Regional and Sex Differences in the Prevalence and Awareness of Hypertension

An H3Africa AWI-Gen Study Across 6 Sites in Sub-Saharan Africa

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ABSTRACT

Background: There is a high prevalence of hypertension and related cardiovascular diseases in sub-Saharan Africa, yet few large studies exploring hypertension in Africa are available. The actual burden of disease is poorly understood and awareness and treatment to control it is often suboptimal.

Objectives: The study sought to report the prevalence of measured hypertension and to assess awareness and control of blood pressure among older adults in rural and urban settings in 6 sites located in West, East, and Southern Africa. In addition, we examined regional, sex, and age differences related to hypertension.

Methods: A population-based cross-sectional study was performed at 6 sites in 4 African countries: Burkina Faso (Nanoro), Ghana (Navrongo), Kenya (Nairobi), and South Africa (Agincourt, Dikgale, Soweto). Blood pressure measurements were taken using standardized procedures on 10,696 adults 40 to 60 years of age. Hypertension was defined as systolic blood pressure ≥140 mm Hg or diastolic blood pressure ≥90 mm Hg or taking antihypertensive medication.

Results: The mean prevalence of hypertension ranged from 15.1% in Nanoro to 54.1% in Soweto. All 3 of the South African sites had a mean prevalence of hypertension of over 40.0%, significantly higher than in Nairobi (25.6%) and Navrongo (24.5%). Prevalence increased with age in both sexes and at all sites. A significantly higher prevalence of hypertension was observed in women in Agincourt, Dikgale, and Nairobi, whereas in Nanoro this trend was reversed. Within the hypertensive group the average proportion of participants who were aware of their blood pressure status was only 39.4% for men and 53.8% for women, and varied widely across sites.

Conclusions: Our study demonstrates that the prevalence of hypertension and the level of disease awareness differ not only between but also within sub-Saharan African countries. Each nation must tailor their regional hypertension awareness and screening programs to match the characteristics of their local populations.

Hypertension is a rising global health problem, with an estimated 1 billion people living with hypertension, and 9.4 million related annual deaths worldwide [1,2]. Low- and middle-income countries suffer two-thirds of the global burden of cardiovascular disease (CVD), which is associated with inadequate treatment of hypertension [3]. In sub-Saharan Africa (SSA) hypertension has become a major public health problem [4,5]. At present, CVDs are considered to be a significant contributor to premature death in this region, with a high prevalence of hypertension found in many SSA settings. The WHO-SAGE (World Health Organization Study on Global Ageing and Adult Health) study [6], which compared nationally representative populations over 50 years of age from China, Russia, India, Ghana, South Africa, and Mexico, reported that the prevalence of hypertension in South Africa was among the highest at over 77%. At the same time, the study reported low levels of awareness and blood pressure control in all of

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these countries [6]. In the absence of an effective intervention strategy to control this epidemic, it is expected that hypertension-associated CVD will continue to rise, with a concomitant increase in mortality and disability [7,8].

Despite global concerns over hypertension, there seems to be a dearth of information for most African countries on its prevalence, the levels of awareness by individuals on their blood pressure status, and how effective treatment is [9]. This is especially so in the population age group of 40 to 60 years of age, which is the age at which individuals suffer the highest levels of blood pressure—related disease [10,11].

The principal aims of the current study were therefore to measure the prevalence, level of awareness, and control of hypertension in a large population of 40- to 60-year-old participants of both sexes in 6 research sites across 4 SSA countries.

METHODS

This study draws on the Africa Wits-INDEPTH (University of the Witwatersrand, Johannesburg, and the International Network for the Demographic Evaluation of Populations and Their Health) [12] partnership for Genomic Studies (AWI-Gen), which is a National Institutes of Health—funded Collaborative Centre of the Human Heredity and Health in Africa (H3Africa) Consortium [13,14]. The primary aim of AWI-Gen is to study genetic and environmental factors that contribute to cardiometabolic disease in African populations. Six study sites in 4 SSA countries are involved in AWI-Gen: in South Africa the MRC/Wits Agincourt Health and Demographic Surveillance System Site (HDSS) [15], Dikgale HDSS [16], and the Soweto cohort located within the MRC/Wits Developmental Pathways for Health Research Unit [17]; in Kenya the Nairobi HDSS [18]; in Ghana the Navrongo HDSS [19]; and in Burkina Faso the Nanoro HDSS [20].

Study design and participant recruitment

This was a cross-sectional population study to serve as a baseline time point for adults between 40 and 60 years of age, who were recruited into the study between August 2013 and August 2016.

Participants who were recruited into the AWI-Gen study [21] were residents at 6 sites that span the African continent. In West Africa, these were the rural areas of Nanoro and Navrongo; in East Africa an urban informal settlement in Nairobi; and in South Africa, the rural areas of Agincourt in the province of Mpumalanga and Dikgale in the province of Limpopo, and the suburban township of Soweto that lies on the outskirts of Johannesburg. Pregnant women, first-degree relatives of existing participants, and individuals with physical impairments preventing measurement of blood pressure were excluded from the study. A resident was defined according to the HDSS criteria (staying within the area for at least 3 months and expecting to stay more than 3 months after the census).

Informed consent, and anonymization of participant identity

All participants provided written informed consent before any study procedures were conducted. Each participant was assigned a random AWI-Gen study participant identity code, which was used on study documentation, and the key linking participant identity and their identity code locked securely away at the research site, and not entered onto any further study documentation.

Measurement of blood pressure

Blood pressure was measured using a sphygmomanometer (Omron M6, Omron, Kyoto, Japan), according to the following standardized procedure: participants were seated upright in a chair, with feet resting firmly on the floor and not crossed. To ensure that the antecubital fossa was at the level of the heart participants were seated with the left arm resting on a desk or arm rest. The cuff was placed on the arm about 2 to 3 cm above the antecubital fossa, and not restricted by clothing. The participant was allowed to relax for 3 to 5 min before blood pressure was measured. Three measurements were taken, at 2-min intervals. During this period, participants remained quiet and still. The mean of the last 2 measurements was used to calculate the final systolic blood pressure and diastolic blood pressure.

Diagnosis of hypertension

Blood pressure measurements were classified according to the JNC7 guidelines of the Joint National Committee of Prevention, Detection, Evaluation, and Treatment of High Blood Pressure [22]. Hypertension was defined as presenting 1 or more of the following conditions: systolic blood pressure $\geq$140 mm Hg, diastolic blood pressure $\geq$90 mm Hg, or the participant reported that they were currently taking medication for hypertension.

Data collection and quality control

A paper questionnaire was administered to participants as part of a wider survey by the AWI-Gen study. This questionnaire asked for demographic information about the participant, as well as historical information about their blood pressure, previous diagnosis of hypertension, and how it was treated. Blood pressure data were also recorded on this questionnaire. These data were then entered into a REDCap (Research Electronic Data Capture) computerized database [23,24]. For quality control purposes, 10% of all entries were checked for consistency between the paper form and the electronic versions. Anonymized data were then transferred though a secure File Transfer Protocol connection to the central REDCap server at the University of the Witwatersrand, where a second process searched for outliers and missing data. Sites were requested to refer back to the paper forms for reconciliation.

TABLE 1. Demographic characteristics of the AWI-Gen participants (40 to 60 years of age) per research site

	Agincourt	Dikgale	Nairobi	Nanoro	Navrongo	Soweto	Total
Sex							
Men	573 (39)	343 (31)	924 (45)	1,034 (50)	917 (46)	1,025 (51)	4,816 (45)
Women	891 (61)	774 (69)	1,112 (55)	1,029 (50)	1,071 (54)	1,002 (49)	5,879 (55)
Total	1,464	1,117	2,036	2,063*	1,988	2,027	10,695
Age, yrs	50.81 ± 5.78	50.41 ± 5.98	48.56 ± 5.45	49.80 ± 5.81	51.02 ± 5.74	49.27 ± 5.83	49.9 ± 5.82
Age group							
40–44 yrs	294 (20)	231 (21)	575 (28)	500 (24)	314 (16)	539 (27)	2,453 (23)
45–49 yrs	281 (19)	253 (23)	625 (31)	499 (24)	510 (26)	539 (27)	2,707 (25)
50–54 yrs	434 (30)	283 (25)	470 (23)	539 (26)	454 (23)	484 (24)	2,664 (25)
55–60 yrs	455 (31)	350 (31)	366 (18)	526 (26)	710 (36)	465 (23)	2,872 (27)
Total	1,464	1,117	2,036	2,064	1,988	2,027	10,696

Values are n (%), n, or mean ± SD.
AWI-Gen, Africa Wits-INDEPTH [University of the Witwatersrand, Johannesburg, and the International Network for the Demographic Evaluation of Populations and Their Health] partnership for Genomic Studies.
*There is a missing value for sex in 1 participant from Nanoro.

Calculation of the awareness of hypertension and statistical analyses

Awareness of hypertension was calculated using the question, "Have you ever been told by a doctor, nurse, or other health care worker that you have hypertension (high blood pressure)?" The response to this question was used to quantify self-reported hypertension and these data in conjunction with the gold standard of measured blood pressure were used to calculate sensitivity, specificity, positive predictive value and negative predictive value of the self-reported disease status.

Normally distributed continuous variables were described as mean ± SD and non-normally distributed variables were described as median (interquartile range). Proportions were used to describe categorical data. Descriptive analyses were performed using proportions, means, and confidence intervals and data were compared across populations using the chi-square test. Statistical analyses were performed using the statistics program STATA, version 13 (StataCorp, College Station, TX, USA).

Research ethics board approval

This study was approved by the Human Research Ethics Committee (Medical) of the University of the Witwatersrand (Protocol Number: M121029). In addition, each study site obtained ethics approval from their respective institutional and national ethics committees as required. The study protocol conforms to the ethical guidelines of the 1975 Declaration of Helsinki as reflected in a priori approval by the institution's human research committee.

RESULTS

Participants

Data were collected from 10,696 individuals between 40 and 60 years of age from the 6 research sites. Table 1 shows the number of men and women, and the age distributions for the entire cohort and according to site. The mean age of the total cohort was 49.9 ± 5.82 years of age, with no significant differences noted for age between the sites. Four of the sites (Soweto, Nairobi, Navrongo, and Nanoro) each contributed 19% of the participants to the final sample, whereas Agincourt (14%) and Dikgale (10%) had fewer participants in this age range. Of the total participants, 63 did not have a full set of study data in the REDCap database (0.58% of the total), and were excluded from the data analysis.

Prevalence

The prevalence of hypertension in the entire cohort was 33.3% (see Table 2), being significantly higher in women (35%; 95% confidence interval [CI]: 33.7 to 36.2) than in men (31%; 95% CI: 30.0 to 32.6). Given this difference, further analyses were stratified by sex. Table 2 shows a breakdown of the prevalence of hypertension according to the JNC7 definition stratified for sex and site. The highest prevalence was observed in the South African sites (ranging from 41.6% to 54.1%) and the lowest in Burkina Faso (15%). Sex stratified prevalence showed that women had significantly higher rates of hypertension in Agincourt, Dikgale, and Nairobi, whereas men had significantly higher rates in Nanoro. Navrongo, and Soweto had no significant sex differences in hypertension. Hypertension significantly increased with age, both for the entire population, and for men and women separately (Table 2).

Awareness and diagnosis

Of the 3,543 individuals who were hypertensive, 51 did not answer the question on self-reported hypertension status, so awareness was reported on 3,492 individuals. Among those hypertensive participants that answered the question about awareness of hypertension, only 1667 (47.7%) were aware of their status. By sex, a significantly

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TABLE 2. Prevalence of hypertension based on the JNC7 definitions per site, age group, and sex

	Total Sample*			Men			Women		
	Study Population	High Blood Pressure	Prevalence (95% CI)	Study Population	High Blood Pressure	Prevalence (95% CI)	Study Population	High Blood Pressure	Prevalence (95% CI)
Sex									
Men	4,816 (45)	1,503	31.3 (30.0–32.6)						
Women	5,879 (55)	2,040	35.0 (33.7–36.2)						
Total	10,695*	3,543	33.3 (32.4–34.2)	4,797†	1,503	31.3 (30.0–32.6)	5,835†	2,040	35.0 (33.7–36.2)
Site									
Agincourt	1,432 (13.5)	678	47.3 (44.8–49.9)	556 (11.6)	222	39.9 (35.8–44.0)	876 (15.0)	456	52.1 (48.7–55.4)
Dikgale	1,115 (10.5)	464	41.6 (38.7–44.5)	343 (7.1)	100	29.2 (24.3–34.0)	772 (13.2)	364	47.2 (43.6–50.7)
Nairobi	2,003 (19.1)	521	25.6 (23.7–27.5)	924 (19.3)	202	21.9 (19.2–24.5)	1,111 (19.0)	319	28.7 (26.0–31.4)
Nanoro	2,063 (19.4)	311	15.1 (13.5–16.6)	1,034 (21.6)	198	19.1 (16.7–21.6)	1,028 (17.6)	113	11.0 (9.1–12.9)
Navrongo	1,988 (18.7)	487	24.5 (22.6–26.4)	917 (19.1)	221	24.1 (21.3–26.9)	1,071 (18.4)	266	24.8 (22.2–27.4)
Soweto	2,000 (18.8)	1,082	54.1 (51.9–56.3)	1,023 (21.3)	560	54.7 (51.7–57.8)	977 (16.7)	522	53.4 (50.3–56.6)
Age group									
40–44 yrs	2,434 (22.9)	553	22.7 (21.1–24.4)	1,149 (24.0)	270	23.5 (21.0–26.0)	1,284 (22.0)	283	22.0 (19.8–24.3)
45–49 yrs	2,692 (25.3)	789	29.3 (27.6–31.0)	1,197 (25.0)	339	28.3 (25.8–30.9)	1,495 (25.6)	450	30.1 (27.8–32.4)
50–54 yrs	2,648 (24.9)	945	35.7 (33.9–37.5)	1,171 (24.3)	365	31.2 (28.5–33.9)	1,478 (25.3)	580	39.2 (36.7–41.7)
55–60 yrs	2,859 (26.9)	1,256	43.9 (42.1–45.8)	1,281 (26.7)	529	41.3 (38.6–44.0)	1,578 (27.0)	727	46.1 (43.6–48.5)

Values are n (%) or n unless otherwise indicated.
CI, confidence interval.
*Total sample was 10,696 but 1 person had missing sex.
†Sixty-three individuals (44 women and 19 men) were excluded from hypertension analysis because they did not have blood pressure measurements.

higher percentage of women knew their status compared to men (53.8% vs. 39.4%; p <0.001) (Figs. 1A and 1B).

Table 3 presents correctness of self-knowledge of being hypertensive with respect to sensitivity (how many of the hypertensive subjects knew they were hypertensive) and specificity (what proportion of those subjects who thought they were hypertensive actually were hypertensive [i.e., controlled on medication or hypertensive at the time of measurement]). We observe that across the entire cohort, specificity was very high for both men (97.9%) and women (91.2%). However, sensitivity was low in both men (39.4%) and women (53.8%). Comparison by site indicated higher levels of awareness in Agincourt (63.1%), Dikgale (60.8%) and Nairobi (60.0%), while levels of awareness were much lower in Nanoro (39.9%), Soweto (37.2%), and Navrongo (38.6%). There were also significant differences in awareness between men and women (Fig. 1). In addition, Navrongo (21.4%) and Soweto (39.4%) had the lowest sensitivity among men, whereas Navrongo (34.6%), Soweto (35.1%) and Nanoro (37.0%) had the lowest sensitivity among women. Specificity was high (>85.0%) in all sites for both sexes, with the exception being women in Soweto (50.8%).

Blood pressure control

To examine how well hypertension was being managed (Fig. 1), we found that of the women that were aware of their hypertensive status, 87% were being treated. Of those, only 51% had controlled blood pressure. For men, 78% of those who were aware of their hypertensive condition were on treatment, but only 39% were controlled. When measuring how well hypertensive blood pressure was controlled by site, we observed that the rates for women (as a proportion of those on treatment) with well-controlled blood pressure levels was 61% in Nanoro, 57% in Dikgale, 50% in Nairobi, 49% in Agincourt, 45% in Soweto, and 40% in Navrongo (Fig. 1B). The rate of controlled blood pressure in men at these sites was 61% in Dikgale, 54% in Nanoro, 38% in Navrongo, 36% in Agincourt, 32% in Soweto, and 30% in Nairobi (Fig. 1A).

Finally, hypertension prevalence (Fig. 2A), awareness, and control data by sex and by sites (Fig. 2B) are shown, and demonstrate a high prevalence of hypertension in the South African sites compared to the general low levels of awareness and control in all sites.

DISCUSSION

In this study we found differences in the prevalence, awareness, and blood pressure control of hypertension at the study sites in west, east, and southern Africa. Our aim was to document these differences and to more fully understand how hypertension affects SSA countries and could inform the need to customize awareness, treatment and prevention approaches according to the needs of each individual region and country. Such information is essential to the design of effective interventions that could impact the downstream consequences of the rising rates of hypertension, most particularly CVDs [25].

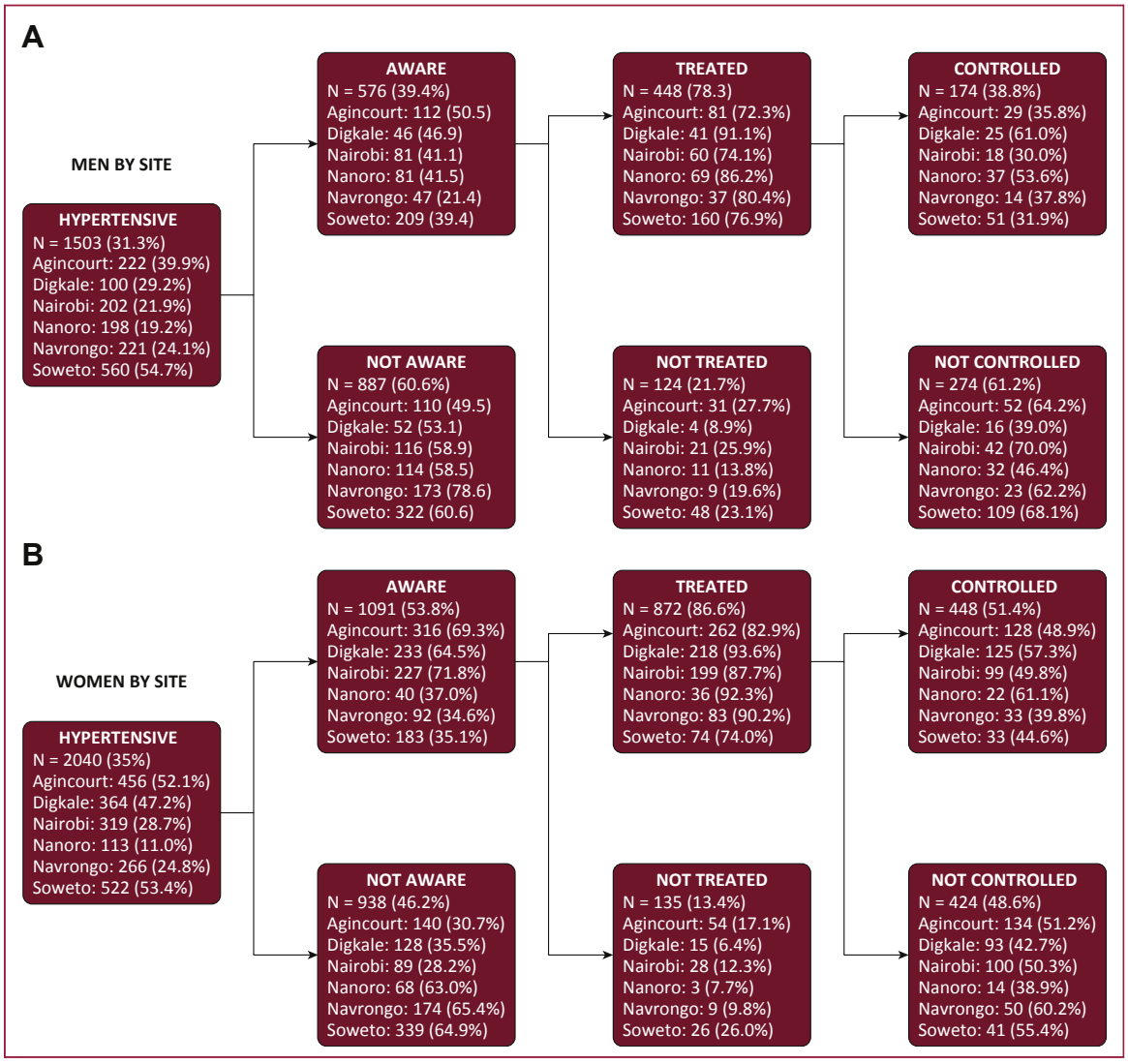

FIGURE 1. Diagnosis, awareness, treatment and control of hypertension in (A) men and (B) women by site in the AWI-Gen (Africa Wits-INDEPTH [University of the Witwatersrand, Johannesburg, and the International Network for the Demographic Evaluation of Populations and Their Health] partnership for Genomic Studies) study. Please note that when the numbers do not add up to the previous category, this is due to missing data (see Methods).

Overall, only 39.4% of men and 53.8% of women who were hypertensive knew their status (Table 3); an observation that is common in many studies of hypertension in SSA [26]. In all sites, except Nanoro and Soweto, women were more aware of their condition, compared to men. In terms of blood pressure control, we note that among all hypertensive women, 22% have controlled blood pressure compared to only 12% of men. This indicates that only a fifth (18%) of those found to be hypertensive in this study had controlled blood pressure; this is striking, but not surprising given the low levels of awareness. In contrast, 3 of 4 participants who were aware of their status received treatment, which could indicate a high level of engagement with primary health care providers. However, that only half of these participants had controlled blood pressure is a concern. Similar results were found in other studies in Africa. Comparing our data to the WHO-SAGE study [6] where women were more aware of their status than men (54% vs. 42%), women had significantly higher levels of controlled blood pressure than men (11% vs. 9%) although the levels of control and the difference between sexes were smaller than in the AWI-Gen study. These data are congruent with a review on hypertension in SSA, which found levels of awareness under 40% and levels of controlled blood pressure under 20% [4]. Interestingly, a study in Bangladesh and India in 2000 showed a hypertension awareness of 45% with controlled levels of 10% [27], suggesting a higher level of control in SSA than in Bangladesh and India.

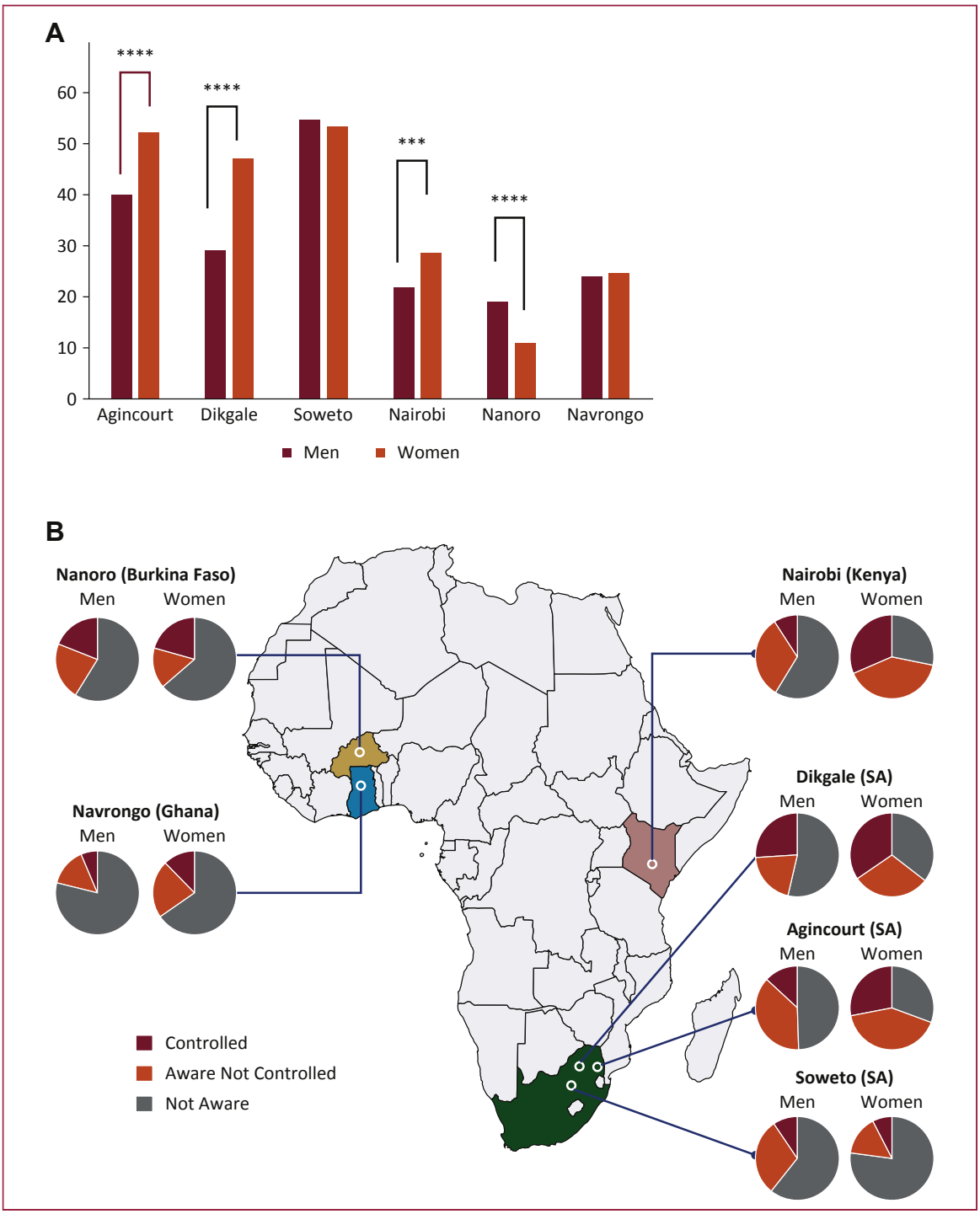

FIGURE 2. (A) Comparison of the prevalence of hypertension at each of the 6 AWI-Gen (Africa Wits-INDEPTH [University of the Witwatersrand, Johannesburg, and the International Network for the Demographic Evaluation of Populations and Their Health] partnership for Genomic Studies) study sites: Burkina Faso, Ghana, Kenya, and South Africa (SA). There are significant differences between the proportions of men and women who have hypertension at the following sites: Agincourt, Dikgale, and Nanoro (each with $p < 0.00001$) and Nairobi ($p < 0.0001$). (B) Awareness and control of hypertension at each site. The pie charts represent all individuals with hypertension and show the proportion with controlled blood pressure (magenta), those who are aware that they are hypertensive, but who had high blood pressure at the time of measurement (orange), and those who were not aware that they had high blood pressure (gray).

TABLE 3. Awareness of hypertension in the AWI-Gen study cohort by research site and sex

	AWI-Gen Total		Agincourt		Dikgale		Nairobi		Nanoro		Navrongo		Soweto	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Sensitivity, %	39.4	53.8	50.5	69.3	46.9	64.5	41.1	71.8	41.5	37.0	21.4	34.6	39.4	35.1
Specificity, %	97.9	91.2	92.8	86.7	95.9	97.5	99.2	97.7	98.2	98.4	99.3	99.2	98.4	50.8
PPV	89.6	76.9	82.4	84.9	82.1	95.9	93.1	92.7	84.4	74.1	90.4	93.9	96.8	45.0
NPV	78.2	78.4	73.8	72.2	81.6	75.3	85.9	89.6	87.6	92.7	79.8	82.0	58.0	40.5

AWI-Gen, AWI-Gen, Africa Wits-INDEPTH (University of the Witwatersrand, Johannesburg, and the International Network for the Demographic Evaluation of Populations and Their Health) partnership for Genomic Studies; NPV, negative predictive value; PPV, positive predictive value.

West Africa: Burkina Faso and Ghana

Across all study sites, we observed the lowest prevalence of hypertension among men (19.2%) and women (11.0%) in rural Nanoro, Burkina Faso. Interestingly, our data show that the other West African site in rural Navrongo (Ghana), approximately 250 km from Nanoro, had significantly higher rates among men (24.1%), and more than double the prevalence among women (24.8%).

In 2013, the STEPS (Study of Transitions and Education Pathways) study conducted in Burkina Faso reported an overall prevalence of hypertension of 17.6% (95% CI: 15.7 to 19.4), with a prevalence of 14.8% (95% CI: 13.1 to 16.5) in the rural areas and a prevalence of 14.2% (95% CI: 9.5 to 19.0) in the Centre-West region where Nanoro is based [28], which is similar to the prevalence of 15.1% (95% CI: 13.5 to 16.6) reported in the AWI-Gen study. The prevalence of hypertension in Nanoro is also similar to that reported in informal settings in Ouagadougou [29] but higher than the 9.4% observed in the semiurban area of the Kaya HDSS site in the Center-North region [30]. In this study, Nanoro is the only site to display a significant sex disparity in favor of men having hypertension, in line with the observation in the STEPS study with prevalence of 19.4% for men and 16.0% for women [28].

The Nanoro cohort had an overall awareness of hypertension of 41.4% for men and 30.7% for women, which although still low is the highest awareness level reported recently in the country compared to the STEPS survey (31.8%), the Ouagadougou HDSS (27.4%), and the Kaya HDSS (26.8%). The levels of controlled blood pressure in those on treatment were 53.6% for men, and 61.1% for women, and were among the highest reported in the country, but when represented as the percentage of controlled blood pressure among all hypertensive individuals, only 18.5% and 18.8% were controlled. Although awareness was low, treatment levels for those aware of hypertension (86.2% for men, 92.3% for women) was higher than had been recorded by previous studies [31-33].

In Ghana, over the last 3 to 4 decades, several population-based studies have examined the epidemiology of hypertension [33], but only 1 was conducted in the north, where Navrongo is situated [34]. This study, which examined 207 men and 367 women, reported the prevalence of high blood pressure at 19.3%. The AWI-Gen study is the first large-scale population-based study to examine prevalence and awareness of hypertension among older adults in rural northern Ghana. Overall, 24.1% of men and 24.8% of women participants from Navrongo were hypertensive. The rate is similar to previous studies in rural southern Ghana with a prevalence of 24.1% [33] but is an appreciable increase in hypertension prevalence from 19.3% observed in 2008 in the same study area [34]. Our study demonstrates a significant change in measured hypertension with increasing age, which is consistent with other population-based surveys conducted in Ghana [32,35].

Examination of the levels of awareness of hypertension in Ghana reveals that it has not changed significantly compared to previous studies in rural areas. Between 1979 and 2008, 7 studies examined awareness of hypertension in Ghana, 4 of them were conducted in rural communities and 3 in urban communities. Awareness ranged from 22% to 54%, with minimal sex differences, and rural areas being lower than urban [33]. Other studies reported awareness levels of between 25.4% and 34% for rural communities in southern Ghana [31,32]. This study also showed low levels of awareness (21.4% for men and 34.6% for women) which indicates a continued need to intensify public education around regular blood pressure monitoring. An explanation for these low levels of awareness could be the high level of illiteracy in this Ghanaian rural area. The health-seeking behavior of inhabitants in the study area is also a likely contributor because a considerable number of people still prefer to seek health care from traditional healers. It also reflects a limited health awareness and promotion program on noncommunicable diseases (NCDs), and especially in a community that has disproportionate burden of communicable diseases (especially malaria) over NCDs.

In Navrongo, the majority of those who are aware of their hypertensive status are on treatment, and this is higher among women (90.0%) than men (80.0%). This high rate of treatment might be attributed to general improvements in access to health care in the study area. The introduction of the national health insurance scheme in Ghana in 2003 has also led to significant improvements in access to medications for chronic diseases such as hypertension [36].

Although the greater proportion of participants with hypertension are being treated, it is important to examine whether treatment is effective. This study indicated that only 4 of 10 hypertensive individuals on treatment were controlled (37.8% for men, 39.8% for women). Expressed as a percentage of total hypertensive individuals in Navrongo, this means that only 1 of 10 of the total hypertensive population in Navrongo is being adequately managed. This raises serious issues regarding the effectiveness of treatment as well as the extent to which people are following their treatment regimen. Similar studies in 2006 also found low rates of control among rural communities in Ghana [32], which documented 24% on treatment, yet just 6.2% controlled. Addo et al. [31] also documented a control rate of 16.7% in 4 rural areas in the Ga district of Ghana. These observations are consistent with a systematic review that showed a treatment level ranging from 7% to 31% with a controlled range of 4% to 13% [33].

West Africa therefore shows a similar trend, with significant heterogeneity in the prevalence, treatment, and awareness of hypertension in 2 rural areas just about 250 km apart and may reflect general health awareness and approaches to health care.

East Africa: Nairobi

In a Nairobi informal settlement in East Africa we observed an overall prevalence of hypertension of 21.9% for men and 28.7% for women, which is similar to the national STEPS survey conducted in Kenya in 2015 (24%) [37], which included adults aged 18 to 69 years. However, looking only at the 45- to 59-year-old adults, the STEPS study reports hypertension at 38.7% in men and 48.5% in women. These rates of prevalence are much higher than those we found in the AWI-Gen study among individuals of a similar age group. This could be due to the fact that the AWI-Gen study was conducted among participants under a different socioeconomic and health profile to the rest of the population. In a larger population-based study conducted in 2008 to 2009, of 5,190 adults 18 years of age or older in the same study area, the prevalence of hypertension was 12.3% (12.7% in women and 12.0% in men) [38]. A baseline survey done in 2012 among all adults 35 years of age or older in the same study area as part of an intervention [39] to reduce hypertension found a prevalence of 24% [40], which is similar to the findings of this study. In a study conducted in a different urban informal settlement (Kibera) in 2010, among 2,200 adults, the crude prevalence of hypertension was 12.6% [41]. In this study, it was also reported that prevalence increased with age and was significantly higher among women in the strata of 35 to 44 years of age. These age differences by sex in the prevalence of hypertension could be associated with higher magnitudes of obesity and physical inactivity among the study population as reported by previous studies. Thus, a large population-based study conducted in 2008 to 2009 in the same study area showed a prevalence of hypertension of 24.5% among women 40 to 49 years of age and 36.4% among women 50 to 59 years of age. For men the observed prevalence was 13.2% for those 40 to 49 years of age and 27.9% among men 50 to 59 years of age [38].

At the Nairobi site, 41.1% of men and 71.8% of women with hypertension correctly reported their blood pressure status. The high level of awareness may be a result of several screening programs, health campaigns, and intervention studies conducted in the study area since 2008 [42,43].

Treatment levels were higher in women (87.7%) than men (74.1%), which is possibly related to higher levels of awareness among women. As age increased, both the percentage of hypertensive patients on treatment and those not on treatment increased. This is due to an increasing overall prevalence of hypertension. The Kenyan STEPS survey reported that only 2.7% of men and 6.9% of women with hypertension were receiving treatment. More specifically, 8.3% of hypertensive patients between 45 and 59 years of age were receiving treatment. The higher proportion found in the AWI-Gen study compared to the STEPS survey may be due to several programs to increase access to hypertension diagnostic and treatment services in the study area [42,43].

A study describing the profile of people with hypertension in Nairobi's informal settlement has shown that this population has a high prevalence of overweight (30%) and obesity (21%) as well as behavioral risk factors for hypertension such as smoking (8%), high alcohol intake (8%), and a low vegetable and fruit intake (68%) [42]. Besides, three-quarters of hypertensive patients in Nairobi informal settlements do not take antihypertensive medication, and even the ones who do show little adherence [42].

South Africa

The prevalence of hypertension was highest in South Africa, but we did not observe a marked urban-rural difference, especially among women. In urban Soweto 53.4% of women were hypertensive and in rural Agincourt 52.1% of women were hypertensive. In Dikgale, another rural area about 300 km northwest of Agincourt, the prevalence of hypertension among women was 47.2%. However, men showed a significantly higher prevalence in Soweto (54.7%) compared to Agincourt (39.9%) and Dikgale (29.2%).

The National SAGE study on populations 50 years of age and older showed high levels of self-reported hypertension (75.3%) in South Africa [44], which is the highest prevalence of hypertension compared to other SAGE national studies in various low- and middle-income countries [6]. In the AWI-Gen study, the 3 South African sites also had the highest proportion of hypertensive individuals among 40- to 60-year-olds across all sites, with 54% in Soweto, 47% in Agincourt, and 42% in Dikgale. These percentages are considerably higher than in recent data

from the SANHANES (South African National Health and Nutrition Examination Survey) study [45], which reported a prevalence of 19.5% in the 45 to 54 years of age group. A similar prevalence (19.8%) was found in the METS (Modeling the Epidemiological Transition Study) study [46]. Longitudinal data from the PURE (Prospective Urban Rural Epidemiology) study [47] found that 47.7% of black South Africans 30 years and older were classified as hypertensive, a prevalence similar to that reported here. In the CRIBSA (Cardiovascular Risk in Black South Africans) study, the burden of hypertension was measured in an urban black population in Cape Town, with the finding that age-standardized prevalence of hypertension of adults 25 to 64 years old was 38.9%, prevalence in 45- to 54-year-old men was 58.2% and in women was 60.6% [48].

The CRIBSA study [48] also found that among the participants with hypertension, significantly more women than men were detected, treated, and controlled on treatment, with the proportion detected and treated increasing in the women but not the men between 1990 and 2008 to 2009. In our study, the Agincourt site had the higher levels of awareness; however, Dikgale presented the highest levels of treatment and controlled blood pressure, with Soweto presenting low levels of awareness and controlled blood pressure. Given the urban context of Soweto, with good accessibility to health services, this is a concern, indicating the need for greater communication around hypertension and screening in this population. It is important to further explore the sociodemographic determinants associated with these findings, and whether primary health care programs in neighboring provinces could help explain the variations observed between sites in South Africa.

CONCLUSIONS

Hypertension is a rising global health problem and it is affecting most African regions. Although related diseases such as stroke, heart failure, kidney failure, and others are associated with higher mortality, there is still a low level of awareness of hypertension among African populations. Low awareness has a direct impact on the levels of the hypertensive population that receive the necessary treatment and achieve well-controlled blood pressure levels. Controlled blood pressure in the majority of individuals has the potential to significantly lower the risk of several chronic NCDs in SSA.

Implications for public health

This study shows that hypertension is a critical health problem in different regions and settings in Africa. Our data show stark sex-specific and region-specific differences that will require further detailed understanding to inform effective intervention strategies. Moreover, given the low levels of awareness of hypertension shown in this study, and the related consequences of low levels of awareness in the control of hypertension, we believe that improvements in health promotion and system strengthening could help improve awareness, treatment, and control of hypertension among African rural and urban populations. It is crucial to plan and implement more active campaigns aiming to increase awareness and diagnosis of hypertension. However, this alone would not be enough, as we observed that only half of those who are aware and who are on treatment have controlled blood pressure levels. This speaks to the need for programmatic systems to ensure effective adherence and follow up, in particular outreach and community-based approaches. With increasing life expectancy due both to the rollout of antiretroviral treatment to all individuals with HIV, and general improvements in health care, it is expected that the prevalence of hypertension will continue to increase. Consequently, NCDs including hypertension need to be prioritized and managed to reduce the public health burden.

Further research questions

There are several areas for future research. First, it is clear that a series of complex health transitions are occurring in Africa, and as such, this underlines the importance of better understanding determinants of change such as social, biological, and health care factors as this will influence policy responses. Second, in a changing society, it will become increasingly important to study the relationship among hypertension and associated risks, diseases, comorbidities, and mortality in large SSA cohorts. Third, with an improved understanding of the underlying changes, what would the effects of changes in lifestyle be? Will it be possible to reverse the incoming tide of hypertension? And finally, to what extent might the susceptibility of the population to hypertension be due to genetics: are there specific gene-environment interactions that may lead to increases in hypertension related diseases in Africa? These are just some of the questions that the H3Africa AWI-Gen study aims to address.

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