful, it has limitations such as excluding individuals under 40 years of age. Risk assessment tools should be developed using local data on prevalent risk factors and should account for the impact of infectious diseases and undernutrition on cardiovascular risk. In addition, mobile-based applications or digital tools that calculate region-specific risk scores should be developed to ensure ease of use and accessibility.

Second, existing research has predominantly focused on isolated implementation strategies at the facility or provider level. However, lessons from managing other chronic diseases, such as HIV in SSA, underscore the importance of adopting multifaceted, community-based approaches.[64] Initiatives such as the Addressing Cardiovascular Health Inequities in Emerging Settings and Populations project seek to address this gap in SSA.[65] This initiative introduces an innovative, ecosystem-driven strategy to tackle hypertension in Africa. The approach employs an iterative implementation cycle, focusing on creating and deploying context-specific solutions that address barriers and enhance facilitators. Central to this strategy is ensuring effective communication and active participation from all stakeholders involved in the implementation process.[66]

Finally, studies to date have failed to consider the broader health system context, hindering scale-up and sustainability. A contextualized community-based program that addresses overall cardiovascular disease risk through a combination of strategies has the potential to significantly improve cardiovascular disease outcomes in SSA, but evidence to guide such an approach is lacking. This is discussed in more detail in the following.

## Lack of Contextualized Mechanistic Research

There has been little research on the mechanisms, phenotypes, and drug response in SSA to understand and improve treatment outcomes in SSA. Most of such research in diasporan Africans has largely focused on the RAS. However, the role of the systemic RAS in the pathophysiology of hypertension in Black populations especially native Africans has been questioned. There are reports, mainly from diasporan Africans, of significantly lower levels of plasma renin in Black populations compared with White independent of age and blood pressure status.[67–69] Reports from Southern Africa show a lack of

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difference in renin levels in normotensive and hypertensive Black patients, further supporting the theory of low renin levels as being a feature in Black populations.[70] The low plasma renin levels in Black populations are attributed to their higher sodium retention and consequent decrease of renin release from the juxtaglomerular apparatus and suppression of the systemic RAS[71,72] (a phenotype that may have been selected among survivors of the slave trade sea crossings and that may, therefore, differ between diasporan and native Black Africans). This has major treatment implications such that drugs blocking the RAS are not recommended as monotherapy in Black patients in the absence of other compelling indications.[73] This treatment recommendation, however, is still a subject of controversy.[74]

The low plasma renin levels found in Black individuals may be paradoxical and misleading as the RAS may truly be activated at the tissue level in the kidney, which would then feedback via high sodium retention to suppress plasma renin levels.[75] The main sites of intrarenal RAS activation are the proximal and distal tubule and collecting duct segments of the nephron. As depicted in Figure 2, almost none of the plasma angiotensinogen and renin and little circulating angiotensin I and II (<10%) are filtered across the glomeruli.[76,77] However, the proximal tubule secretes angiotensinogen, which is converted to angiotensin I and subsequently angiotensin II through the actions of intrarenally derived renin- and angiotensin-converting enzymes. Both are also detected in the distal nephron and with spillover of angiotensinogen distally; this leads to enhanced angiotensin II production. Angiotensin II in the distal nephron (1) stimulates luminal AT1 (angiotensin II receptor type 1) receptors leading to enhanced sodium reabsorption and (2) synergistically enhances proximal sodium reabsorption rate. All these together with the effect of aldosterone result in the elevation of blood pressure. Angiotensin II also exerts a positive feedback action on intrarenal angiotensinogen mRNA and protein (therefore, resulting in higher angiotensinogen concentrations).[77,78] As a result, the angiotensinogen detected in the urine reflects overall kidney function and intrarenal RAS activity.

Despite the strong evidence for intrarenal activation as a driver of hypertension in Black people, it has not been comprehensively studied in African populations. There have only been 2 reports in African populations to the best of our knowledge. The first included a small sample size of 12 African men.[79] The other study, which included a larger sample size, predominantly included women and subjects with obesity, thus limiting its generalizability.[80] It is, therefore, crucial to conduct research on the RAS, which may offer valuable insights and improve treatment outcomes.

Besides research on the RAS, there is also a lack of data on PA in SSA. Most of the available evidence from

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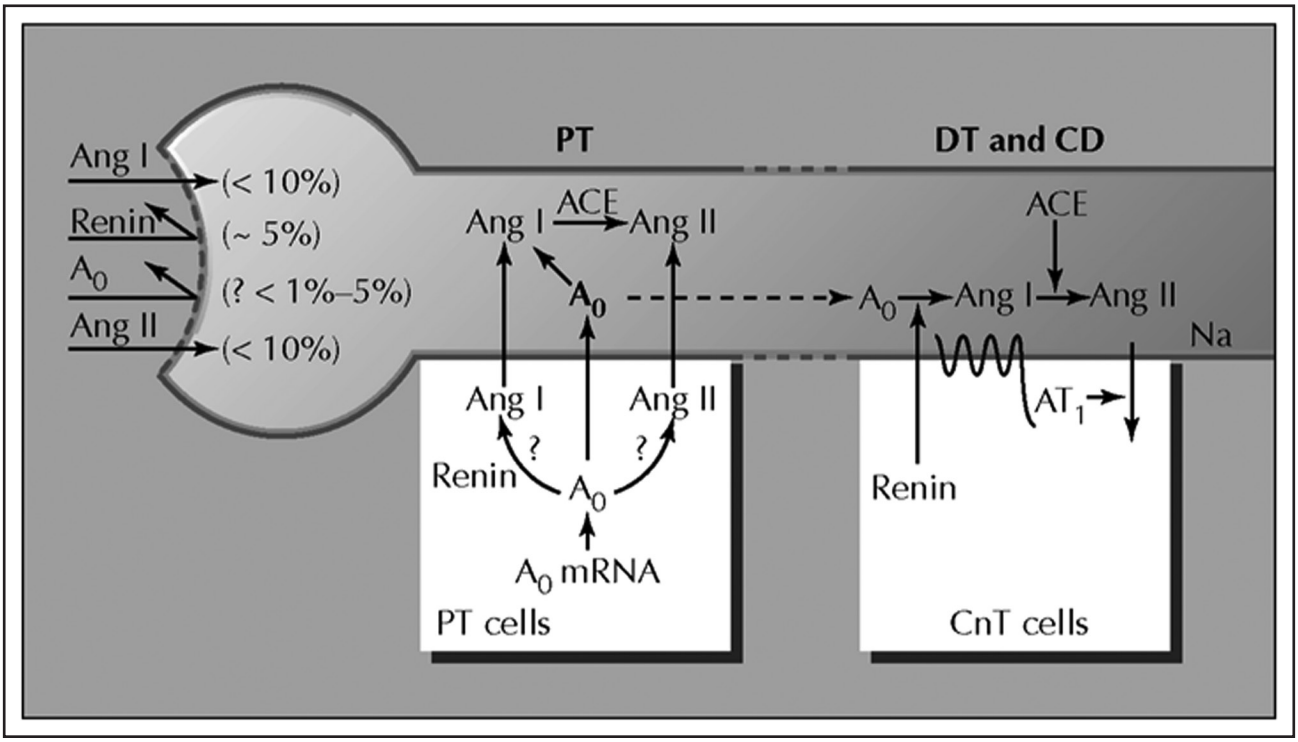


**Figure 2. Tubular renin-angiotensin system in proximal and distal nephron segments.**
In Ang (angiotensin) II hypertension, increased proximal tubular secretion of Ao (angiotensinogen) spills over into the distal nephron and increases Ang II effects on distal tubular reabsorption. ACE indicates angiotensin-converting enzyme; CD, collecting duct; CnT, connecting tubule; DT, distal tubule; and PT, proximal tubule. Reproduced from Navar et al[76] with permission from Springer Nature.

the continent is from Southern Africa. This may not represent the genetic diversity and environmental influences on the continent. Furthermore, more investment in diagnostic infrastructure is also required to provide access to sensitive assays for renin and aldosterone, which are mostly unavailable in many settings in Africa.

## ADDRESSING THE BARRIERS: PRACTICE AND POLICY APPROACHES

In the following, we discuss various practice and policy approaches to address the hypertension burden in SSA. These strategies encompass both preventive and clinical measures, each of which should be carefully considered.

### Preventative

The high prevalence of hypertension underscores the need for a coordinated, multisectoral approach to comprehensive noncommunicable disease prevention and control programs. Currently, population-wide strategies for preventing hypertension and other noncommunicable diseases are insufficient. Many existing programs in SSA remain predominantly clinical rather than preventative, and where preventative initiatives do exist, they are often limited to a few municipalities rather than being implemented on a broader, population-wide scale.[81] Without such intervention, the region's underresourced health systems are likely to face a significant burden of complications from target organ damage, including stroke, ischemic heart disease, and chronic kidney disease. These complications often affect the most productive age groups, leading to greater economic burden to individuals, their families and national economies, and premature mortality. A strategy developed using a participatory approach and reaching all sectors of society is urgently needed. A coordinated multipronged prevention program addressing 3 main areas should be considered.

1. Health and nutrition education and promotion: These programs have been shown to be effective in reducing the burden of noncommunicable diseases, including hypertension,[81–83] and should be adapted and embedded in school programs, workplaces, health facilities, and into community activities to achieve the maximum effect. These health programs could be delivered through electronic media (radio and television), print media (eg, newspapers), and other platforms. They should be led by relevant units within ministries of health, other government departments, and development partners. The World Health Organization recognizes and promotes this approach.[84]

This approach will empower individuals and communities with the knowledge needed to adopt healthier lifestyles, including understanding hypertension, its risk factors, and its consequences. It will also raise awareness about the importance of blood pressure screening for early detection and timely management. While not exhaustive, such programs should encourage healthy dietary habits, such as reducing salt intake, increasing consumption of potassium-rich foods, minimizing trans fats, and promoting physical activity. Importantly, these programs should be tailored to meet the specific needs of different populations. By addressing modifiable risk factors, these initiatives have the potential to significantly reduce the incidence of hypertension, help individuals better manage their condition, and reduce disparities in hypertension prevalence and outcomes, particularly among underserved and high-risk populations.[85]

2. Improve quality of food supply: This involves developing and implementing policies to enhance the processing and manufacturing of foods, increasing their availability and affordability. This critical public health strategy tackles key dietary risk factors for high blood pressure by ensuring access to healthier food options and reducing the availability of unhealthy foods. Countries should regulate or restrict the marketing of unhealthy foods, particularly to children, and implement front-of-package labeling systems, such as traffic light labels, to help consumers easily identify healthier choices. These labels should be designed to be clear and accessible, even to individuals with limited literacy. Efforts to increase the availability of fresh fruits and vegetables, such as supporting community gardens, are essential, especially in SSA, where they provide affordable, locally grown produce. In addition, taxing sugary drinks and other unhealthy products can effectively reduce their consumption.[86] Such measures have proven effective in lowering hypertension rates and preventing other cardiometabolic diseases.[87]
3. Transportation policy and environmental design: Countries in SSA have undergone rapid unplanned urbanization in recent years. Urbanization is strongly linked to hypertension and other cardiometabolic diseases. To address this, governments should implement robust policies to promote health-focused urban design. This includes creating environments that limit automobile dependency, encourage walking and cycling, and enhance public safety.[88] This can play a transformative role in improving cardiovascular health. By promoting active transportation, such as walking and cycling, and ensuring access to recreational spaces, communities can encourage regular physical activity. This not only helps lower blood pressure but also strengthens overall cardiovascular health. At the same time, creating quieter, greener, and more walkable environments can significantly reduce stress levels, which are a known contributor to hypertension. These calming spaces offer a respite

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from the hustle and bustle of urban life, fostering mental and physical well-being.[88]

## Clinical

1. Enhance screening: To the best of our knowledge, there is no formal policy for population-wide hypertension screening in SSA. Although opportunistic screening occurs during consultations in most health care settings,[89] this is not always available due to a lack of resources (eg, blood pressure monitors).[90,91] Blood pressure monitors should be made available in health care facilities to facilitate mass screening for both patients and healthy individuals seeking blood pressure checks. Evidence suggests that screening programs in nontraditional settings such as schools, places of worship (eg, mosques and churches), markets, and barbershops complement clinical consultations and serve as an effective strategy for identifying risk factors, detecting undiagnosed cases, and initiating appropriate treatment and long-term management.[92] A 3-year, community-based intervention program in Tunisia, which promoted physical activity, healthy dietary habits, and tobacco cessation, led to significant reductions in blood pressure and a decline in hypertension prevalence at the population level.[93] Similarly, in Ethiopia, health extension workers were trained as part of the multicomponent Health Extension Program to actively screen individuals in their communities to detect hypertension early.[94] These trained health extension workers were found to be as effective in detecting high blood pressure as trained health personnel.[95] Besides, this strategy has helped to overcome barriers such as distance and transportation costs to health facilities.[96] Such scalable programs could be adapted to other contexts in SSA. There are currently other initiatives to use community health workers and village health workers to improve detection and management of hypertension in SSA.[97,98]

Current evidence indicates that hypertension is highly prevalent across the continent and is increasingly affecting younger populations. Implementing a policy for periodic screening, including younger individuals, should be considered. This will require training and recruiting more health care personnel, as well as adopting task-shifting strategies to improve access to hypertension diagnosis and management.

2. Increase treatment access: Access to treatment should be improved to ensure that untreated patients receive treatment. As mentioned above, several barriers exist at both the individual and system levels. At the individual level, these include a lack of understanding about hypertension, fear of treatment, and reluctance to take medication, especially when symptoms are absent.[99] These challenges highlight the need for education on hypertension and the benefits of treatment. At the health system level, barriers include health care workers' limited understanding of guidelines or their reluctance to follow them. It is, therefore, essential to establish policies and training programs to ensure that health care workers adhere to standardized treatment protocols. In addition, training and recruitment of more health care personnel, as well as adopting task-shifting approaches to increase access to diagnosis and management of hypertension, are required. These approaches should be carefully planned and implemented with key considerations to ensure their success and sustainability. Engaging local communities is crucial, as it raises awareness and fosters their support and active participation.[100] In addition, such programs should be integrated into existing health systems or structures, such as primary health care clinics and HIV clinics, to facilitate scalability and long-term success, as has been demonstrated in Uganda and Tanzania.[101] This integration must be complemented by a strong commitment from health authorities and partner institutions to ensure that low-cost or free antihypertensive medications are consistently available and accessible to patients. However, this remains a significant challenge in many sub-Saharan African settings, where there are limited resources, reliance on donor funding, and competing health priorities. Success with this approach has been reported in other settings. A cluster-randomized controlled trial was conducted in rural districts in Bangladesh, Pakistan, and Sri Lanka to address poor hypertension treatment outcomes and control. The intervention, comprising mainly home blood pressure monitoring and counseling, was performed by trained government community health workers linked with public health care infrastructure and led to a greater reduction in blood pressure.[102]
3. Revisiting current treatment approaches: This requires a multifaceted approach, including the development of comprehensive strategies to strengthen support for patients and their caregivers. Adherence to treatment must be reinforced among those currently receiving care. Given that many patients receiving treatment fail to achieve optimal outcomes, current pharmacological treatment guidelines should be revisited to develop more effective therapies tailored to native African populations. Most guidelines recommend a combination of thiazide diuretics and calcium-channel blockers as first-line agents for Black patients, as these have been reported to be more effective than renin-angiotensin blockers.[103] However, such research is

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now being contested. Future research should also systematically evaluate health service and system structures, strengthen the evidence base for identifying individuals who would benefit most from treatment, and develop more effective risk stratification approaches suitable for low-income settings.

The WHO HEARTS technical package offers evidence-based guidelines for hypertension management in low-resource settings.[104] Adapting these strategies to SSA requires addressing the region's unique challenges. These include limited health care infrastructure, which was primarily designed for managing communicable diseases, conditions that often do not require long-term follow-up. To ensure scalability and sustainability, task shifting and capacity building should be prioritized, and hypertension care should be integrated into existing health systems.

## CONCLUSIONS

The current state of hypertension in SSA is a public health concern requiring urgent attention. Tangible and innovative research approaches are required to urgently address the rising trend and identify barriers to management, thereby improving treatment outcomes. A coordinated multisectoral approach including task shifting and task sharing will significantly improve prevention and increase case detection, treatment allocation, and outcomes. Finally, research should be streamlined and adapted to respond to priorities in SSA.

## ARTICLE INFORMATION

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## REFERENCES

1. Egan BM, Kjeldsen SE, Grassi G, Esler M, Mancia G. The global burden of hypertension exceeds 1.4 billion people: should a systolic blood pressure target below 130 become the universal standard? *J Hypertens*. 2019;37:1148–1153. doi: 10.1097/HJH.0000000000002021
2. Mills KT, Stefanescu A, He J. The global epidemiology of hypertension. *Nat Rev Nephrol*. 2020;16:223–237. doi: 10.1038/s41581-019-0244-2
3. Abbafati C, Abbas KM, Abbasi-Kangevari M, Abd-Allah F, Abdelalim A, Abdollahi 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;396:1223–1249. doi: 10.1016/S0140-6736(20)30752-2
4. Zhou B, Perel P, Mensah GA, Ezzati M. Global epidemiology, health burden and effective interventions for elevated blood pressure and hypertension. *Nat Rev Cardiol*. 2021;18:785–802. doi: 10.1038/s41569-021-00559-8
5. Jones DW, Clark DC. Hypertension (blood pressure) and lifetime risk of target organ damage. *Curr Hypertens Rep*. 2020;22:75. doi: 10.1007/s11906-020-01086-6
6. Mills KT, Bundy JD, Kelly TN, Reed JE, Kearney PM, Reynolds K, Chen J, He J. Global disparities of hypertension prevalence and control: a systematic analysis of population-based studies from 90 countries. *Circulation*. 2016;134:441–450. doi: 10.1161/CIRCULATIONAHA.115.018912
7. Peters MA, Noonan CM, Rao KD, Edward A, Alonge OO. Evidence for an expanded hypertension care cascade in low- and middle-income countries: a scoping review. *BMC Health Serv Res*. 2022;22:827. doi: 10.1186/s12913-022-08190-0
8. Zhou B, Bentham J, Di Cesare M, Bixby H, Danaei G, Cowan MJ. Worldwide trends in blood pressure from 1975 to 2015: a pooled analysis of 1479 population-based measurement studies with 19·1 million participants. *Lancet*. 2017;389:37–55. doi: 10.1016/S0140-6736(16)31919-5
9. Adeloye D, Basquill C. Estimating the prevalence and awareness rates of hypertension in Africa: a systematic analysis. *PLoS One*. 2014;9:e104300. doi: 10.1371/journal.pone.0104300
10. Geldsetzer P, Manne-Goehler J, Marcus ME, Ebert C, Zhumadilov Z, Wesseh CS, Tsabedze L, Supiyev A, Sturua L, Bahendeka SK, et al. The state of hypertension care in 44 low-income and middle-income countries: a cross-sectional study of nationally representative individual-level data from 1·1 million adults. *Lancet*. 2019;394:652–662. doi: 10.1016/S0140-6736(19)30955-9
11. Adane E, Atnafu A, Aschalew AY. The cost of illness of hypertension and associated factors at the University of Gondar Comprehensive Specialized Hospital Northwest Ethiopia, 2018. *Clinicoecon Outcomes Res*. 2020;12:133–140. doi: 10.2147/CEOR.S234674
12. Kirkland EB, Heincelman M, Bishu KG, Schumann SO, Schreiner A, Axon RN, Mauldin PD, Moran WP. Trends in healthcare expenditures among US adults with hypertension: national estimates, 2003-2014. *J Am Heart Assoc*. 2018;7:2003–2014. doi: 10.1161/JAHA.118.008731
13. Campbell NRC, Bovet P, Schutte AE, Lemogoum D, Nkwescheu AS. High blood pressure in sub-Saharan Africa: why prevention, detection, and control are urgent and important. *J Clin Hypertens (Greenwich)*. 2015;17:663–667. doi: 10.1111/jch.12599
14. Taha AM, Roshdy MR, Abdelma'amboud Mostafa H, Abdelazeem B. Ischemic heart disease in Africa: an overnight epidemiological transition. *Curr Probl Cardiol*. 2024;49:102337. doi: 10.1016/j.cpcardiol.2023.102337
15. Gallagher J, McDonald K, Ledwidge M, Watson CJ. Heart failure in sub-Saharan Africa. *Card Fail Rev*. 2018;4:21–24. doi: 10.15420/cfr.2018:4:1
16. Muntner P, He J, Cutler JA, Wildman RP, Whelton PK. Trends in blood pressure among children and adolescents. *JAMA*. 2004;291:2107–2113. doi: 10.1001/jama.291.17.2107
17. Lackland DT. Racial differences in hypertension: implications for high blood pressure management. *Am J Med Sci*. 2014;348:135–138. doi: 10.1097/MAJ.0000000000000308
18. Cooper R, Rotimi C, Ataman S, Mcgee D, Osotimehin B, Kadiri S, Muna W, Kingue S, Fraser H, Forrester T, et al. The prevalence of hypertension in seven populations of West African origin. *Am J Public Health*. 1997;87:160–168. doi: 10.2105/ajph.87.2.160
19. Woodiwiss AJ, Orchard A, Mels CMC, Uys AS, Nkeh-Chungag BN, Kolkenbeck-Ruh A, Ware LJ, Yates S, Jones ESW, Peterson VR, et al. High prevalence but lack of awareness of hypertension in South Africa, particularly among men and young adults. *J Hum Hypertens*. 2025;39:111–119. doi: 10.1038/s41371-023-00873-3
20. Gu A, Yue Y, Desai RP, Argulian E. Racial and ethnic differences in antihypertensive medication use and blood pressure control among US adults with hypertension: the National Health and Nutrition Examination Survey, 2003 to 2012. *Circ Cardiovasc Qual Outcomes*. 2017;10:1–10. doi: 10.1161/CIRCOUTCOMES.116.003166
21. Gomez F, Hirbo J, Tishkoff SA. Genetic variation and adaptation in Africa: Implications for human evolution and disease. *Cold Spring Harb Perspect Biol*. 2014;6:a008524–a008524. doi: 10.1101/cshperspect.a008524

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22. Mabhida SE, Mashatola L, Kaur M, Sharma JR, Apalata T, Muhamed B, Benjeddou M, Johnson R. Hypertension in African populations: review and computational insights. *Genes (Basel)*. 2021;12:532. doi: 10.3390/genes12040532
23. Carey RM, Schoeffel CD, Gildea JJ, Jones JE, McGrath HE, Gordon LN, Park MJ, Sobota RS, Underwood PC, Williams J, et al. Salt sensitivity of blood pressure is associated with polymorphisms in the sodium-bicarbonate cotransporter. *Hypertension*. 2012;60:1359–1366. doi: 10.1161/HYPERTENSIONAHA.112.196071
24. Cooper RS, Wolf-Maier K, Luke A, Adeyemo A, Banega JR, Forrester T, Giampaoli S, Joffres M, Kastarinen M, Primatesta P, et al. An international comparative study of blood pressure in populations of European vs. African descent. *BMC Med*. 2005;3:2. doi: 10.1186/1741-7015-3-2
25. Williams B, Mancia G, Spiering W, Agabiti Rosei E, Azizi M, Burnier M, Clement DL, Coca A, de Simone G, Dominiczak A, et al. 2018 ESC/ESH guidelines for the management of arterial hypertension: the Task Force for the Management of Arterial Hypertension of the European Society of Cardiology (ESC) and the European Society of Hypertension (ESH). *Eur Heart J*. 2018;39:3021–3104. doi: 10.1093/eurheartj/ehy339
26. M'Buyamba-Kabangu JR, Anisiuba BC, Ndiaye MB, Lemogoum D, Jacobs L, Ijoma CK, Thijs L, Boombhi HJ, Kaptue J, Kolo PM, et al; Newer Versus Older Antihypertensive Agents in African Hypertensive Patients Trial (NOAAH) Investigators. Efficacy of newer versus older antihypertensive drugs in black patients living in sub-Saharan Africa. *J Hum Hypertens*. 2013;27:729–735. doi: 10.1038/jhh.2013.56
27. Ojji DB, Mayosi B, Francis V, Badri M, Cornelius V, Smythe W, Kramer N, Barasa F, Damasceno A, Dzudie A, et al; CREOLE Study Investigators. Comparison of dual therapies for lowering blood pressure in black Africans. *N Engl J Med*. 2019;380:2429–2439. doi: 10.1056/NEJMoa1901113
28. Unger T, Borghi C, Charchar F, Khan NA, Poulter NR, Prabhakaran D, Ramirez A, Schlaich M, Stergiou GS, Tomaszewski M, et al. 2020 International Society of Hypertension Global Hypertension Practice Guidelines. *Hypertension*. 2020;75:1334–1357. doi: 10.1161/HYPERTENSIONAHA.120.15026
29. Mancia G, Kreutz R, Brunström M, Burnier M, Grassi G, Januszewicz A, Muiesan ML, Tsioufis K, Agabiti-Rosei E, Algharably EAE, et al. 2023 ESH guidelines for the management of arterial hypertension: the Task Force for the Management of Arterial Hypertension of the European Society of Hypertension: endorsed by the International Society of Hypertension (ISH) and the European Renal Associat. *J Hypertens*. 2023;41:1874–2071. doi: 10.1097/HJH.0000000000003480
30. Flack JM, Bitner S, Buhnerkempe M. Evolving the role of black race in hypertension therapeutics. *Am J Hypertens*. 2024;37:739–744. doi: 10.1093/ajh/hpae093
31. Bartolome RE, Chen A, Handler J, Platt ST, Gould B. Population care management and team-based approach to reduce racial disparities among African Americans/Blacks with hypertension. *Perm J*. 2016;20:53–59. doi: 10.7812/TPP/15-052
32. Cogswell ME, Loria CM, Terry AL, Zhao L, Wang CY, Chen TC, Wright JD, Pfeiffer CM, Merritt R, Moy CS, et al. Estimated 24-hour urinary sodium and potassium excretion in US Adults. *JAMA*. 2018;319:1209–1220. doi: 10.1001/jama.2018.1156
33. Rank S Acks FM, Aura S Vetkey LP, Illiam V Ollmer WM, Awrence A Ppel LJ, Eorge B Ray GA, Avid Arsha DH, et al. Effects on blood pressure of reduced dietary sodium and the dietary approaches to stop hypertension (DASH) diet. DASH-Sodium Collaborative Research Group. *N Engl J Med*. 2001;344:3–110. doi: 10.1056/NEJM200101043440101
34. Keadle SK, McKinnon R, Graubard BI, Troiano RP. Prevalence and trends in physical activity among older adults in the United States: a comparison across three national surveys. *Prev Med*. 2016;89:37–43. doi: 10.1016/j.ypmed.2016.05.009
35. Akpa OM, Made F, Ojo A, Ovbiagele B, Adu D, Motala AA, Mayosi BM, Adebamowo SN, Engel ME, Tayo B, et al; as members of the CVD Working Group of the H3Africa Consortium. Regional patterns and association between obesity and hypertension in Africa: evidence from the H3Africa CHAIR study. *Hypertension*. 2020;75:1167–1178. doi: 10.1161/HYPERTENSIONAHA.119.14147
36. Jobe M, Mactaggart I, Bell S, Kim MJ, Hydara A, Bascaran C, Njai M, Badjie O, Perel P, Prentice AM, et al. Prevalence of hypertension, diabetes, obesity, multimorbidity, and related risk factors among adult Gambians: a cross-sectional nationwide study. *Lancet Glob Health*. 2024;12:e55–e65. doi: 10.1016/S2214-109X(23)00508-9
37. Muluvhu TC, Monyeki MA, Strydom GL, Toriola AL. Relationship between obesity and blood pressure among employees in the Vhembe district municipality of Limpopo Province, South Africa. *Cardiovasc J Afr*. 2019;30:361–368. doi: 10.5830/CVJA-2019-035
38. Turcu AF, Yang J, Vaidya A. Primary aldosteronism — a multidimensional syndrome. *Nature Research*. 2022;18:665–682. doi: 10.1038/s41574-022-00730-2
39. Calhoun DA, Nishizaka MK, Zaman MA, Thakkar RB, Weissmann P. Hyperaldosteronism among black and white subjects with resistant hypertension. *Hypertension*. 2002;40:892–896. doi: 10.1161/01.hyp.0000040261.30455.b6
40. van Rooyen JM, Poglitsch M, Huisman HW, Gafane-Matemane LF, Breet Y, Malan L. A primary aldosteronism-like phenotype identified with the aldosterone-to-angiotensin II ratio in black men: The SABPA study. *Cardiovasc J Afr*. 2020;31:130–135. doi: 10.5830/CVJA-2019-059
41. Nanba K, Omata K, Gomez-Sanchez CE, Stratakis CA, Demidowich AP, Suzuki M, Thompson LDR, Cohen DL, Luther JM, Gellert L, et al. Genetic characteristics of aldosterone-producing adenomas in blacks. *Hypertension* 2019;73:885–892. doi: 10.1161/HYPERTENSIONAHA.118.12070
42. Spence JD, Rayner BL. Hypertension in Blacks: individualized therapy based on renin/aldosterone phenotyping. *Hypertension*. 2018;72:263–269. doi: 10.1161/HYPERTENSIONAHA.118.11064
43. Wright JT, Rahman M, Scarpa A, Fatholahi M, Griffin V, Jean-Baptiste R, Islam M, Eissa M, White S, Douglas JG. Determinants of salt sensitivity in black and white normotensive and hypertensive women. *Hypertension*. 2003;42:1087–1092. doi: 10.1161/01.HYP.0000101687.89160.19
44. Elias SO, Azinge EC, Umoren GA, Jaja SI, Sofola OA. Salt-sensitivity in normotensive and hypertensive Nigerians. *Nig Q J Hosp Med*. 2011;21:85–91.
45. Elijovich F, Kirabo A, Laffer CL. Salt sensitivity of blood pressure in black people: the need to sort out ancestry versus epigenetic versus social determinants of its causation. *Hypertension*. 2024;81:456–467. doi: 10.1161/HYPERTENSIONAHA.123.17951
46. Sofola OA, Elias SO, Azinge EA, Oloyo AK. Salt intake, salt sensitivity and hypertension in Nigerians: an overview. *Proc Nigerian Acad Sci*. 2013;6:1–9. doi: 10.57046/CYVS4114
47. Sahinoz M, Elijovich F, Ertuglu LA, Ishimwe J, Pitzer A, Saleem M, Mwesigwa N, Kleyman TR, Laffer CL, Kirabo A. Salt sensitivity of blood pressure in Blacks and women: a role of inflammation, oxidative stress, and epithelial $Na^+$ channel. *Antioxid Redox Signal*. 2021;35:1477–1493. doi: 10.1089/ars.2021.0212
48. Jones ESW, Patricia Owen E, Rayner BL. The association of the R563Q genotype of the ENaC with phenotypic variation in southern Africa. *Am J Hypertens*. 2012;25:1286–1291. doi: 10.1038/ajh.2012.125
49. Jones ES, Spence JD, McIntyre AD, Nondi J, Gogo K, Akintunde A, Hackam DG, Rayner BL. High frequency of variants of candidate genes in black Africans with low renin-resistant hypertension. *Am J Hypertens*. 2017;30:478–483. doi: 10.1093/ajh/hpw167
50. Davis K, Perez-Guzman P, Hoyer A, Brinks R, Gregg E, Althoff KN, Justice AC, Reiss P, Gregson S, Smit M. Association between HIV infection and hypertension: a global systematic review and meta-analysis of cross-sectional studies. *BMC Med*. 2021;19:228. doi: 10.1186/s12916-021-02112-3
51. Zevin AS, McKinnon L, Burgener A, Klatt NR. Microbial translocation and microbiome dysbiosis in HIV-associated immune activation. *Curr Opin HIV AIDS*. 2016;11:182–190. doi: 10.1097/COH.0000000000000234
52. Boccara F, Auclair M, Cohen A, Lefèvre C, Prot M, Bastard JP, Capeau J, Caron-Debarle M. HIV protease inhibitors activate the adipocyte renin angiotensin system. *Antivir Ther*. 2010;15:363–375. doi: 10.3851/IMP1533
53. Freitas P, Carvalho D, Santos AC, Madureira AJ, Xerinda S, Martinez E, Pereira J, Sarmento A, Medina JL. Central/peripheral fat mass ratio is associated with increased risk of hypertension in HIV-infected patients. *J Clin Hypertens (Greenwich)*. 2012;14:593–600. doi: 10.1111/j.1751-7176.2012.00671.x
54. Prakash P, Swami Vetha BS, Chakraborty R, Wenegieme TY, Masenga SK, Muthian G, Balasubramaniam M, Wanjalla CN, Hinton AO, Kirabo A, et al. HIV-associated hypertension: risks, mechanisms, and knowledge gaps. *Circ Res*. 2024;134:e150–e175. doi: 10.1161/circresaha.124.323979
55. Anand AR, Rachel G, Parthasarathy D. HIV proteins and endothelial dysfunction: implications in cardiovascular disease. *Front Cardiovasc Med*. 2018;5:185. doi: 10.3389/fcvm.2018.00185
56. Wozniak G, Khan T, Gillespie C, Sifuentes L, Hasan O, Ritchey M, Kmetik K, Wynia M. Hypertension control cascade: a framework to improve hypertension awareness, treatment, and control. *J Clin Hypertens (Greenwich)*. 2016;18:232–239. doi: 10.1111/jch.12654
57. Herbst AG, Olds P, Nuwagaba G, Okello S, Haberer J. Patient experiences and perspectives on hypertension at a major referral hospital in rural southwestern Uganda: a qualitative analysis. *BMJ Open*. 2021;11:e040650. doi: 10.1136/bmjopen-2020-040650


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58. Lasco G, Mendoza J, Renedo A, Seguin ML, Palafox B, Palileo-Villanueva LM, Amit AML, Dans AL, Balabanova D, McKee M. Nasa dugo ('It's in the blood'): lay conceptions of hypertension in the Philippines. *BMJ Glob Health*. 2020;5:e002295–e002298. doi: 10.1136/bmjgh-2020-002295
59. Manavalan P, Minja L, Wanda L, Hertz JT, Thielman NM, Okeke NL, Mmbaga BT, Watt MH. "It's because I think too much": perspectives and experiences of adults with hypertension engaged in HIV care in northern Tanzania. *PLoS One*. 2020;15:e0243059–e0243015. doi: 10.1371/journal.pone.0243059
60. Heller DJ, Kumar A, Kishore SP, Horowitz CR, Joshi R, Vedanthan R. Assessment of barriers and facilitators to the delivery of care for noncommunicable diseases by nonphysician health workers in low- and middle-income countries: a systematic review and qualitative analysis. *JAMA Netw Open*. 2019;2:e1916545. doi: 10.1001/jamanetworkopen.2019.16545
61. Sarfo FS, Mobula LM, Burnham G, Ansong D, Plange-Rhule J, Sarfo-Kantanka O, Ofori-Adjei D. Factors associated with uncontrolled blood pressure among Ghanaians: Evidence from a multicenter hospital-based study. *PLoS One*. 2018;13:e0193494–e0193419. doi: 10.1371/journal.pone.0193494
62. Visseren F, Mach F, Smulders YM, Carballo D, Koskinas KC, Bäck M, Benetos A, Biffi A, Boavida J-M, Capodanno D, et al. 2021 ESC guidelines on cardiovascular disease prevention in clinical practice. *Eur Heart J*. 2021;42:3227–3337. doi: 10.1093/eurheartj/ehab484
63. WHO. *World Health Organization/International Society of Hypertension Risk Prediction Charts for 14 WHO Epidemiological Sub-Regions WHO*; 2007.
64. Vogt F, Kalenga L, Lukela J, Salumu F, Diallo I, Nico E, Lampart E, Van den Bergh R, Shah S, Ogundahunsi O, et al. Decentralizing art supply for stable HIV patients to community-based distribution centers: program outcomes from an urban context in Kinshasa, DRC. *J Acquir Immune Defic Syndr*. 2017;74:326–331. doi: 10.1097/QAI.0000000000001215
65. Bayaraa N, Mohd Azahar N, Kitaoka K, Kobayashi Y, Yano Y. African Control of Hypertension Through Innovative Epidemiology and a Vibrant Ecosystem (ACHIEVE): a holistic approach for hypertension control in Africa. *J Hum Hypertens*. 2025;39:83. doi: 10.1038/s41371-023-00828-8
66. Owolabi M, Olowoyo P, Mocumbi A, Ogah OS, Odili A, Wahab K, Ojji D, Adeoye AM, Akinyemi R, Akpalu A, et al. African Control of Hypertension Through Innovative Epidemiology and a Vibrant Ecosystem (ACHIEVE): novel strategies for accelerating hypertension control in Africa. *J Hum Hypertens*. 2023;39:86. doi: 10.1038/s41371-023-00828-8
67. Williams SF, Nicholas SB, Vaziri ND, Norris KC. African Americans, hypertension and the renin angiotensin system. *World J Cardiol*. 2014;6:878–889. doi: 10.4330/wjc.v6.i9.878
68. Tu W, Eckert GJ, Pratt JH, Jan Danser AH. Plasma levels of prorenin and renin in Blacks and Whites: their relative abundance and associations with plasma aldosterone concentration. *Am J Hypertens*. 2012;25:1030–1034. doi: 10.1038/ajh.2012.83
69. Gafane-Matemane LF, Mokae NL, Breet Y, Malan L. Relation of the renin–angiotensin–aldosterone system with potential cardiac injury and remodelling: the SABPA study. *Blood Press*. 2020;29:31–38. doi: 10.1080/08037051.2019.1645587
70. Sever PS, Gordon D, Peart WS, Beighton P. Blood-pressure and its correlates in urban and Tribal Africa. *Lancet*. 1980;316:60–64. doi: 10.1016/s0140-6736(80)92940-2
71. Williams SK, Ravenell J, Seyedali S, Nayef S, Ogedegbe G. Hypertension treatment in Blacks: discussion of the U.S. clinical practice guidelines. *Prog Cardiovasc Dis*. 2016;59:282–288. doi: 10.1016/j.pcad.2016.09.004
72. Sagnella GA. Why is plasma renin activity lower in populations of African origin? *J Hum Hypertens*. 2001;15:17–25. doi: 10.1038/sj.jhh.1001127
73. NICE. Hypertension in adults: diagnosis and management: National Institute for Health and Clinical Excellence. NICE; 2019. https://www.nice.org.uk/guidance/ng136
74. Sinnott SJ, Douglas IJ, Smeeth L, Williamson E, Tomlinson LA. First line drug treatment for hypertension and reductions in blood pressure according to age and ethnicity: Cohort study in UK primary care. *BMJ*. 2020;371:m4080–m4010. doi: 10.1136/bmj.m4080
75. Price DA, Fisher NDL. The renin-angiotensin system in Blacks: active, passive, or what? *Curr Hypertens Rep*. 2003;5:225–230. doi: 10.1007/s11906-003-0025-x
76. Kobori H, Alper AB, Shenava R, Katsurada A, Saito T, Ohashi N, Urushihara M, Miyata K, Satou R, Hamm LL, et al. Urinary angiotensinogen as a novel biomarker of the intrarenal renin-angiotensin system status in hypertensive patients. *Hypertension*. 2009;53:344–350. doi: 10.1161/HYPERTENSIONAHA.108.123802
77. Navar LG, Kobori H, Prieto-Carrasquero M. Intrarenal angiotensin II and hypertension. *Curr Hypertens Rep*. 2003;5:135–143. doi: 10.1007/s11906-003-0070-5
78. Kobori H, Nangaku M, Navar LG, Nishiyama A. The intrarenal renin-angiotensin system: from physiology to the pathobiology of hypertension and kidney disease. *Pharmacol Rev*. 2007;59:251–287. doi: 10.1124/pr.59.3.3
79. Kobori H, Urushihara M, Xu JH, Berenson GS, Navar LG. Urinary angiotensinogen is correlated with blood pressure in men (Bogalusa Heart Study). *J Hypertens*. 2010;28:1422–1428. doi: 10.1097/HJH.0b013e3283392673
80. Michel FS, Norton GR, Maseko MJ, Majane OHI, Sareli P, Woodiwiss AJ. Urinary angiotensinogen excretion is associated with blood pressure independent of the circulating renin-angiotensin system in a group of African ancestry. *Hypertension*. 2014;64:149–156. doi: 10.1161/HYPERTENSIONAHA.114.03336
81. Owusu MF, Adu J, Dortey BA, Gyamfi S, Martin-Yeboah E. Exploring health promotion efforts for non-communicable disease prevention and control in Ghana. *PLOS Global Public Health*. 2023;3:e0002408. doi: 10.1371/journal.pgph.0002408
82. Mondal R, Sarker RC, Acharya NP, Banik PC. Effectiveness of health education-based conventional intervention method to reduce noncommunicable diseases risk factors among rural population. *Cardiovasc Diagn Ther*. 2019;9:30–34. doi: 10.21037/cdt.2018.10.09
83. Talwar KK, Grover A, Thakur JS. Role of medical education in preventing and control of noncommunicable diseases in India. *Indian J Community Med*. 2011;36(SUPPL.):S63. doi: 10.4103/0970-0218.94711
84. *Health Literacy Development for the Prevention and Control of Noncommunicable Diseases: Volume 1. Overview*. Geneva: World Health Organization; 2022.
85. Shin J, Konlan KD, Mensah E. Health promotion interventions for the control of hypertension in Africa, a systematic scoping review from 2011 to 2021. *PLoS One*. 2021;16:e0260411. doi: 10.1371/journal.pone.0260411
86. Valizadeh P, Ng SW. Promoting healthier purchases: ultraprocessed food taxes and minimally processed foods subsidies for the low income. *Am J Prev Med*. 2024;67:3–14. doi: 10.1016/j.amepre.2024.02.019
87. Oladele CR, Khandpur N, Johnson S, Yuan Y, Wambugu V, Plante TB, Lovasi GS, Judd S. Ultraprocessed food consumption and hypertension risk in the REGARDS cohort study. *Hypertension*. 2024;81:2520. doi: 10.1161/HYPERTENSIONAHA.123.22341
88. Lowe M, Adlakha D, Sallis JF, Salvo D, Cerin E, Moudon AV, Higgs C, Hinckson E, Arundel J, Boeing G, et al. City planning policies to support health and sustainability: an international comparison of policy indicators for 25 cities. *Lancet Glob Health*. 2022;10:e882–e894. doi: 10.1016/S2214-109X(22)00069-9
89. Sartorello A, Benoni R, Ramirez L, Mundjane A, Kalombola F, Ramos A, Meque E, Massaro P, Jessen N, Putoto G, et al. Effectiveness of the hypertension screening corner in enhancing the cascade of care at primary healthcare center level: evidence from Zambezia, Mozambique. *Glob Heart*. 2024;19:58. doi: 10.5334/gh.1339
90. Gafane-Matemane LF, Mokwatsi GG, Boateng D. Hypertension management in sub-Saharan Africa: an overview of challenges and opportunities for telemedicine. *Connected Health*. 2023;2:9–22. doi: 10.20517/ch.2022.21
91. Cappuccio FP, Miller MA. Cardiovascular disease and hypertension in sub-Saharan Africa: burden, risk and interventions. *Intern Emerg Med*. 2016;11:299–305. doi: 10.1007/s11739-016-1423-9
92. Legorreta AP, Schaff SR, Leibowitz AN, Van Meijgaard J. Measuring the effects of screening programs in asymptomatic employees: detection of hypertension through worksite screenings. *J Occup Environ Med*. 2015;57:682–686. doi: 10.1097/JOM.0000000000000434
93. Ghammam R, Maatoug J, Harrabi I, Ben Fredj S, Zammit N, Laatikainen T, Vartiainen E, Neupane D, Ghannem H. Effectiveness of a 3-year community-based intervention for blood pressure reduction among adults: a repeated cross-sectional study with a comparison area. *J Hum Hypertens*. 2024;38:336–344. doi: 10.1038/s41371-022-00672-2
94. Teshome DF, Alemu S, Ayele TA, Atnafu A, Gelaye KA. Effect of health extension workers led home-based intervention on hypertension management in Northwest Ethiopia, 2021: study protocol for a cluster randomised controlled trial. *BMJ Open*. 2022;12:e051178. doi: 10.1136/bmjopen-2021-051178
95. Teshome DF, Balcha SA, Ayele TA, Atnafu A, Sisay M, Asfaw MG, Mitike G, Gelaye KA. Trained health extension workers correctly identify high blood pressure in rural districts of northwest Ethiopia: a diagnostic accuracy study. *BMC Health Serv Res*. 2022;22:375. doi: 10.1186/s12913-022-07794-w
96. Teshome DF, Alemu S, Ayele TA, Atnafu A, Gelaye KA. Effect of health extension workers-led home-based multicomponent intervention on blood pressure reduction among hypertensive patients in rural districts of northwest Ethiopia: a cluster-randomised controlled trial. *BMJ Open*. 2024;14:e084029. doi: 10.1136/bmjopen-2024-084029


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97. Gerber F, Gupta R, Lejone TI, Tahirsylaj T, Lee T, Sanchez-Samaniego G, Kohler M, Haldemann M-I, Raeber F, Chitja M, et al. Community-based management of arterial hypertension and cardiovascular risk factors by lay village health workers for people with controlled and uncontrolled blood pressure in rural Lesotho: joint protocol for two cluster-randomized trials within the ComBaCaL cohort study (ComBaCaL aHT Twic 1 and ComBaCaL aHT TwiC 2). *Trials*. 2024;25:365. doi: 10.1186/s13063-024-08226-2
98. Perkins AD, Awori JO, Jobe M, Lucinde RK, Siemonsma M, Oyando R, Leon DA, Herrett E, Prentice AM, Shah Anoop SV, et al; The IHCoR-Africa Collaborators. Determining the optimal diagnostic and risk stratification approaches for people with hypertension in two rural populations in Kenya and The Gambia: a study protocol for IHCoR-Africa Work Package 2. *NIHR Open Research*. 2024;3:68. doi: 10.3310/nihropenres.13509.2
99. Jeemon P, Séverin T, Amodeo C, Balabanova D, Campbell NRC, Gaita D, Kario K, Khan T, Melifonwu R, Moran A, et al. World heart federation roadmap for hypertension – A 2021 update. *Glob Heart*. 2021;16:63. doi: 10.5334/gh.1066
100. Naanyu V, Njuguna B, Koros H, Andesia J, Kamano J, Mercer T, Bloomfield G, Pastakia S, Vedanthan R, Akwanalo C. Community engagement to inform development of strategies to improve referral for hypertension: perspectives of patients, providers and local community members in western Kenya. *BMC Health Serv Res*. 2023;23:854. doi: 10.1186/s12913-023-09847-0
101. Birungi J, Kivuyo S, Garrib A, Mugenyi L, Mutungi G, Namakoola I, Mghamba J, Ramaiya K, Wang D, Maongezi S, et al. Integrating health services for HIV infection, diabetes and hypertension in sub-Saharan Africa: a cohort study. *BMJ Open*. 2021;11:e053412. doi: 10.1136/bmjopen-2021-053412
102. Jafar TH, Gandhi M, de Silva HA, Jehan I, Naheed A, Finkelstein EA, Turner EL, Morisky D, Kasturiratne A, Khan AH, et al; COBRA-BPS Study Group. A community-based intervention for managing hypertension in rural South Asia. *N Engl J Med*. 2020;382:717–726. doi: 10.1056/NEJMoa1911965
103. Whelton PK, Carey RM, Aronow WS, Casey DE, Collins KJ, Himmelfarb CD, DePalma SM, Gidding S, Jamerson KA, Jones DW, et al. ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA Guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *J Am Coll Cardiol*. 2018;71:e127–e248. doi: 10.1016/j.jacc.2017.11.005
104. Khan T, Moran AE, Perel P, Whelton PK, Brainin M, Feigin V, Kostova D, Richter P, Ordunez P, Hennis A, et al. The HEARTS partner forum—supporting implementation of HEARTS to treat and control hypertension. *Front Public Health*. 2023;11:1146441. doi: 10.3389/fpubh.2023.1146441

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