Prevalence, awareness, treatment, and control of hypertension in Nigeria in 1995 and 2020: A systematic analysis of current evidence

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Abstract
Improved understanding of the current burden of hypertension, including awareness, treatment, and control, is needed to guide relevant preventative measures in Nigeria. A systematic search of studies on the epidemiology of hypertension in Nigeria, published on or after January 1990, was conducted. The authors employed random-effects meta-analysis on extracted crude hypertension prevalence, and awareness, treatment, and control rates. Using a meta-regression model, overall hypertension cases in Nigeria in 1995 and 2020 were estimated. Fifty-three studies (n = 78,949) met our selection criteria. Estimated crude prevalence of pre-hypertension (120-139/80-89 mmHg) in Nigeria was 30.9% (95% confidence interval [CI]: 22.0%-39.7%), and the crude prevalence of hypertension (≥140/90 mmHg) was 30.6% (95% CI: 27.3%-34.0%). When adjusted for age, study period, and sample, absolute cases of hypertension increased by 540% among individuals aged ≥20 years from approximately 4.3 million individuals in 1995 (age-adjusted prevalence 8.6%, 95% CI: 6.5-10.7) to 27.5 million individuals with hypertension in 2020 (age-adjusted prevalence 32.5%, 95% CI: 29.8-35.3). The age-adjusted prevalence was only significantly higher among men in 1995, with the gap between both sexes considerably narrowed in 2020. Only 29.0% of cases (95% CI: 19.7-38.3) were aware of their hypertension, 12.0% (95% CI: 2.7-21.2) were on treatment, and 2.8% (95% CI: 0.1-5.7) had at-goal blood pressure in 2020. Our study suggests that hypertension prevalence has substantially increased in Nigeria over the last two decades. Although more persons are aware of their hypertension status, clinical treatment and control rates, however, remain low. These estimates are relevant for clinical care, population, and policy response in Nigeria and across Africa.
1 | INTRODUCTION

Hypertension (HTN) is a leading risk factor for cardiovascular disease (CVD) worldwide.\textsuperscript{1,2} Low- and middle-income countries (LMICs), including Nigeria, appear to be worst hit, with relatively higher number of cases and limited awareness, treatment, and control rates, against the trend observed in developed countries.\textsuperscript{3,4}

In Nigeria, HTN is the most frequently diagnosed CVD risk equivalent, with HTN-related complications accounting for approximately a quarter of emergency admissions in urban hospitals.\textsuperscript{5,6} The Nigerian population’s mean blood pressure is higher than that of populations in Europe and the United States.\textsuperscript{7} In prior work,\textsuperscript{8} we reported that one in four adult Nigerians is hypertensive and that HTN unawareness is a likely contributor to deaths from CVD in the country.\textsuperscript{5,9}

Though numerous prior studies have provided estimates on the prevalence of HTN in Nigeria,\textsuperscript{7,9-11} few studies have examined HTN trends over time. These data may be particularly informative in light of the substantial and more recent demographic shifts occurring in the Nigerian population.\textsuperscript{3}

The goal of this systematic review was to estimate both the prevalence of pre-HTN and HTN in Nigeria, and the level of awareness, treatment, and control of HTN. Further, we sought to examine for evidence of geographic, urban/rural, and sex-based differences in these estimates. These data are required to understand the likely trajectory of HTN in the country (useful for regional and global comparisons) and guide relevant country-wide strategies to address the burden of HTN-related disease.

2 | METHODS

2.1 | Search strategy

We conducted a systematic search of four databases—MEDLINE, EMBASE, Global Health, and Africa Journals Online (AJOL)—for studies on the prevalence of HTN in Nigeria. We also searched for studies on cardio-metabolic risk as we identified from an initial scoping exercise that a high proportion of such studies report on the prevalence of HTN (search terms are shown in Table 1). Unpublished (gray) documents were mainly sourced from Google Scholar and Google searches. Titles and abstracts of studies were reviewed, and full texts of relevant studies were accessed for further screening. The reference lists of accessed full texts were hand-searched for additional studies. Authors of selected papers were contacted for any missing information.

2.2 | Selection criteria

Studies were selected if they were (i) original population (or community)-based studies reporting on the prevalence of HTN in Nigeria, (ii) published on or after January 1, 1990, (iii) conducted among individuals aged at least 15 years, and (iv) providing estimates on the prevalence, awareness, control, or treatment of HTN in Nigeria. We excluded hospital-based reports, studies on Nigerians in diaspora, reviews, viewpoints, and commentaries.

2.3 | Case definitions

The main outcome measures in this study were (i) prevalence of pre-HTN, (ii) prevalence of HTN, (iii) awareness of HTN (expressed as percent of HTN cases aware of their status, (iv) treatment of HTN (expressed as percent of HTN cases on antihypertensive medication), and (v) control of HTN (expressed as percent of HTN cases with blood pressure controlled). The American College of Cardiology (ACC) and American Heart Association (AHA) recently published an updated report on the prevention, detection, evaluation, and management of HTN in adults.\textsuperscript{12} In this report, stage 1 HTN was defined as a systolic blood pressure (SBP) of 130-139 mmHg or a diastolic blood pressure (DBP) of 80-89 mmHg, and stage 2 as SBP of 140 mmHg or more or a DBP of 90 mmHg or more. However, as this classification has not been employed by several epidemiologic studies in Nigeria, we maintained the definition of HTN by the Joint National Committee on prevention, detection, evaluation, and treatment of high blood pressure.\textsuperscript{13,14} Therefore, we defined HTN as SBP of 140 mmHg or more, a DBP of 90 mmHg or more, taking antihypertensive medication, or having been diagnosed as hypertensive by a physician (corresponding to stage 2 HTN in the 2017 ACC/AHA classification). When available, we also extracted the prevalence of pre-HTN (defined as SBP of 120-139 mmHg or a DBP of 80-89 mmHg). For the awareness of HTN, we defined this as self-reported prior diagnosis of HTN by a doctor or a certified health worker, excluding women who were diagnosed with HTN during pregnancy.\textsuperscript{15} We defined treatment of

| No. | Searches |
|-----|----------|
| 1   | africa/ or africa, sub-sahara/ or africa, western/ or nigeria/ |
| 2   | exp vital statistics/ |
| 3   | (incidence* or prevalence* or morbidity or mortality).tw. |
| 4   | (disease adj3 burden).tw. |
| 5   | exp “cost of illness”/ |
| 6   | case fatality rate.tw |
| 7   | hospital admissions.tw |
| 8   | Disability adjusted life years.mp. |
| 9   | (initial adj2 burden).tw. |
| 10  | exp risk factors/ |
| 11  | 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 |
| 12  | exp hypertension/ or high blood pressure/ or hypertensive heart disease/ or cardiovascular risks/ or cardio-metabolic risks |
| 13  | 1 and 11 and 12 |
| 14  | Limit 13 to “1990-current” |
HTN as self-reported medication use to lower blood pressure at the time of interview.\textsuperscript{15} Control of HTN was defined as SBP below 140 mmHg and DBP below 90 mmHg while currently on antihypertensive medication.\textsuperscript{15}

2.4 | Data extraction

Literature searches and assessment of eligible studies were conducted independently by three reviewers (DA, EOO, and AA), according to the selection criteria to ensure consistency in final selection of studies. Disagreements in study selection were resolved by consensus. Data on the study site, period, design, setting (urban or rural), sample size, and mean age of the population were extracted. These were matched with corresponding data on the number of HTN cases and prevalence of HTN in each study.

2.5 | Quality assessment

We adapted a previously used quality assessment criteria for studies on chronic diseases\textsuperscript{16} to provide insights on the quality of selected studies. We screened for explicit description of methods, protocols, case ascertainment, and sampling and representativeness of reported estimates within the larger geopolitical zone. We graded studies as high (4-5), moderate (2-3), or low quality (0-1) (see Supplemental Material for details of quality grading).

2.6 | Data analysis

We conducted a random-effects meta-analysis, using the DerSimonian and Laird Method,\textsuperscript{17} on the individual study estimates to generate national and subnational pooled crude estimates of the respective study outcomes in Nigeria. Standard errors were determined from the reported crude estimates and population denominators, assuming a binominal (or Poisson) distribution. We assessed heterogeneity between studies using I\(^2\) statistics. Subgroup analysis was conducted to detect causes of heterogeneity. We investigated publication bias using the Funnel plot and Egger’s test. As described in previous studies,\textsuperscript{6,9,16} we constructed a meta-regression epidemiologic model accounting for study sample, year, and mean age to determine age-adjusted prevalence distribution of HTN by age of the Nigerian population. Model expressed as:

\[
\text{Prev}_{\text{HTN}\text{,i}} = \alpha + \beta_1 \times \text{Mean age} + \beta_2 \times \text{Study year} + u_i
\]

where \(\text{Prev}_{\text{HTN}\text{,i}}\) is the prevalence of hypertension in percentage, \(\alpha\) is the constant, \(\beta_1\) and \(\beta_2\) are regression coefficients for mean age and study year, and \(u_i\) represents study-level variance.

From this model and the age-adjusted prevalence rates, we estimated the absolute number of adult individuals with HTN in Nigeria at midpoints of the United Nation (UN) population 5-year age groups for Nigeria for the years 1995 and 2020.\textsuperscript{18} All statistical analyses were conducted on STATA (Stata Corp V.14, Texas, USA). The study was conducted in line with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.\textsuperscript{19} The complete dataset employed in this review is available in the Supplemental Material. Further details on searches, data extraction, and analysis are available on reasonable request from corresponding author.

3 | RESULTS

3.1 | Search results

Our searches returned 4154 studies—4132 from the four databases (MEDLINE, 1691; EMBASE, 2123; Global Health, 246; and AJOL, 72), and an additional 22 studies identified from Google Scholar, Google searches, and reference lists of relevant studies. After duplicates were removed, 1897 titles were screened for relevance (ie, for evidence of a population-based study on HTN in Nigeria). On applying the selection criteria, 1709 studies were excluded. We assessed 188 full texts, which were screened explicitly using the selection and quality criteria. Fifty-three studies were finally selected for both qualitative and quantitative syntheses (Figure 1).

3.2 | Study characteristics

The 53 studies were selected across the six geopolitical zones of Nigeria and covering a total population of 78,949 individuals (Table 2). The South-west and South-east were represented by 15 studies each, followed by the South-south with 14 studies. North-central had three studies, North-west, three; and North-east, two. One study was conducted across multiple sites in the country. Twenty-one studies each were conducted in urban and rural settings, with 13 in mixed urban-rural settings. We rated 32 studies as high quality, and the remaining 21 rated as moderate quality. Study periods ranged from 1995 to 2017, with most studies (90%) were conducted within a one-year period. Sample mean age ranged from 23.0 to 71.1 years. Heterogeneity was high across studies, with I\(^2\) estimated at 99.1% \((P < .001)\). The Funnel plot suggests no publication bias, with the Egger’s test \((P = .309)\) further confirming no small study effects (Supplemental Material).

3.3 | Prevalence of pre-HTN in Nigeria

The prevalence of pre-HTN (SBP 120-139 mmHg or DBP 80-89 mmHg) reported in studies ranged from 17.2% estimated from two cities in the South-south in 2012,\textsuperscript{20} to 42.5% recorded in Anambra State, South-east Nigeria, in 2016.\textsuperscript{21} The estimated pooled
The crude prevalence of pre-HTN in Nigeria was 30.9% (95% CI: 22.0-39.7) (Figure 2). No sex-specific estimates were reported.

### 3.4 | Crude prevalence of HTN in Nigeria

From individual study estimates, the highest prevalence of HTN (SBP ≥ 140 mmHg or DBP ≥ 90 mmHg) was recorded in an urban community in Kaduna State, North-west Nigeria, at 55.9% in 2018,\(^{22}\) with the lowest prevalence estimated in Ibadan Oyo State, South-west Nigeria, at 9.3% in 1999.\(^ {23}\) When pooled crude prevalence of HTN across the geopolitical zones was considered, pooled estimates in the four zones were relatively similar and above 30%. The highest prevalence was in the South-east at 33.3% (95% CI: 27.3-39.4), closely followed by the North-central with a prevalence of 32.2% (95% CI: 13.5-34.0); while the North-west had 31.9% (95% CI: 14.9-48.9), and the South-west had 30.2% (95% CI: 23.6-36.8) (Figure 3). The North-east and the South-south had a pooled HTN prevalence of 24.7% (95% CI: 22.4-27.1) and 27.6% (95% CI: 21.4-33.9), respectively. The overall pooled crude prevalence of HTN in Nigeria was 30.6% (95% CI: 27.3-34.0) (Figure 3). Although no significant difference, the prevalence was slightly higher among women (30.4%, 95% CI: 25.2-35.6) than among men (29.5%, 95% CI: 25.4-33.6) (Table 3 and Supplemental Material). Across both sexes, the pooled prevalence was consistently higher among urban dwellers (33.5%, 95% CI: 25.1-42.0) than among rural dwellers (25.5%, 95% CI: 21.1-29.9) (Table 3).

### 3.5 | Pooled mean SBP and DBP in Nigeria

The pooled mean population SBP in Nigeria was 130.9 mmHg (128.4-133.4) and the pooled mean DBP was 81 mmHg (79.5-82.8) (Table 3 and Supplemental Material).

### 3.6 | Awareness, treatment, and control of HTN in Nigeria

The pooled HTN awareness rate (expressed as a percentage of all HTN cases) was 29.0% (95% CI: 19.7-38.3), while 12.0% (95% CI:
| Author                     | Study period | Location            | Geopolitical zone | Study design                                         | Study setting        | HTN prevalence % |
|----------------------------|--------------|---------------------|-------------------|-----------------------------------------------------|----------------------|------------------|
| Abegunde and Owoaje        | 2011         | Oyo State           | South-west        | Descriptive cross-sectional study                   | Mixed                | 34.8             |
| Adedoyin et al             | 2008         | Ile-Ife, Osun State | South-west        | Descriptive cross-sectional study                   | Semi-urban           | 36.6             |
| Adedoyin et al             | 2012         | Maiduguri, Borno State | North-east     | Population-based cross-sectional study             | Semi-urban           | 25.2             |
| Ahaneku et al              | 2011         | Enugu, Enugu State  | South-east        | Population-based cross-sectional study             | Rural                | 44.5             |
| Alikor et al               | 2013         | Port-Harcourt, River State | South-south   | Descriptive cross-sectional study                   | Rural                | 20.2             |
| Amina et al                | 2010         | Lagos State         | South-west        | Descriptive cross-sectional study                   | Urban                | 33.0             |
| Amole et al                | 2008         | Ogbomoso, Oyo State | South-west        | Descriptive cross-sectional study                   | Mixed                | 50.5             |
| Asekun-Olarinmoye et al    | 2011         | Osogbo, Osun State  | South-west        | Population-based cross-sectional study             | Rural                | 13.2             |
| Cooper et al               | 1995         | Ibadan, Oyo State   | South-west        | Descriptive cross-sectional study                   | Urban                | 14.5             |
| Ejim et al                 | 2006         | Enugu, Enugu State  | South-east        | Population-based cross-sectional study             | Rural                | 46.4             |
| Ekanem et al               | 2012         | Abak, Akwa Ibom State | South-south     | Descriptive cross-sectional study                   | Semi-urban           | 47.0             |
| Ekwunife et al             | 2009         | Nsukka, Enugu State | South-east        | Population-based cross-sectional study             | Mixed                | 21.1             |
| Erhun et al                | 2003         | Ile-Ife, Osun State | South-west        | Descriptive cross-sectional study                   | Semi-urban           | 21.0             |
| Hendriks et al             | 2011         | Ilorin, Kwara State | North-central     | Population-based cross-sectional study             | Rural                | 21.0             |
| Isezu et al                | 2010         | Sokoto, Sokoto State | North-west       | Population-based cross-sectional study             | Mixed                | 24.8             |
| Kadiri et al               | 1998         | Ibadan, Oyo State   | South-west        | Descriptive cross-sectional study                   | Urban                | 9.3              |
| Mbah et al                 | 2012         | Nsukka, Enugu State | South-east        | Population-based cross-sectional study             | Semi-urban           | 32.5             |
| Odugbemi et al             | 2010         | Tejuosho, Lagos     | South-west        | Descriptive cross-sectional study                   | Urban                | 34.8             |
| Ogah et al                 | 2012         | Umuahia, Abia State | South-east        | Population-based cross-sectional study             | Mixed                | 31.4             |
| Oghagbon et al             | 2007         | Ilorin, Kwara State | North-central     | Population-based cross-sectional study             | Urban                | 27.1             |
| Oladapo et al              | 2005         | Egbeda, Oyo State   | South-west        | Descriptive cross-sectional study                   | Rural                | 20.8             |
| Omorogiuwa et al           | 2008         | Ekpoma, Edo State   | South-south       | Descriptive cross-sectional study                   | Urban                | 33.0             |
| Omuemwu et al              | 2004         | Edo State           | South-south       | Population-based cross-sectional study             | Rural                | 20.2             |
| Suleiman et al             | 2011         | Amassoma, Bayelsa State | South-south   | Descriptive cross-sectional study                   | Semi-urban           | 15.0             |
| Ulasi et al                | 2008         | Enugu State         | South-east        | Population-based cross-sectional study             | Mixed                | 32.8             |
| Ulasi et al                | 2010         | Enugu State         | South-east        | Population-based cross-sectional study             | Mixed                | 42.2             |
| Agaba et al                | 2014         | Jos, Plateau State  | North-central     | Descriptive cross-sectional study                   | Urban                | 48.5             |
| Akinbodewa et al           | 2014         | Akure & Ondo, Ondo State | South-west   | Descriptive cross-sectional study                   | Mixed                | 43.4             |
| Emerole et al              | 2007         | Owerri, Imo State   | South-east        | Descriptive cross-sectional study                   | Urban                | 29.1             |
| Ibekwe                     | 2012         | Oghara, Delta State | South-south       | Descriptive cross-sectional study                   | Rural                | 21.0             |
| Ige et al                  | 2013         | Ibadan, Oyo State   | South-west        | Descriptive cross-sectional study                   | Urban                | 21.5             |
| Okaka and Eiya             | 2013         | Ovia, Edo State     | South-south       | Population-based cross-sectional study             | Rural                | 19.3             |

(Continues)
| Author                        | Study period | Location                        | Geopolitical zone | Study design                                         | Study setting | HTN prevalence % |
|-------------------------------|--------------|---------------------------------|-------------------|------------------------------------------------------|---------------|------------------|
| Oyeyemi and Adeyemi           | 2013         | Maiduguri, Borno State          | North-east        | Population-based cross-sectional study              | Semi-urban    | 23.1             |
| Oguoma et al                  | 2015         | Kwale, Delta State              | South-south       | Population-based cross-sectional study              | Mixed         | 35.5             |
| Ezejimofor et al              | 2014         | Niger Delta, Rivers State       | South-south       | Community-based cross-sectional study               | Rural         | 51.1             |
| Adebayo et al                 | 2013         | Ife North, Osun State           | South-west        | Population-based cross-sectional study              | Rural         | 26.4             |
| Andy et al                    | 2012         | Cross River & Akwa Ibom States  | South-south       | Population-based cross-sectional study              | Rural         | 23.6             |
| Akpan et al                   | 2015         | Akwa Ibom State                 | South-south       | Population-based cross-sectional study              | Urban         | 28.6             |
| Egbe et al                    | 2013         | Yenagoa, Bayelsa State          | South-south       | Population-based cross-sectional study              | Rural         | 21.3             |
| Bello-Ovosi et al             | 2017         | Kwo, Kaduna State               | North-west        | Population-based cross-sectional study              | Urban         | 55.9             |
| Chukwuonye et al              | 2013         | Abia State                      | South-east        | Population-based house-to-house survey              | Mixed         | 40.2             |
| Ekpe et al                    | 2015         | Adim, Cross River State         | South-south       | Population-based cross-sectional study              | Rural         | 19.9             |
| Ezeala-Adikaibe et al         | 2016         | Enugu State                     | South-east        | Population-based cross-sectional study              | Urban         | 52.5             |
| Ezekwesili et al              | 2016         | Anambra State                   | South-east        | Population-based cross-sectional study              | Mixed         | 22.8             |
| Iloh et al                    | 2009         | Imo State                       | South-east        | Descriptive cross-sectional study                   | Rural         | 16.3             |
| Iloh et al                    | 2008         | Imo State                       | South-east        | Descriptive cross-sectional study                   | Rural         | 18.4             |
| Murthy et al                  | 2013         | National                        | National          | Population-based cross-sectional study              | Mixed         | 44.9             |
| Ofuya                        | 2007         | Niger Delta, Rivers State       | South-south       | Population-based cross-sectional study              | Rural         | 13.8             |
| Okafor et al                  | 2014         | Enugu, Enugu State              | South-east        | Population-based cross-sectional study              | Urban         | 47.7             |
| Olamoyegun et al              | 2016         | Ekiti State                     | South-west        | Population-based cross-sectional study              | Semi-urban    | 55.5             |
| Shittu et al                  | 2016         | Oke-Ogun, Oyo State             | South-west        | Population-based cross-sectional study              | Semi-urban    | 38.5             |
| Ugwuua et al                  | 2015         | Igbaegu, Ebonyi State           | South-east        | Population-based cross-sectional study              | Rural         | 23.2             |
| Wahab et al                   | 2006         | Katsina, Katsina State          | North-west        | Population-based cross-sectional study              | Urban         | 16.0             |
2.7-21.2) were on antihypertensive medications, and 2.8% (95% CI: 0.1-5.7) of these had at-goal blood pressure (Figure 4).

3.7 Estimated number of individuals with HTN in Nigeria

The meta-regression epidemiologic modeling showed that age and study period were statistically significant determinants of HTN prevalence in Nigeria, \( P < .001 \) (Supplemental Material). The prevalence of HTN increased significantly with advancing age and year of study. For example, in 1995, the prevalence of HTN at ages 20-24 and 50-59 years was 1.0% and 15.6%, respectively, and by 2020, the prevalence rates at these age brackets had increased to 23.5% and 40.0%, respectively (Table 4). Using the United Nations demographic projections for Nigeria, we estimated that approximately 4.3 million individuals over the age of 19 had HTN in Nigeria in 1995 (age-adjusted prevalence of 8.6%, 95% CI: 6.5-10.7). This figure increased by 540% to 27.5 million individuals over the age of 19 with HTN in 2020 (age-adjusted prevalence of 32.5%, 95% CI: 29.8-35.3) (Table 4). When the sexes were considered, cases increased significantly from 3 million (12.0%, 95% CI: 9.3-14.8) to 14.2 million (33.5%, 95% CI: 29.3-37.7) among men, and 1.3 million (5.2%, 95% CI: 2.5-7.9) to 13.2 million (31.5%, 95% CI: 27.0-35.9) among women between 1995 and 2020, respectively. The age-adjusted prevalence was only significantly higher in men in 1995, with the gap in prevalence between both sexes considerably narrowed in 2020.

4 DISCUSSION

In this systematic review of 53 studies on the prevalence of HTN in Nigeria, we found strong evidence that HTN has become far more common among Nigerian adults in recent years and that awareness of the condition remains alarmingly low. We also provide the first country-specific estimates of pre-HTN for Nigeria, and present strong evidence of geographic heterogeneity in this condition. These results have strong implications for future preventative and educational campaigns.

Our results suggest that between 1995 and 2020, HTN cases in Nigeria increased by over 540% from four million individuals to 28 million individuals. We estimated that the age-adjusted HTN prevalence in 2020 was 32.5%, a substantially higher number than the 28.0% prevalence we estimated in 2010 in a prior study. Likely contributors to this high and steady increase in HTN include population aging, increased urbanization, unhealthy lifestyles, and the absence of effective nation-wide preventative measures. Our results lend credence to concerns that HTN and related complications may soon represent the most significant public health and economic threat in many African countries, overshadowing epidemics such as malaria and other infectious diseases.7,24,25
FIGURE 3  Crude prevalence of hypertension in Nigeria
A possible table is shown below:

### Table 3: Pooled crude estimates of prevalence of hypertension in Nigeria

| Region               | Both sexes | Men | Women |
|----------------------|------------|-----|-------|
|                      | Prevalence % (95% CI) | \(I^2\), P-value | Prevalence % (95% CI) | \(I^2\), P-value | Prevalence % (95% CI) | \(I^2\), P-value |
| Nation-wide          |            |     |       |
| Hypertension         | 30.6 (27.3-34.0) | 99.1, .<.001 | 29.5 (25.4-33.6) | 98.2, .<.001 | 30.4 (25.2-35.6) | 99.2, .<.001 |
| Pre-hypertension     | 30.9 (22.0-39.6) | 99.3, .<.001 | - | - | - | - |
| Awareness\(^a\)      | 29.0 (19.7-38.3) | 98.9, .<.001 | - | - | - | - |
| Treatment\(^a\)      | 12.0 (2.7-21.2) | 97.9, .<.001 | - | - | - | - |
| Control\(^a\)        | 2.8 (0.0-5.7) | 83.1, .015 | - | - | - | - |
| SBP (mmHg)           | 130.9 (128.4-133.4) | 90.7, .<.001 | - | - | - | - |
| DBP (mmHg)           | 81.1 (79.5-82.8) | 95.0, .<.001 | - | - | - | - |
| Geopolitical zone    |            |     |       |
| North-central        | 32.2 (13.5-34.0) | 99.1, .<.001 | 35.9 (21.6-50.2) | 99.3, .<.001 | 24.8 (21.3-28.4) | 97.1, .<.001 |
| North-east           | 24.7 (22.4-27.1) | 0.0, .457 | 23.3 (19.5-27.1) | 28.7, .236 | 24.8 (21.3-28.4) | 0.0, .867 |
| North-west           | 31.9 (14.9-48.9) | 97.7, .<.001 | 20.1 (7.2-33.1) | 90.9, .<.001 | 34.0 (13.9-54.1) | 97.2, .<.001 |
| South-east           | 33.3 (27.3-39.4) | 99.0, .<.001 | 40.8 (33.7-48.0) | 95.1, .<.001 | 35.8 (29.0-42.6) | 96.1, .<.001 |
| South-south          | 27.6 (21.4-33.9) | 98.3, .<.001 | 24.4 (18.9-29.8) | 92.2, .<.001 | 20.9 (15.6-26.3) | 94.6, .<.001 |
| South-west           | 30.2 (23.6-36.8) | 99.2, .<.001 | 27.3 (17.3-37.2) | 98.0, .<.001 | 30.9 (20.0-41.8) | 99.4, .<.001 |
| Settings             |            |     |       |
| Urban                | 33.6 (25.1-42.0) | 98.8, .<.001 | 27.2 (17.3-37.2) | 97.9, .<.001 | 34.5 (23.2-45.8) | 98.3, .<.001 |
| Rural                | 25.5 (21.1-29.9) | 98.6, .<.001 | 26.4 (20.6-32.2) | 94.5, .<.001 | 22.9 (17.8-28.1) | 95.5, .<.001 |
| Mixed                | 33.7 (26.7-40.7) | 99.3, .<.001 | 35.8 (27.8-43.7) | 98.6, .<.001 | 34.1 (25.0-43.1) | 99.1, .<.001 |

\(^a\)Awareness, treatment, and control rates expressed as percent of HTN cases.

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Given our pooled mean SBP and DBP estimates of 131 mmHg and 81 mmHg, respectively, our study findings may indicate that many Nigerians are also in the pre-hypertensive stage. Though pre-HTN does not connote inevitable progression to HTN, studies had long shown that the presence of pre-HTN increases the risk for HTN, cardiovascular complications, and target organ damage by 30% in the absence of lifestyle modifications or treatment.\(^{26-28}\) We estimated that nearly one in three Nigerians is pre-hypertensive. Our estimate is in the range of pre-HTN prevalence estimates from Ghana (30.7%) and South Africa (29.4%), but higher than the pooled estimate in four sub-Saharan African countries that included Nigeria (21.0%).\(^{25,30}\) In contrast, Chow et al\(^{31}\) estimated that pre-HTN prevalence was 36.8% from a multicountry study, although this does not include Nigeria. Comparison between prior studies and ours may be challenging due to the differences in the methodology between studies. However, several studies\(^{32-34}\) including the current have pointed to a high prevalence of pre-HTN and HTN in Nigeria and neighboring countries, calling for more awareness and education.

We found evidence of substantial regional variation in the prevalence of HTN in Nigeria, which ranged from 25.0% to 33.3% across the geopolitical zones. The highest prevalence was in the South-east and North-central at 33.3% and 32.2%, respectively. Although the regional pattern of distribution may be subject to further studies, Murthy et al\(^{32}\) reported high prevalence of HTN in 2013 among the Nupe and Igbo communities in the North-central and South-east at 50.5% and 40.4%, respectively. Dietary differences in these regions, particularly in the amount of oil and salt used in food, may be the contributing factor. The significant variations in socio-economic conditions also have important implications on dietary choices, particularly in urban settings characterized by high consumption of processed foods, without population-wide strategies promoting healthy diets.\(^{33,34}\) Moreover, varying weather and climatic conditions in Nigeria considerably affect farming and the type of food crops produced, possibly another important factor for the dietary differences. Our findings of a higher prevalence of HTN among urban dwellers and those of advanced age are consistent with findings from numerous previous studies.\(^{25,27-29}\)

Our estimates clearly indicate a narrowing prevalence gap between men and women, with a difference of 7% in 1995 and 2% in 2020. In prior work,\(^{8}\) we reported a 5% difference between the two sexes (30% men vs 25% women) in 2010. Although the current crude prevalence difference in both sexes was not statistically significant, this was slightly higher among women (30.4%) compared with men (29.5%). These findings are consistent with those from a 2013 study of 13 504 Nigerians, in which the prevalence of HTN was higher among women (46.8%) than among men (42.6%). The rising prevalence of HTN among women could be linked to increasing obesity, decreasing physical inactivity and unhealthy diets.\(^{38-41}\) Moreover, women appear to suffer worse...
mental, psychological, and emotional consequences from increasing security challenges in Nigeria, with repeated anxiety and panic attacks likely having adverse effects on the overall cardiovascular health of many. In addition, it is worth noting that women are more likely to participate in community medical outreach efforts, possibly leading to selection bias and relatively higher prevalence reported for females.8,9

Compared with our previous pooled awareness rate (17.4%),8 HTN status awareness (expressed as a percentage of HTN cases in the country) increased to 29%. This rate is higher than recorded in some African countries (Gabon, Uganda, and Kenya), which ranged from 9% to 12%.7,42 Despite the improvement in awareness of HTN in the country, the treatment and control rates of HTN (also expressed as percentage of HTN cases) were relatively low at 12% and 3%, respectively. These rates are very low compared with treatment and control rates in other African countries such as Zimbabwe and South Africa, which are above 30%.40,41,43 Addressing the relatively low awareness, treatment, and control rates of HTN in Nigeria is key to reducing cardiovascular health burden. However, an important consideration are the challenges relating to acquiring and adhering to antihypertensive medications.9,44 Although cardiology training program for medical doctors has relatively improved over the years, and there are ongoing studies and trials on medications, several doctors particularly in primary and secondary health facilities lack the requisite knowledge of the standard management for hypertension. Prescriptions are often too complex, and there is a lack of follow-up of cases, resulting in both poor adherence and suboptimal control of HTN.33,45

Targeted community-wide programs, commonly organized by non-governmental organizations and research groups, are an important avenue for blood pressure screening in Nigeria.7,9–11 The government, ministry of health and other stakeholders can collaborate with these organizations and groups in observing the annual May Measurement Month (MMM) across primary care levels in the country to raise awareness and facilitate blood pressure screening in catchment communities. According to Beaney et al,46 the MMM is an inexpensive intervention that can be employed to address a shortfall in screening of blood pressures across world regions, with over 35 000 (28%) newly diagnosed cases reported in sub-Saharan Africa alone in 2017. In addition to initiatives and

### Table: Awareness, treatment, and control of hypertension in Nigeria

| Author          | Year  | Zone   | HTN Cases | HTN (%) | Prev % | Percent of HTN cases (95% CI) |
|-----------------|-------|--------|-----------|---------|--------|------------------------------|
| AWARE           | 2011  | South-east | 97        | 44.5    | 26.77  | (17.07, 34.48)               |
| Erhun et al     | 2003  | South-west | 210       | 21      | 15.24  | (10.38, 20.10)               |
| Hendriks et al  | 2011  | North-central | 583    | 21      | 8.70   | (6.37, 11.03)                |
| Iseuzo et al    | 2010  | North-west  | 194       | 24.8    | 13.92  | (9.05, 18.79)                |
| Oladapo et al   | 2005  | South-west  | 415       | 20.8    | 14.22  | (10.88, 17.58)               |
| Suleiman et al  | 2011  | South-south | 50        | 15      | 91.67  | (84.87, 88.86)               |
| Ulasi et al     | 2010  | South-east  | 290       | 42.2    | 29.31  | (24.07, 34.55)               |
| Ezajimofo et al | 2014  | South-south | 1038     | 51.08   | 24.03  | (21.43, 26.64)               |
| Andy et al      | 2012  | South-south | 914      | 23.6    | 11.82  | (9.72, 13.91)                |
| Akpan et al     | 2015  | South-south | 169      | 28.6    | 37.28  | (29.99, 44.57)               |
| Akpan et al     | 2015  | South-south | 433      | 44.3    | 14.55  | (11.23, 17.87)               |
| Eke et al       | 2015  | South-south | 164      | 19.9    | 3.05   | (0.42, 5.68)                 |
| Ezekwesili et al| 2016  | South-east  | 208       | 22.81   | 73.08  | (67.05, 79.10)               |
| Olamoyegun et al| 2018  | South-west  | 416       | 55.5    | 48.88  | (42.08, 51.67)               |
| **Subtotal**    |       |         |           |         |        | (I-squared = 98.9%, p = 0.000)|

| TREATED         |       |         |           |         |        |                             |
| Oladapo et al   | 2005  | South-west | 415       | 20.8    | 0.96   | (0.02, 1.90)                |
| Ulasi et al     | 2010  | South-east  | 290       | 42.2    | 5.86   | (3.16, 8.57)                |
| Ezekwesili et al| 2016  | South-east  | 208       | 22.81   | 22.60  | (16.91, 28.28)              |
| Olamoyegun et al| 2016  | South-west  | 416       | 55.5    | 19.47  | (15.67, 23.28)              |
| **Subtotal**    |       |         |           |         |        | (I-squared = 97.9%, p = 0.000)|

| CONTROLLED      |       |         |           |         |        |                             |
| Ulasi et al     | 2010  | South-east | 290       | 42.2    | 1.38   | (0.04, 2.72)                |
| Olamoyegun et al| 2016  | South-west  | 416       | 55.5    | 4.33   | (2.37, 6.28)                |
| **Subtotal**    |       |         |           |         |        | (I-squared = 83.1%, p = 0.015)|

**Note:** Weights are from random effects analysis

**FIGURE 4** Awareness, treatment, and control of hypertension in Nigeria
| Age (years) | Both sexes | 1995 | 2020 | Men | 1995 | 2020 | Women | 1995 | 2020 |
|-------------|------------|------|------|-----|------|------|-------|------|------|
| 20-24       | 1.0 (0.09) | 95.6 | 23.5 (0.34) | 3752.2 | 1.3 (0.16) | 66.1 | 29.6 (0.51) | 2409.6 | 0.6 (0.11) | 29.4 |
| 25-29       | 1.8 (0.15) | 139.0 | 26.2 (0.37) | 3686.8 | 2.6 (0.25) | 102.1 | 30.9 (0.55) | 2207.9 | 1.0 (0.16) | 36.9 |
| 30-34       | 4.5 (0.26) | 299.0 | 29.0 (0.41) | 3509.6 | 7.8 (0.47) | 258.8 | 32.2 (0.60) | 1981.5 | 1.2 (0.19) | 40.2 |
| 35-39       | 7.3 (0.35) | 404.0 | 31.8 (0.47) | 3170.5 | 12.9 (0.64) | 355.7 | 33.5 (0.66) | 1704.6 | 1.7 (0.25) | 48.2 |
| 40-44       | 10.1 (0.44) | 463.9 | 34.5 (0.54) | 2681.4 | 15.8 (0.76) | 359.1 | 34.7 (0.75) | 1383.7 | 4.5 (0.43) | 104.9 |
| 45-49       | 12.8 (0.54) | 499.3 | 37.3 (0.62) | 2240.1 | 18.6 (0.88) | 361.6 | 36.0 (0.89) | 1094.6 | 7.1 (0.58) | 137.7 |
| 50-54       | 15.6 (0.63) | 519.0 | 40.0 (0.69) | 1999.6 | 21.5 (1.01) | 354.7 | 37.1 (1.01) | 914.3 | 9.8 (0.73) | 164.2 |
| 55-59       | 18.3 (0.75) | 493.6 | 42.8 (0.77) | 1774.6 | 24.3 (1.18) | 319.5 | 38.1 (1.18) | 760.2 | 12.6 (0.89) | 174.0 |
| 60-64       | 21.1 (0.89) | 441.2 | 45.6 (0.86) | 1515.3 | 27.2 (1.40) | 273.4 | 38.9 (1.40) | 611.8 | 15.5 (1.09) | 167.8 |
| 65-69       | 23.9 (1.08) | 368.5 | 48.3 (0.99) | 1234.3 | 30.0 (1.69) | 219.8 | 40.1 (1.69) | 486.2 | 18.3 (1.36) | 148.8 |
| 70-74       | 26.6 (1.37) | 274.7 | 51.1 (1.17) | 930.5 | 32.9 (2.15) | 157.4 | 41.0 (2.14) | 351.2 | 21.2 (1.74) | 117.3 |
| 75-79       | 29.4 (1.89) | 170.9 | 53.8 (1.52) | 580.2 | 35.7 (2.97) | 93.2 | 41.4 (2.97) | 203.9 | 24.2 (2.39) | 77.7 |
| 80+         | 32.4 (2.49) | 114.5 | 56.9 (1.84) | 410.5 | 38.9 (4.04) | 56.6 | 40.7 (4.04) | 126.4 | 27.9 (3.11) | 58.0 |
| All (20+)   | 8.6       | 4283.2 | 32.5 | 27 485.6 | 12.0 | 2978.1 | 33.5 | 14 235.8 | 5.2 | 1305.1 | 31.5 | 13 249.8 |
| Lower CI    | 6.5       | 3224.6 | 29.8 | 25 154.2 | 9.3 | 2295.9 | 29.3 | 12 449.5 | 2.5 | 638.8 | 27.0 | 11 369.8 |
| Upper CI    | 10.7      | 5341.8 | 35.3 | 29 816.9 | 14.8 | 3660.4 | 37.7 | 16 022.0 | 7.9 | 1971.3 | 35.9 | 15 129.8 |

Abbreviations: CI, 95% confidence interval; SE, standard error.
campaigns such as the MMM, primary health workers who are in regular contact with patients can play active roles in promoting screening and regular assessment of blood pressure for early identification of individuals at risk and timely provision of treatments where necessary.

Our study should be considered with respect to its limitations. Heterogeneity across studies was high, reflecting variations in population structures, blood pressure measurement protocols, and overall study designs. Of the 53 studies retained, only eight were conducted in the Northern regions, and data on age- and sex-specific prevalence, and specific geographic settings, were not always provided. It is not so clear why studies are predominantly lower in the North, but this has been observed in previous studies,

possibly a reflection of the overall research capacity in the region. These factors resulted in some discrepancies in the crude sex estimates, although this was accounted for in the final model. Moreover, our estimates were based on JNC classifications, as there were no available studies based on the 2017 ACC/AHA guidelines. Moreover, we reported relatively high age-adjusted estimates in the younger age groups in 2020; this should be cautiously interpreted due to sparse overall data for persons under 30 years. Lastly, these limitations are balanced by the strengths of our study, including its large sample size, rigorous methodology, and its provision of the first nation-wide estimates of the treatment and control of HTN in Nigeria.

5 CONCLUSIONS

In summary, the burden of HTN is increasing in Nigeria and our data suggest that many Nigerians are pre-hypertensive. HTN prevalence appears to be increasing at a faster rate among Nigerian women than among men. Further, though the awareness of HTN has improved over time, more than half of hypertensive individuals in Nigeria are untreated and/or have poorly controlled blood pressure. Our results strongly support a need for improved and comprehensive nationwide population preventive strategies to mitigate the effects of HTN in Nigeria.

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AUTHOR CONTRIBUTIONS

DA conceived and designed the study. DA, EOO, and AA conducted the literature searches and data extraction. DA, EOO, and MOH wrote the first draft. DA and MOH conducted the analysis. DA, AA, DBO, MTD, TOO, OSO, CO, NE, RGM, EA, MG, WA, AOA, MOH, and other authors contributed to the final draft and checked for important intellectual content. All authors approved the manuscript as submitted.

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SUPPORTING INFORMATION
Additional supporting information may be found online in the Supporting Information section.