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Blood pressure and burden of hypertension in Cameroon, a microcosm of Africa: a systematic review and meta-analysis of population-based studies

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Objective: To estimate national and geography-based variations in blood pressure and burden of hypertension in Cameroon, generally called 'miniature Africa'.

Methods: PubMed, Medline, EMBASE, CINHAL, Web of Science, Popline, Scopus and BDSP were searched through November 2018, for hypertension studies among Cameroonians aged at least 18 years. Hypertension was measured as SBP at least 140 mmHg or DBP at least 90 mmHg. Random-effects meta-analysis was used.

Results: Twenty studies involving 46 491 participants met inclusion criteria. Overall hypertension prevalence was 30.9% [95% confidence interval (CI) 27.0–34.8]: 29.6% (24.1–35.1) and 32.1% (27.2–37.1) in 1994–2010 and 2011–2018, respectively. Of hypertensive participants, only 24.4% (18.9–30.0) – 31.6% (21.0–42.3) and 20.8% (14.0–27.7) in 1994–2010 and 2011–2018, respectively – were aware of their status, 15.1% (10.6–19.6) were taking antihypertensive medications and 8.8% (5.7–11.9) – 10.4% (7.5–13.3) and 8.3% (4.4–12.3) in 1994–2010 and 2011–2018, respectively – were controlled. Hypertension prevalence varied by sex: 34.3% (30.0–38.6) for men and 31.3% (26.5–36.1) for women; ethnicity: from 3.3% (0.4–6.2) among Pygmies to 56.6% (49.4–63.8) among Bamileke; urbanity: 25.4% (17.1–33.7) for rural and 31.4% (27.3–35.5) for urban dwellers; agroecological zone: from 35.1% (28.9–41.3) in Tropical highlands to 28% (20.1–35.9) in Guinea-Savannah; and subnational region: from 36.3% (27.8–44.9) in the West to 17.1% (9.9–44.2) in the South.

Conclusion: Cameroon's hypertension prevalence is high and increasing whereas awareness, treatment and control are low and declining. Emerging patterns call urgently for effective campaigns to raise hypertension awareness alongside strategies for hypertension prevention and BP control.

Keywords: Africa, ageing, blood pressure, Cameroon, epidemiology, hypertension, low-income and middle-income countries, noncommunicable disease, review

Abbreviations: BP, blood pressure; GBD, global burden of disease; HBP, high blood pressure; NCD, noncommunicable disease; WHL, World Hypertension League

INTRODUCTION

Hypertension or high blood pressure remains a leading cause of the global burden of disease (GBD) and death [1–4], and is a major risk factor for cerebrovascular, cardiovascular and renal morbidity and

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mortality [5–8]. Hypertension is also causally linked or clustered with behavioural factors (harmful use of alcohol, obesity, insufficient physical activity, high salt/sodium intake, tobacco use) and stress, which are high-risk factors for noncommunicable diseases (NCD) [1–3,5–8]. Over 74% of African countries, including Cameroon, have no guidelines for the management of hypertension [9]. How blood pressure (BP) distribution and hypertension prevalence, awareness, treatment and control rates vary over time countrywide and across population subgroups in Cameroon are unknown. National and subnational estimates of BP levels and burden of hypertension from population-based studies and knowledge of their geography-based differences are needed for effective hypertension prevention and BP control [7,8,10,11]. No previous studies have examined the BP levels and the prevalence, awareness, treatment and control of hypertension separately by place of residence and for the 10 subnational regions nested within all five agroecological zones of Cameroon.

Home to around 25 million people [12], Cameroon is part of Central Africa, has a historic divide between its Anglophone and Francophone populations, and is a trade route between the economies of West and Central Africa. It marks the meeting point of different sub-continental regions of Africa. This is evident in the country's diverse geography, languages, cultures, epidemiologic profiles, dietary patterns and ethnic ancestries of the population, making Cameroon a 'miniature Africa' [13–18]. Cameroon's 10 regions (Adamawa, Centre, East, Far-North, Littoral, North, North-West, South, South-West and West) are nested within five agroecological zones (sub-humid, humid, tropical highlands, guinea savanna and sudano-sahelian) reproduced in all 44 sub-Saharan African countries [16]. Population-level disparities found in Cameroon may, therefore, be seen on a larger scale in different African settings [9–12,15,19].

In Cameroon, stroke (4.6%) and ischaemic heart disease (3.8%) are top killers among all NCD, and fifth and sixth causes of death, respectively [20]. In such settings, the distribution and drivers of hypertension-related disease and their population impact are expected to be geographically heterogeneous. Geography-based differences contributing to hypertension disparities include differences in environment (physical, social, ethnocultural, economic and religious), neighbourhood characteristics, urbanization rates, lifestyles, food security and consumption patterns, healthcare, mounting socioeconomic inequality, adoption of recommended nonpharmacological or pharmacological hypertension management, population aging, health-promoting resources and soil potassium and sodium concentrations [5–7,21–23].

Few studies have considered such geography-based differences, to help design strategies to reduce or eliminate hypertension disparities at global, national and subnational levels [7,8,11]. Like many countries, Cameroon still lacks reliable estimates for adequate national surveillance. Hypertension-related indicators are repeatedly reported in different ways in studies often with suboptimal sample sizes for subnational analysis, which hampers assessing progress at national and subnational levels. The current investigation aimed to review the national and subnational burden of hypertension in Cameroon and identify knowledge gaps. For informing efforts to prevent and control cerebrovascular and cardiovascular disease in high-burden countries like Cameroon [5,12,17,20,23], this review addressed the question: what is the epidemiological landscape and control of hypertension among community dwellers aged 18 years or older in Cameroon?

METHODS

This review was registered in PROSPERO (registration number CRD42017054950). Details on literature search and selection, data extraction and management, evaluation of studies, statistical analysis and definitions used, were published in the review protocol [24]. The methods are summarized below.

Literature search strategy

This study complied with the preferred reporting items for systematic reviews and meta-analysis (PRISMA) [25] and the checklist of items in the meta-analysis of observational studies in epidemiology [26]. The review included all types of population-based studies published by December 31, 2016 and updated through November 30, 2018, in English or French that examined hypertension in Cameroon. Eight bibliographic databases (PubMed, Medline, EMBASE, CINHAL, Web of Science, Popline, Scopus and '*Banque de données en santé publique*' [BDSP]) were searched. Grey literature was also identified, and experts consulted, to minimize publication bias across studies.

Study selection

Studies included those on hypertension, population-based, regardless of design, conducted among community dwellers aged 18 years or older, involving at least 10 participants, and containing numerical information on the diagnosis, prevalence, awareness, treatment and/or control of hypertension in Cameroon. Hospital/primary healthcare/clinic-based studies, studies of pregnant women and studies without a description of how patients with hypertension were identified, were excluded. If there was more than one report for the same study, the one with the most detailed information for our research question was included.

Data extraction and risk of bias in individual studies

Two reviewers independently extracted details of included studies into a database, and integrated them into a synthesis table made available to all review team members. Authors' names, data collection and publication dates, study design, sample size and study population description were extracted. Additionally, all relevant raw data on the presence versus absence of at least one of the outcomes in the total number of participants with/without a given exposure variable (2×2 table) were extracted. Disagreements between the two reviewers were resolved either by consensus or arbitration as appropriate with a third review team member. The sample size was categorized into less than 800 versus higher categories, given standard practices in sample size for prevalence studies that assume a conventional multiplier for power of 0.80 with a two-sided significance

of 0.05 [27,28]. Two data collection periods (1994–2010 versus 2011–2018) were specified so as to compare the BP and hypertension data since the Cameroonian sectoral health strategy launched in 2011 – combatting NCD including hypertension being a public health priority – with prior data when health strategies focused on communicable diseases [12]. Primary study authors were contacted by E-mail up to three times, to obtain additional information about missing relevant data given the research question. The original pooled data reorganized participants into predefined homogeneous subgroups suitable for meta-analysis [29], by study (sample size, period of data collection and study quality score) and participant (sex, age, ethnic ancestry, area of residence, agroecological zone and subnational region) factors [24]. The Downs and Black checklist, covering four risk-of-bias domains – reporting, external validity, internal validity (bias and confounding) and power – was used to appraise the quality of included studies [30]. Quality score cut-offs used to categorize studies were: excellent (26–28), good (20–25), fair (15–19), or poor ($\leq$14) [30].

Outcome definitions

The World Hypertension League (WHL)'s definitions and recommended analyses [31,32] were adopted. The distributions of SBP and DBP were summarized by the mean SBP and DBP and their associated statistics. Hypertension prevalence was defined as the proportion of participants who had SBP at least 140 mmHg or DBP at least 90 mmHg. Hypertension awareness prevalence was defined as the proportion of participants with hypertension who reported either having been diagnosed with hypertension by a health professional or who reported taking medication for high BP. Hypertension treatment prevalence was defined as the proportion of participants with hypertension who reported taking medication for high BP. The prevalence of controlled hypertension was defined as the proportion of participants with hypertension who both reported taking medication for high BP and had SBP less than 140 mmHg and DBP less than 90 mmHg.

Data synthesis and statistical analysis

The unit of analysis was the individual study (data point). Data were pooled across studies using random-effects meta-analysis [29]. Pooled estimates were reported overall and tracked over time. Subgroup meta-analyses preplanned in the review protocol were performed by population-level (sex, age and ethnic origin) and geography-based (area of residence, agroecological zone and subnational region) factors. Sensitivity analyses pre-planned were performed to explore the impact of excluding or including studies in meta-analysis based on methodological quality and sample size. Age-standardized estimates were calculated using the WHO standard population [33] that has a relatively young distribution similar to that of a typical African country like Cameroon [12] (Supplemental Figure 1, http://links.lww.com/HJH/B114). The standard χ^2 test (Q test) (significance level of $P < 0.1$) and I^2 statistic (significance level of $I^2 > 50\%$) were used to test between-study heterogeneity [29,34]. The presence of publication bias was examined using funnel plots, a useful and popular way of investigating publication bias [35]. To test for the publication bias under alternative assumptions about the association between effect size estimate and measure of study size or precision (i.e. standard error), the two most popular statistical tests were used: the Begg's test (an adjusted rank correlation test) [36] and the Egger's test (uses a linear regression approach) [37]. A generous minimum number of studies for the performance of a funnel plot to be warranted is about 10 [38]. Following the WHL's recommendations [31,32] and standard reporting of mean BP and hypertension prevalence, awareness, treatment and control [39,40], each pooled estimate included its 95% confidence interval (CI). Analyses were performed with STATA 12.1 (Stata Corp, College Station, Texas, USA).

RESULTS

Systematic review

The literature search yielded 1121 publications from Web of Science (292), EMBASE (281), PubMed (164), Scopus (156), Medline (137), CINHAL (16), Popline (7) and BDSP (6). A total of 368 publications remained after removing duplicates. On screening titles for relevance, 169 publications were excluded. We then assessed 199 full texts, and excluded 73 reviews, editorials, case reports, animal/plant studies or publications unrelated to hypertension-related outcomes. An additional 86 hospital/primary healthcare/clinic-based publications were excluded. In total 40 population-based studies were assessed, and after applying the criteria for age eligibility, numerical information and multiple publications of the same study, 20 studies were retained for analysis (Fig. 1).

Characteristics of the included studies

The 20 studies [41–59] used objective measure of the hypertension (Supplemental Table 1, http://links.lww.com/HJH/B114). They were all cross-sectional (two in French), were fielded and published between 1994 and 2018, and involved 46 491 rural and urban community dwellers aged 18 years or older (53.0% women; 21 717 and 24 774 participants in the 1994–2010 and 2011–2018 periods, respectively) residing in all Cameroon's 10 regions and five agroecological zones (Supplemental Table 2, http://links.lww.com/HJH/B114 and Supplemental Table 3, http://links.lww.com/HJH/B114). The mean time from data collection to study publication was 3.9 ($\pm$3.4) years. Sample sizes varied from 181 to 15 470 participants. Most studies involved mixed ethnic origins (17); some focused on specific ethnic ancestries: Bamileke (1), Bantu (1), Fulbe (2), Mbororo (1) and Pygmy (1). The 20 studies were fielded in rural (7; 2 being in rural areas only) and urban (18; 13 being in urban areas only) communities. One publication used two studies [46]. There were no community interventions. Nine and eight of the 20 studies included Yaoundé (capital city) and Douala (main economic city) of Cameroon, respectively. The study quality scores ranged from 8 [45] to 18 [57].

Results of random-effects meta-analyses

For each outcome, the data points and resulting pooled samples generated from raw data in primary studies and

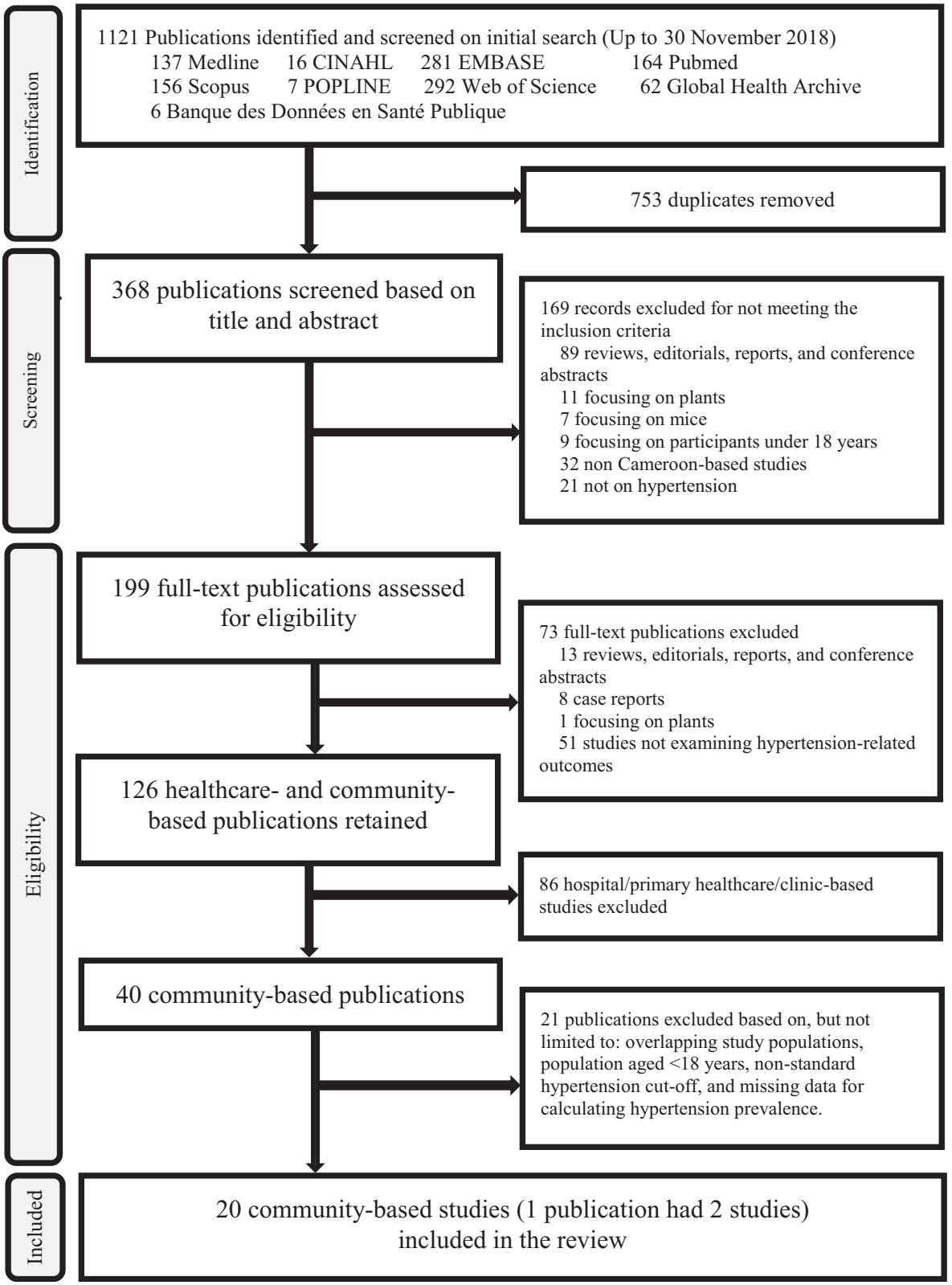

FIGURE 1 Flow chart of study selection.

utilized in meta-analyses to compute overall pooled estimates and separately pooled estimates for each subgroup are provided in Supplemental Table 3, http://links.lww.com/HJH/B114.

Overall pooled estimates and tracked changes between 1994–2010 and 2011–2018

Table 1 shows overall and separately pooled estimates for 1994–2010 and 2011–2018; there were high heterogeneity

TABLE 1. Blood pressure and hypertension prevalence, awareness, treatment and control in Cameroon: estimates and changes between 1994–2010 and 2011–2018

	Blood pressure (mmHg)		Hypertension (%)					
				Prevalence in studies with suitable age group data				
	SBP (95% CI)	DBP (95% CI)	Prevalence (95% CI)	Crude (95% CI)	Age-standardized (95% CI)	Awareness (95% CI)	Treatment (95% CI)	Control (95% CI)
Overall	129.2 (125.0–133.3)	80.0 (77.9–82.1)	30.9 (27.0–34.8)	32.4 (27.6–37.3)	23.5 (21.4–25.6)	24.4 (18.9–30.0)	15.1 (10.6–19.6)	8.8 (5.7–11.9)
Period of data collection								
1994–2010	128.5 (122.5–134.4)	80.2 (76.8–83.7)	29.6 (24.1–35.1)	29.4 (21.3–37.5)	21.7 (19.4–24.1)	31.6 (21.0–42.3)	16.0 (5.5–26.5)	10.4 (7.5–13.3)
2011–2018	129.6 (125.3–133.9)	79.9 (78.4–81.5)	32.1 (27.2–37.1)	35.0 (28.5–41.4)	25.0 (21.0–28.9)	20.8 (14.0–27.7)	14.8 (7.8–21.8)	8.3 (4.4–12.3)

CI, confidence interval.

across studies (Supplemental Figures 1–7, http://links.lww.com/HJH/B114). The overall mean SBP and mean DBP were 129.2 (95% CI 125.0–133.3) mmHg ($P = 0.000$, $I^2 = 99.5\%$) and 80.0 (77.9–82.1) mmHg ($P = 0.000$, $I^2 = 99.4\%$), respectively (Supplemental Figure 2, http://links.lww.com/HJH/B114). The overall crude hypertension prevalence was 30.9% (27.0–34.8) ($P = 0.000$, $I^2 = 98.8\%$) – increasing from 29.6% (24.1–35.1) in 1994–2010 ($P = 0.000$, $I^2 = 98.7\%$) to 32.1% (27.2–37.1) in 2011–2018 ($P = 0.000$, $I^2 = 97.9\%$) (Supplemental Figure 3, http://links.lww.com/HJH/B114). Studies that had meta-analysable and similar age groups data had older people [mean age of 39.9 (±4.7) years] than the general adult Cameroonian population and the WHO standard population; not surprisingly, the overall age-standardized hypertension prevalence was substantially lower than its crude counterpart [23.5% (21.4–25.6) ($P = 0.000$, $I^2 = 94.4\%$) versus 32.4% (27.6–37.3) (P = 0.000, $I^2 = 98.9\%$), respectively)] (Supplemental Figure 4, http://links.lww.com/HJH/B114). The pooled crude estimates from older age structures in these studies likely overstated the actual hypertension prevalence rates in the general population aged 18 years or older in Cameroon.

Among people with hypertension, 24.4% (18.9–30.0) ($P = 0.000$, $I^2 = 97.6\%$) were aware of their status – falling from 31.6% (21.0–42.3) in 1994–2010 ($P = 0.000$, $I^2 = 96.3\%$) to 20.8% (14.0–27.7) in 2011–2018 ($P = 0.000$, $I^2 = 96.9\%$) (Supplemental Figure 5, http://links.lww.com/HJH/B114); 15.1% (10.6–19.6) ($P = 0.000$, $I^2 = 95.1\%$) were taking prescribed antihypertensive medications – decreasing from 16.0% (5.5–26.5) in 1994–2010 ($P = 0.000$, $I^2 = 96.3\%$) to 14.8% (7.8–21.8) in 2011–2018 ($P = 0.000$, $I^2 = 95.8\%$) (Supplemental Figure 6, http://links.lww.com/HJH/B114); and only 8.8% (5.7–11.9) had achieved control ($P = 0.000$, $I^2 = 85.2\%$) – declining from 10.4% (7.7–13.3) in 1994–2010 (1 study) to 8.3% (4.4–12.3) in 2011–2018 (three studies) (Supplemental Figure 7, http://links.lww.com/HJH/B114).

Results of subgroup meta-analyses

Results of subgroup analyses by population-level factors (sex, age group and ethnic ancestry) (Table 2) and geography-based characteristics (area of residence, agroecological zone and subnational region) (Table 3) showed noticeable disparities in BP levels and burden of hypertension over time in Cameroon. Compared with women, men had higher mean SBP [131.9 (127.4–136.4) mmHg] and mean DBP [80.4 (79.2–81.7) mmHg], higher crude hypertension prevalence (34.3%; 30.0–38.6) and higher age-standardized hypertension prevalence (23.8%; 19.2–28.4). Compared with women, men had lower prevalence of hypertension awareness (19.5%; 14.8–24.2), treatment (12.8%; 7.3–18.2) and control (7.4%; 3.7–11.2). The hypertension prevalence rose

TABLE 2. Blood pressure and hypertension prevalence, awareness, treatment and control by demographic characteristics

	Blood pressure (mmHg)		Hypertension (%)					
				Prevalence in studies with suitable age group data				
	SBP (95% CI)	DBP (95% CI)	Prevalence (95% CI)	Crude (95% CI)	Age-standardized (95% CI)	Awareness (95% CI)	Treatment (95% CI)	Control (95% CI)
Sex								
Male	131.9 (127.4–136.4)	80.4 (79.2–81.7)	34.3 (30.0–38.6)	38.0 (30.8–45.3)	23.8 (19.2–28.4)	19.5 (14.8–24.2)	12.8 (7.3–18.2)	7.4 (3.7–11.2)
Female	127.6 (123.2–131.9)	79.4 (77.6–81.2)	31.3 (26.5–36.1)	35.6 (27.2–44.1)	21.3 (18.1–24.5)	27.1 (19.8–34.4)	16.5 (10.3–22.6)	10.3 (7.0–13.5)
Age group (in years)								
< 35	–	–	24.0 (20.4–27.6)	–	–	8.0 (4.6–11.4)	3.5 (1.2–5.8)	1.2 (0.1–2.6)
35–44	–	–	35.3 (30.6–40.0)	–	–	16.1 (12.0–20.1)	9.5 (6.3–12.7)	4.3 (0.5–8.0)
45–54	–	–	54.4 (50.3–58.5)	–	–	28.5 (22.4–34.6)	17.9 (14.6–21.2)	9.7 (0.7–18.6)
≥ 55	–	–	66.4 (46.7–86.2)	–	–	37.2 (12.9–61.5)	25.2 (14.3–36.1)	14.4 (8.5–20.2)
Ethnic group								
Bamileke	135.7 (132.3–139.1)	84.6 (82.0–87.3)	56.6 (49.4–63.8)	–	–	–	–	–
Bantu	119.0 (116.3–121.7)	78.0 (75.9–80.1)	28.0 (20.8–35.2)	–	–	–	–	–
Fulbe	131.1 (125.3–136.9)	80.2 (79.5–80.9)	35.6 (29.4–41.7)	35.6 (29.4–41.7)	27.5 (23.8–31.1)	18.6 (14.5–22.7)	5.4 (3.0–7.8)	–
Mbororo	127.9 (126.4–129.4)	80.4 (79.5–81.3)	30.6 (27.6–33.6)	30.6 (27.6–33.6)	24.2 (21.4–27.0)	–	–	–
Pygmy	107.0 (105.1–108.9)	71.0 (69.2–72.8)	3.3 (0.4–6.2)	–	–	–	–	–
Mixed	129.7 (124.9–132.0)	80.2 (77.6–82.7)	29.9 (25.8–34.1)	31.8 (26.5–37.0)	22.9 (20.7–25.1)	25.2 (19.1–31.2)	17.1 (12.5–21.7)	8.8 (5.7–11.9)

CI, confidence interval.

TABLE 3. Blood pressure and hypertension prevalence, awareness, treatment and control by geography-based characteristics

	Blood pressure (mmHg)		Hypertension (%)					
				Prevalence in studies with suitable age group data				
	SBP (95% CI)	DBP (95% CI)	Prevalence (95% CI)	Crude (95% CI)	Age-standardized (95% CI)	Awareness (95% CI)	Treatment (95% CI)	Control (95% CI)
Area of residence								
Rural	123.2 (117.3–129.6)	76.7 (73.7–79.8)	25.4 (17.1–33.7)	31.7 (28.9–34.4)	24.6 (22.8–26.3)	22.3 (14.7–29.9)	11.7 (5.4–28.9)	6.1 (3.0–9.2)
Urban	129.1 (124.8–133.4)	80.5 (78.8–82.1)	31.4 (27.3–35.5)	33.0 (27.6–38.4)	23.6 (21.3–25.9)	25.8 (19.4–32.1)	14.6 (10.1–19.1)	9.7 (5.8–13.6)
Agroecological zone								
Guinea savannah	130.2 (127.0–133.5)	81.3 (79.0–83.7)	28.0 (20.1–35.9)	25.9 (15.1–36.6)	20.7 (12.6–28.7)	14.1 (9.5–18.7)	–	–
Humid	132.4 (126.8–138.0)	82.3 (80.8–83.7)	32.1 (24.3–40.0)	35.5 (6.8–64.1)	26.1 (14.8–37.4)	22.5 (15.8–29.2)	13.9 (9.6–18.1)	3.9 (0.1–7.7)
Sub-humid	125.4 (119.9–130.8)	78.3 (75.0–81.5)	29.1 (23.5–34.6)	32.7 (27.5–37.9)	22.9 (20.3–25.4)	27.8 (17.9–37.8)	16.8 (9.4–24.3)	7.6 (2.1–13.1)
Sudano-sahelian	132.9 (130.9–135.0)	81.3 (78.8–83.7)	33.4 (28.7–38.1)	38.5 (35.3–41.7)	29.1 (26.1–32.1)	18.6 (13.1–24.1)	8.1 (2.8–13.4)	–
Tropical highlands	130.8 (123.2–138.4)	81.1 (79.0–83.2)	35.1 (28.9–41.3)	45.1 (37.1–53.2)	28.1 (22.5–33.6)	25.3 (15.6–35.1)	23.2 (11.6–34.7)	19.1 (5.3–32.8)
Subnational region								
Adamawa	130.2 (127.0–133.5)	79.9 (79.1–80.6)	28.0 (20.1–35.9)	25.9 (15.1–36.6)	20.7 (12.6–28.7)	14.1 (9.5–18.7)	–	–
Centre	127.9 (122.2–133.5)	78.6 (76.0–81.1)	31.8 (26.0–37.5)	33.6 (25.6–41.6)	22.4 (19.1–25.6)	31.4 (23.7–39.0)	16.8 (9.4–24.3)	7.6 (2.1–13.1)
East	130.2 (126.9–133.6)	79.7 (79.2–80.1)	30.8 (29.3–32.2)	30.5 (27.9–33.1)	24.3 (21.9–26.7)	–	–	–
Far North	133.0 (131.0–135.1)	79.8 (79.1–80.5)	35.5 (29.5–41.5)	38.5 (35.3–41.7)	29.1 (26.1–32.0)	18.6 (14.5–22.7)	5.4 (3.0–7.8)	–
Littoral	132.4 (126.6–138.2)	81.6 (79.2–84.0)	32.3 (23.3–41.2)	35.5 (6.8–64.1)	26.1 (14.8–37.4)	23.9 (21.7–26.2)	11.5 (9.8–13.1)	2.2 (1.1–3.4)
North	131.9 (130.1–133.7)	79.5 (78.4–80.6)	30.6 (28.1–33.1)	–	–	23.0 (20.0–26.0)	10.8 (8.6–13.0)	–
North-West	131.8 (130.4–133.1)	80.5 (78.1–82.9)	34.9 (28.6–41.2)	–	–	23.0 (20.0–26.0)	10.8 (8.6–13.0)	–
South	119.5 (95.1–143.9)	75.3 (67.0–83.6)	17.1 (9.9–44.2)	–	–	–	–	–
South-West	131.9 (130.1–133.7)	79.5 (78.4–80.6)	30.9 (28.8–33.0)	–	–	28.9 (23.0–34.8)	20.6 (15.4–25.9)	6.1 (3.0–9.2)
West	130.8 (122.2–139.4)	80.3 (78.2–82.3)	36.3 (27.8–44.9)	41.4 (39.1–43.7)	25.7 (23.7–27.8)	16.1 (6.1–26.1)	14.8 (12.2–17.4)	12.4 (10.0–14.8)

CI, confidence interval.

steadily from 24.0% (20.4–27.6) at age less than 35 to 66.4% (46.7–86.2) at age at least 55; likewise, the hypertension awareness prevalence increased from 8.0% (4.6–11.4) at age less than 35 to 37.2% (12.9–61.5) at age at least 55 years. The hypertension treatment prevalence also rose from 3.50% (1.2–5.8) at age less than 35 to 25.2% (14.3–36.1) at age at least 55 years, and the hypertension control prevalence increased from 1.2% (0.1–2.6) at age less than 35 years to 14.4% (8.5–20.2) at age at least 55 years. Mean SBP/DBP were the highest among Bamileke people (135.7/84.6 mmHg) and the lowest among Pygmies (107.0/71.0 mmHg), and community dwellers of Bamileke ancestry also stood out with the highest hypertension prevalence (56.6%) whereas the Pygmies had the lowest prevalence (3.3%).

We estimated pooled mean SBP/DBP to be: 123.2/76.7vmmHg for rural inhabitants versus 129.1/80.5 mmHg for their urban counterparts; lowest for the subhumid zone (125.4/78.3 mmHg) and highest for the Sudano-sahelian zone (132.9/81.3 mmHg); and lowest for the South region (119.5/75.3 mmHg) and highest for the Far North region (133.0/79.8 mmHg). The hypertension prevalence was higher in urban (31.4%) than rural (25.4%), highest in the tropical highlands agroecological zone (35.1%) – where the majority of inhabitants are people of Bamileke descent – and lowest in the Guinea-savannah (28.0%), and highest the West region (36.3%) – which is mostly populated by dwellers of Bamileke ancestry – and lowest in the South region (17.1%). The prevalence of undiagnosed, untreated and uncontrolled hypertension was uniformly high in the different demographic and geographic subgroups for which meta-analysable data were available. Specifically, the high burden of undiagnosed hypertension was generalized nationwide, higher among rural (77.7%) than urban (74.2%) dwellers, highest among inhabitants of the Guinea-savannah zone (85.9%) and lowest among those of the sub-humid zone (72.2%).

Sensitivity meta-analyses

We explored sources of heterogeneity with respect to the methodological quality and sample size of the included studies (Table 4). Studies of higher quality score had lower pooled mean SBP/DBP (125.4/79.0 mmHg), lower crude hypertension prevalence (28.7%), higher burden of undiagnosed hypertension (82.2%) and uncontrolled hypertension (91.7%) than studies with lower quality score. However, for the 11 studies with suitable age group data for which meta-analysis was conducted, estimates of crude hypertension prevalence were robustly similar between studies of lower (32.9%) and higher (31.5%) quality score; likewise, the age-standardized hypertension prevalence was 23.6 and 23.3% for studies of higher and lower quality score, respectively. These findings suggested that the age distribution of the participants in included studies partly explained the between-study heterogeneity. Mean BP values and burden of hypertension by sample size depicted no consistent patterns: studies of sample size less than 800 or 800–1999 were not more likely to report more extreme results compared with studies of sample size at least 2000.

TABLE 4. Blood pressure and hypertension prevalence, awareness, treatment and control by study quality score and sample size

	Blood pressure (mmHg)		Hypertension (%)					
				Prevalence in studies with suitable age group data				
	SBP (95% CI)	DBP (95% CI)	Prevalence (95% CI)	Crude (95% CI)	Age-standardized (95% CI)	Awareness (95% CI)	Treatment (95% CI)	Control (95% CI)
Quality score								
<15	131.6 (124.9–138.2)	80.7 (77.9–83.5)	32.3 (26.2–38.4)	32.9 (23.9–41.9)	23.3 (20.0–26.6)	29.4 (23.4–35.3)	14.8 (9.6–20.0)	9.4 (3.6–15.2)
15–19	125.4 (119.7–131.1)	79.0 (76.6–81.4)	28.7 (25.3–32.1)	31.5 (28.3–34.7)	23.6 (20.9–26.2)	17.8 (11.9–23.7)	15.7 (3.8–27.6)	8.3 (4.1–12.5)
Sample size								
<800	127.7 (117.6–137.7)	80.6 (76.8–84.4)	31.9 (25.3–38.5)	32.4 (18.8–46.0)	19.2 (15.9–22.5)	19.8 (2.0–37.6)	20.6 (15.4–25.9)	6.1 (3.0–9.2)
800–1999	130.4 (122.4–138.4)	79.8 (77.1–82.5)	32.0 (24.7–39.3)	34.3 (27.5–41.1)	24.7 (21.5–28.0)	27.9 (18.6–37.1)	13.8 (5.0–22.6)	11.6 (9.6–13.5)
≥2000	129.6 (121.1–138.1)	79.5 (74.2–84.9)	27.9 (19.9–36.0)	30.7 (22.1–39.3)	24.8 (21.3–28.3)	22.9 (13.9–31.8)	14.8 (6.8–22.9)	6.5 (5.0–8.0)

CI, confidence interval.

Publication bias

Visual inspection of the funnel plots indicated substantial asymmetry (Supplemental Figures 8–13, http://links.lww.com/HJH/B114). For the mean SBP, the Egger's test ($P = 0.805$) and the Begg's test ($P = 0.951$) did not indicate evidence of publication bias; similarly, for the mean DBP (Egger, $P = 0.151$; Begg, $P = 0.246$). These tests fail to find evidence of publication bias for the prevalence of hypertension for all 20 included studies (Egger, $P = 0.539$; Begg, $P = 0.581$) or for the studies, which had suitable age group data for age-standardized hypertension prevalence (Egger, $P = 0.627$; Begg, $P = 0.640$); they also did not indicate evidence of publication bias for the prevalence of hypertension awareness (Egger, $P = 0.550$; Begg, $P = 0.755$), and for the prevalence of hypertension treatment (Egger, $P = 0.231$; Begg, $P = 0.452$). For the prevalence of hypertension control, the Begg's test found no evidence of publication bias ($P = 0.806$), but the Egger's test did ($P = 0.029$); however, the small number of studies (<10) used may account for the discrepancy in these test results.

DISCUSSION

Reliable, large-scale, population-based data on hypertension in Africa are scarce. Using nationwide pooled data on 46 491 participants covering all regions and agroecologies of Cameroon, this study provided improved estimates and tracked changes in BP distribution and hypertension prevalence, awareness, treatment and control over time. It used the WHL's definitions and recommended analyses [31,32] to pinpoint agroecologies, regions and population subgroups with heightened BP and at risk for developing cardiovascular disease (CVD).

This review found high mean BP values and prevalence of hypertension contrasting with strikingly low prevalence of hypertension awareness, treatment and control observed in Cameroon. Moreover, the proportion of people aged 18 years or older living with hypertension in Cameroon has increased over time, currently affecting 32% of adults; among these people with hypertension, 76% were unaware of their hypertension status, 85% were not taking antihypertensive medication and 91% had uncontrolled BP. This reflects epidemiological processes unfolding in Africa [60] and its countries of sub-Saharan Africa [10], East Africa [61–66], Central Africa [67–70], North Africa [61,71,72], West Africa [39,61,73–75] and Southern Africa [61,76]. Our estimates are quite close to those reported in sub-Saharan Africa where the hypertension prevalence was 30%; among people with hypertension, 73% were unaware of their status, 82% were not receiving treatment and 93% had uncontrolled BP [10]; but our analysis adds an in-depth picture of the geographic and demographic variability around the population means. These estimates concur with those on hypertension in Africa [10,77,78] and worldwide with about one-third of adults in most communities being hypertensive [6]. The burden of hypertension in Cameroon and in much of Africa, contrasts with the markedly higher prevalence of hypertension awareness, treatment and control reported in high-income countries [4,5,11], and other low-income and middle-income countries [21,79].

We found higher hypertension prevalence for men than women as is generally the case in Africa [77,78], excepting a few countries where the prevalence is higher in women: Algeria (31.6 versus 25.7%), Botswana (37.0 versus 28.8%) and Mali (25.8 versus 16.6%) [60]. A higher prevalence of hypertension was found in urban versus rural areas of Cameroon. This finding is in accordance with those generally reported in high-income, middle-income and low-income countries [21], and in other African countries [39,40,60,61,78]. The structurally higher levels of hypertension in urban than in rural settings has been attributed mainly to contextual and behavioural factors associated with urban environments, including unhealthy dietary patterns and sedentary lifestyle [60]. In contrast, most rural locations generally favor intense physical activities including walking for long periods and rigorous farming coupled with better nutrition, rich in locally produced fruits and vegetables [39,78,80]. There were also remarkable disparities in mean BP values and burden of hypertension across all regions. These regional disparities may reflect differences in urbanization rates, lifestyle factors, food security and consumption patterns, behavioural and stress-related factors, ethnic composition of the population, socioeconomic inequality, population aging, health-promoting resources and soil potassium and sodium concentrations [5,7,8,11,22]. That so many individuals' hypertension was untreated and uncontrolled may also reflect the high burden of undiagnosed hypertension. The latter is consistent with enduring constraints in access to quality and affordable healthcare, poor public health facilities network coverage, scarcity of health professionals, frequent rupture of stocks of NCD drugs, very limited accessibility to

inexpensive and/or essential medicines [81], limited hypertension knowledge among health professionals and patients [6,8,10] and poor adherence to medication among hypertensive patients under treatment.

To our knowledge, this is the first study that attempted to generate nationally and subnationally pooled data, to pinpoint ethnic disparities in hypertension and geography-based variation of BP distribution and hypertension statistics for all five agroecological zones and 10 regions, in both rural and urban areas, in Cameroon. This study revealed that: hypertension prevalence is high and increasing over time in Cameroon; and the burden of undiagnosed, untreated and uncontrolled hypertension in community-dwelling residents is extremely high nationwide and widespread across diverse population subgroups, across all five agroecological zones and 10 subnational regions, and areas of residence. This situation is compounded by the fact that many patients cannot afford the out-of-pocket payment, which impedes their accessibility to healthcare or adherence to treatment in various communities. These new and improved indicators reflect the state of response to the growing burden of hypertension in Cameroon, and most likely of the prevailing situation in much of Africa. Such statistics are crucial for understanding the geography and public health significance of hypertension, and provide data for evaluating the effects of public health policies and programs for population health promotion. Policymakers and public health practitioners may use these geography-based data on BP distribution and hypertension mapping in planning hypertension awareness programs, and to determine the best manner to allocate resources for reducing hypertension risk and hypertension-related diseases and deaths nationwide and across regions. Structural changes are needed to address hypertension in Cameroon where education and screening may not be sufficient without parallel efforts to improve hypertension treatment and control. The most direct implication of these findings is that Cameroon needs a universal, rather than a targeted, approach to hypertension and that the obstacles to control must be determined [12,17,82].

This review also highlighted salient ethnic differences in BP values and the burden of hypertension. Further research is needed to tease out the distinctive features that predispose people of Bamileke descent to higher BP values and burden of hypertension irrespective of geographic location in Cameroon [42,49,51] and probably in other countries in the world. Such research should be designed to assess epidemiological, genetic, socioeconomic, cultural, behavioral, lifestyle and environmental factors affecting BP levels, hypertension awareness and treatment [83], individual responses to pharmacological therapy [84], emotional stress in sub-Saharan Africans [85] and gene–environment interactions [86].

This review had some limitations. First, the evaluation of blood pressure was done on a single occasion, which tends to overestimate the prevalence of hypertension [6,40,53]. Second, the data were unavailable for all outcomes in included studies. This limitation was addressed by showing the number of studies and samples used for each separately pooled estimate. Third, there was considerable between-study heterogeneity, due in part to differences in study methodology and population age distribution. However, the patterns of estimates were generally robust across population-level and geography-based factors. Thus, emerging patterns may represent true disparities across subgroups where substantial disparities in access to healthcare exist. Fourth, all studies were cross-sectional and there was no community-based intervention study to examine the feasibility of reducing or eliminating hypertension disparities. This highlights the need for community-engaged hypertension disparities research using life-course public health approaches [87,88].

In conclusion, this review produced much needed population-level data nationwide and yielded pooled estimates, which tracked changes over time and showed their variation by sex, ethnic ancestry, area of residence, agroecological zone and subnational region. It identified noticeable geography-based disparities in BP values and hypertension in Cameroon, known as miniature Africa. These disparities are embedded in the high burden of undiagnosed, untreated and uncontrolled hypertension simultaneously with the rising burden of hypertension nationwide. These contrasting patterns call for effective campaigns to raise hypertension awareness together with strategies for hypertension prevention and control, and a better policy response.

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Conflicts of interest

Members of the review team who were authors of the studies reviewed were allowed to participate in discussions and appraisal of evidence from published work, including their own studies and recused themselves from voting on evidence statements and recommendations related to their studies. J.C.T. reported grants from Amarin, AstraZeneca, Esperion, Ionis, Merck, personal fees from Pfizer and Sanofi, personal fees and minor equity interest from DalCor, grants and personal fees from Servier, as well as a patent Pharmacogenomics-guided CETP inhibition pending, all of which were outside the submitted work. All the other review team members declared no conflicts of interest.

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