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Elevated blood pressure among adolescents in sub-Saharan Africa: a systematic review and meta-analysis

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Summary

Background More people from sub-Saharan Africa aged between 20 years and 60 years are affected by end-organ damage due to underlying hypertension than people in high-income countries. However, there is a paucity of data on the pattern of elevated blood pressure among adolescents aged 10–19 years in sub-Saharan Africa. We aimed to provide pooled estimates of high blood pressure prevalence and mean levels in adolescents aged 10–19 years across sub-Saharan Africa.

Methods In this systematic review and meta-analysis, we searched PubMed, Google Scholar, African Index Medicus, and Embase to identify studies published from Jan 1, 2010, to Dec 31, 2021. To be included, primary studies had to be observational studies of adolescents aged 10–19 years residing in sub-Saharan African countries reporting the pooled prevalence of elevated blood pressure or with enough data to compute these estimates. We excluded studies on non-systemic hypertension, in African people not living in sub-Saharan Africa, with participant selection based on the presence of hypertension, and with adult cohorts in which we could not disaggregate data for adolescents. We independently extracted relevant data from individual studies using a standard data extraction form. We used a random-effects model to estimate the pooled prevalence of elevated blood pressure and mean systolic blood pressure (SBP) and diastolic blood pressure (DBP) levels overall and on a sex-specific basis. This study is registered with PROSPERO (CRD42022297948).

Findings We identified 2559 studies, and assessed 81 full-text studies for eligibility, of which 36 studies comprising 37 926 participants aged 10–19 years from ten (20%) of 49 sub-Saharan African countries were eligible. A pooled sample of 29 696 adolescents informed meta-analyses of elevated blood pressure and 27 155 adolescents informed meta-analyses of mean blood pressure. Sex data were available from 26 818 adolescents (14 369 [53·6%] were female and 12 449 [46·4%] were male) for the prevalence of elevated blood pressure and 23 777 adolescents (12 864 [54·1%] were female and 10 913 [45·9%] were male) for mean blood pressure. Study quality was high, with no low-quality studies. The reported prevalence of elevated blood pressure ranged from 4 (0·2%) of 1727 to 1755 (25·1%) of 6980 (pooled prevalence 9·9%, 95% CI 7·3–12·5; I^2=99·2%, $p_{heterogeneity}$<0·0001). Mean SBP was 111 mm Hg (95% CI 108–114) and mean DBP was 68 mm Hg (66–70). 13·4% (95% CI 12·9–13·9; $p_{heterogeneity}$<0·0001) of male participants had elevated blood pressure compared with 11·9% (11·3–12·4; $p_{heterogeneity}$<0·0001) of female participants (odds ratio 1·04, 95% CI 0·81–1·34; $p_{heterogeneity}$<0·0001).

Interpretation To our knowledge, this systematic review and meta-analysis is the first systematic synthesis of blood pressure data specifically derived from adolescents in sub-Saharan Africa. Although many low-income countries were not represented in our study, our findings suggest that approximately one in ten adolescents have elevated blood pressure across sub-Saharan Africa. Accordingly, there is an urgent need to improve preventive heart-health programmes in the region.

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Introduction

Elevated blood pressure and hypertension affect 1·2 billion people worldwide. These are highly detectable and preventable conditions that lead to approximately 7 million deaths per year.[1] In low-income and middle-income countries, where 80% of the disease burden occurs,[2] the pattern of secondary organ damage is more pronounced in people aged between 20 years and 60 years and people who are pregnant than in high-income countries.[3] This pattern is particularly true for people living across sub-Saharan Africa.[4] For example, in the Heart of Soweto cohort, the mean age of adults presenting with hypertension and end-organ damage, two-thirds of whom were women, was 58 years.[5] Overall, 27 (55%) of 49 sub-Saharan African countries comprising relatively young populations are low-income countries.[6] A combination of factors, including economic development and urbanisation,[7] has led to an increase in many non-communicable conditions, including stroke and hypertensive heart disease.[8] As a key indicator of cardiometabolic health, obesity rates are

Research in context

Evidence before this study
More people from sub-Saharan Africa aged between 20 years and 60 years are affected by end-organ damage due to underlying hypertension than people in high-income countries. However, there is a paucity of data on the pattern of elevated blood pressure among adolescents aged 10–19 years in sub-Saharan Africa. A previous systematic review and meta-analysis of 51 studies in Africa derived a pooled prevalence of 5·5% for elevated blood pressure among a composite of children and adolescents aged between 2 years and 19 years living in some African countries and incorporating data from north Africa.

We searched PubMed, Google Scholar, African Index Medicus, and Embase for studies published between Jan 1, 2010, and Dec 31, 2021, in English. Relevant search terms were "hypertension", "blood pressure", "systolic hypertension", and "diastolic hypertension" in conjunction with "adolescent", "teens", "teenage", "school", and "youth". To be included, primary studies had to include individuals aged 10–19 years living in sub-Saharan Africa, have a sample size of more than 100 people, and focus on hypertension. Risk of bias was evaluated using the tool developed by Hoy and colleagues. No studies were included according to the criteria above.

Added value of this study
To the best of our knowledge, this is the first systematic review and meta-analysis to specifically estimate the pooled prevalence of elevated blood pressure and report on mean blood pressure among adolescents living in sub-Saharan Africa. Our findings suggest that approximately one in ten adolescents living in the region now have elevated blood pressure. This prevalence is almost twice as large as the previous estimate. However, many sub-Saharan countries were not represented in our study. Unlike in adults aged 20 years or older, no clear sex-specific differences were evident within adolescents. However, blood pressure became more elevated with increasing age and BMI. As demographic, socioeconomic, and anthropometric profiles vary across sub-Saharan Africa, our findings reinforce the need to map blood pressure more systematically among adolescents across the region.

Implications of all the available evidence
We believe our results support increasing calls to develop and fund appropriate policies and initiatives in sub-Saharan Africa to improve the rapid detection, formal diagnosis, and appropriate management of hypertension across the entire lifespan. Because of the high prevalence of adolescents with hypertension, most of whom were attending school, there is a strong argument to incorporate regular blood pressure monitoring into wider efforts to implement heart health monitoring in young people living in sub-Saharan Africa. Furthermore, there is a continued need to apply proactive primary prevention strategies to address elevated blood pressure and the subsequent elevated risk of stroke and hypertensive heart disease at an early age in sub-Saharan Africa. From a research perspective, there is an urgent need to conduct a wider geographical distribution of methodologically standardised studies of elevated blood pressure among adolescents living in the region. Furthermore, a better understanding of the natural history of hypertension and end-organ damage is needed among people aged 20–40 years in sub-Saharan Africa. Such data will better inform efforts to reduce the future burden of hypertension-related disease in the region through targeted prevention and treatment programmes.

reportedly increasing among adolescents across sub-Saharan Africa.[9] Therefore, people in sub-Saharan Africa are at risk of developing hypertension at a younger age than people living in high-income countries.[10] Consequently, the already substantive disease burden attributable to undetected and untreated hypertension in the region is likely to increase.[3]

A previous systematic review and meta-analysis of 51 studies in Africa, including north Africa, reported a pooled prevalence of elevated blood pressure and hypertension of 5·5% (95% CI 4·2–6·9) among 54 196 participants aged 2–19 years.[11] These studies typically relied on normative blood pressure levels derived from North America.[12] Crucially, most studies mixed data from children and adolescents. Moreover, the meta-analysis largely relied on data from Nigeria and the Seychelles, with only six sub-Saharan African countries included overall.[11]

We aimed to conduct a more contemporary systematic review of research reports to establish the distribution of studies focusing on elevated blood pressure among adolescents across sub-Saharan Africa. We then conducted a meta-analysis, accounting for the sex of participants, to derive a pooled estimate of the prevalence of adolescents with hypertension in sub-Saharan Africa. We also analysed mean systolic blood pressure (SBP) and diastolic blood pressure (DBP) underpinning this estimate and conducted multiple subgroup and meta-regression analyses.

Methods

Search strategy and selection criteria

For this systematic review and meta-analysis, two investigators (AC and LW) and an expert librarian did a comprehensive search of PubMed, Google Scholar, African Index Medicus, and Embase to identify all relevant articles on elevated blood pressure in adolescents in sub-Saharan Africa published in English from Jan 1, 2010, to Dec 31, 2021, to generate contemporary data and reduce heterogeneity between studies due to the reduced difference in when the studies were conducted. The search strategy was a combination of relevant terms and variations of the names of each of the 49 sub-Saharan African countries (eg, "Ivory Coast" and "Côte d'Ivoire").

Relevant search terms were "hypertension", "blood pressure", "systolic hypertension", and "diastolic hypertension" in conjunction with "adolescent", "teens", "teenage", "school", and "youth". The full search strategy is available in the appendix (p 2). This search strategy was conducted in PubMed, then adapted to other databases by changing the syntax. The reference lists of all relevant articles were searched by AC to identify additional data sources, with input from AOM and DBO.

To be included, primary studies had to be observational studies of adolescents aged 10–19 years residing in sub-Saharan African countries (irrespective of their ethnic, socioeconomic, and educational backgrounds) reporting the pooled prevalence of elevated blood pressure or with enough data to compute these estimates. We excluded studies on non-systemic hypertension (ie, intracranial or pulmonary hypertension), studies focused on African people not living in sub-Saharan Africa, studies with participant selection based on the presence of hypertension (eg, clinical trials or case-control studies), and studies with adult cohorts in which we could not disaggregate data for adolescents. We also excluded case series with a small sample size (<100 participants), letters, reviews, commentaries, editorials, and studies without primary data or an explicit description of methods. For studies reporting duplicated analyses, we chose to include the most comprehensive report and largest sample size. Some studies included only prevalence data, whereas some studies included only actual blood pressure data.

Two investigators (AC and LW) independently screened the titles and abstracts of articles retrieved from the literature search. Full texts of articles that were potentially eligible were obtained and further assessed for final inclusion by consensus of three investigators (AC, LW, and SS). Disagreements between authors were reconciled through discussion and consensus by all authors.

Data analysis

Three investigators (AC, LW, and SS) independently extracted relevant data from individual studies using a standardised data extraction form. This form included the last name of each first author, year of publication, recruitment period, area (ie, rural *vs* urban), country, study design, setting, sample size, mean or median age, age range, proportion of male participants, BMI, criteria used to identify elevated blood pressure, blood pressure measurement methods (ie, mercury sphygmomanometer or digital sphygmomanometer), and study cohort (eg, community or population). All duplicates were removed during the study selection process. We assigned a UN Statistics Division (UNSD) African region (ie, central [refers to central Africa], eastern, northern, southern, and western) to each country studied.

A qualitative synthesis of eligible studies was conducted. We evaluated the methodological quality of eligible studies using the tool developed by Hoy and

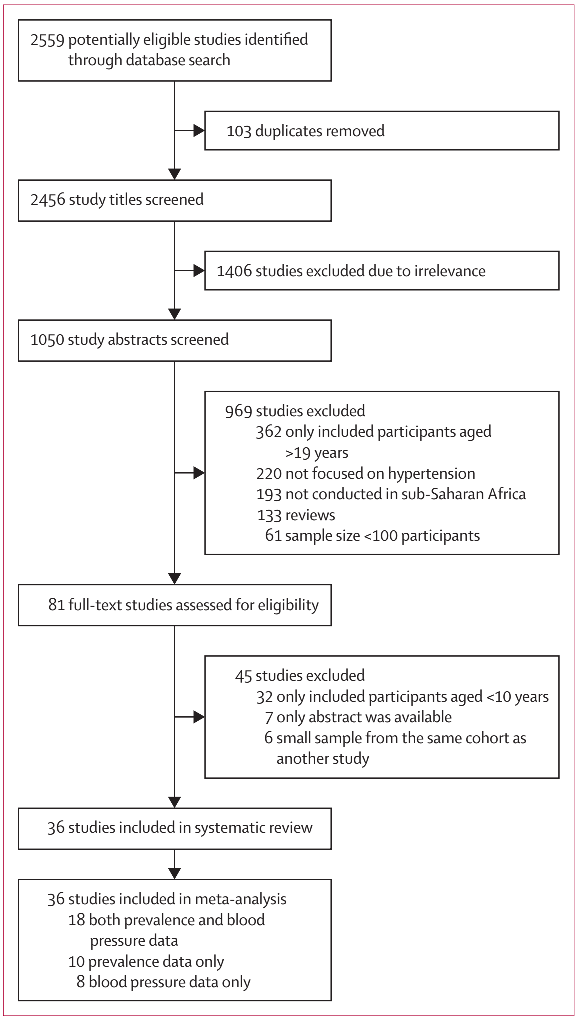

Figure 1: **Study selection**

See Online for appendix

colleagues.[13] We assigned each item a score of 1 (yes) or 0 (no) and summed scores across items to generate an overall quality score that ranged from 0 to 10. According to the overall scores, we classified studies as having a low (0–3), moderate (4–6), or high (7–9) risk of bias. Three investigators (AC, LW, and SS) independently assessed study quality, with disagreements resolved by consensus.

The distribution and origin of eligible study data (both in the size of cohorts and number of studies) are reported against the estimated regional distribution and population of sub-Saharan Africa.

We used meta-analyses to summarise both prevalence of hypertension data and reported SBP and DBP levels. To be included in the prevalence meta-analysis, studies had to define elevated blood pressure, comprise a random selection of participants with no specific disease or profile, have low risk of bias, and describe prospective data collection. We established SEs for study-specific estimates from the point estimate and the appropriate

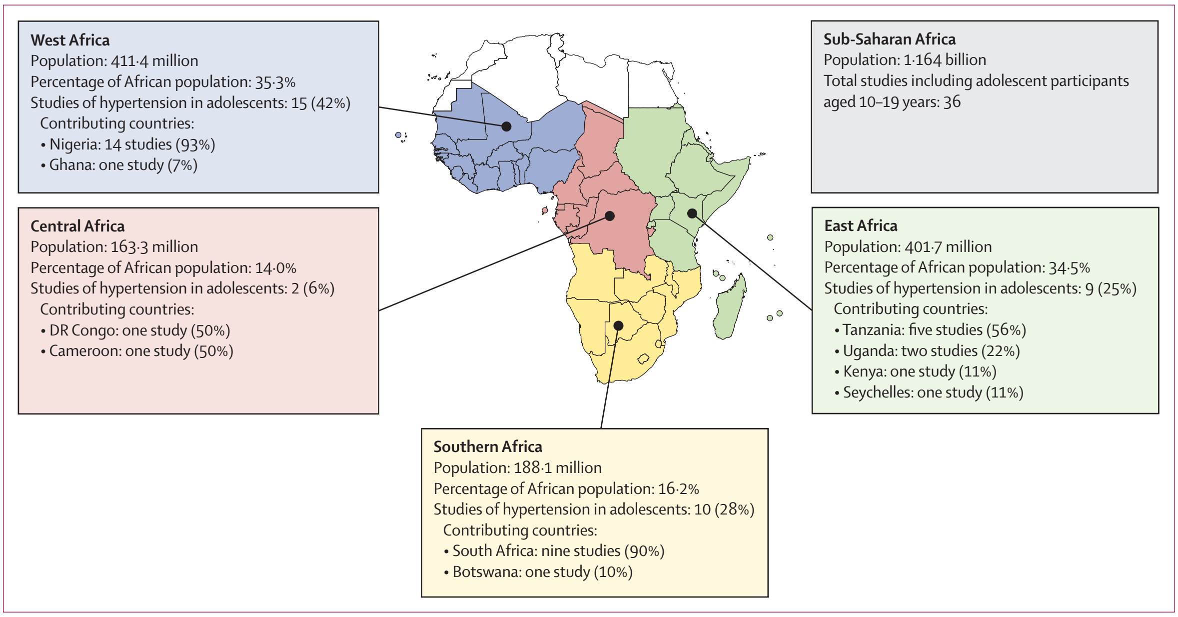

Figure 2: **Regional distribution of studies**
All population data were sourced from The World Bank Open Data.

For **The World Bank Open Data** see https://data.worldbank.org/

denominators. We pooled the study-specific estimates using a random-effects meta-analysis model to obtain an overall summary estimate of the prevalence across studies after stabilising the variance of individual studies with the use of the Freeman-Tukey double-arcsine transformation. In addition to the pooled analyses, data were analysed on a sex-specific basis. The odds ratio (OR) analysis method used was binary random effects. The random-effects method used was the DerSimonian-Laird test with 95% CI and a correction factor of 0·5.

We assessed heterogeneity using the χ^2 test on Cochran's Q statistic and quantified heterogeneity by calculating the I^2 statistic; a value of 25% represented low heterogeneity, a value of 50% represented medium heterogeneity, and a value of 75% represented high heterogeneity.

A series of subgroup analyses (appendix pp 23–28) were also conducted. These subgroup analyses included meta-regression analyses on SBP and DBP levels by age and BMI. We also conducted a sensitivity analysis on different definitions of adolescence with people aged 10–24 years. We analysed data using OpenMetaAnalyst for Windows version 12.11.14 (Brown University, Providence, RI, USA).

This systematic review and meta-analysis was registered and approved in the PROSPERO International Prospective Register of Systematic Reviews (CRD42022297948; appendix p 2) and is reported according to PRISMA guidelines.[14] The study protocol is available online.[15]

Role of the funding source

There was no funding source for this study.

Results

We identified 2559 studies and removed 103 duplicates (figure 1). After screening 2456 titles and 1050 abstracts, a further 2375 studies were excluded. The inter-rater agreement for study selection was high (κ=0·85). We assessed 81 full-text studies for eligibility, of which 45 were excluded. We therefore included a total of 36 full-text studies in this systematic review and meta-analysis, including 36 926 adolescent participants.[16–51] Inter-rater agreements were high for both study inclusion (0·86) and data extraction (0·92). Available data from a pooled sample of 29 696 adolescents (participating in 28 studies) were used to derive pooled estimates of the prevalence of elevated blood pressure and a pooled sample of 27 155 adolescents (participating in 26 studies) were used to derive mean blood pressure levels. From these studies, sex data were available to conduct equivalent analyses on a sex-specific basis from 26 818 adolescents (participating in 23 studies; 14 369 [53·6%] of 26 818 participants were female and 12 449 [46·4%] were male) for the prevalence of elevated blood pressure and 23 777 adolescents (participating in 21 studies; 12 864 [54·1%] participants were female and 10 913 [45·9%] were male) for mean blood pressure levels.

Data were derived from ten (20%) of the 49 countries in all four UNSD regions of sub-Saharan Africa. 14 (39%) of 36 studies came from Nigeria, a lower-middle-income country in west Africa, and nine (25%) came from South Africa, an upper-middle-income country (figure 2). Thus, much of sub-Saharan Africa, including many low-income countries, did not contribute data to this systematic review and meta-analysis.

The methodological quality of included studies is summarised in the appendix (pp 9–18). All included data were extracted from cross-sectional studies (table). 35 (97%) studies included in this systematic review and meta-analysis had low risk of bias and one (3%) study had low–medium risk of bias; all studies randomly selected participants. The specific design and characteristics of each of the 36 studies are presented in the appendix (pp 9–18). Only four (11%) studies were population-based, national studies. Four (11%) studies only included cohorts living in rural settings, five (14%) studies only included cohorts living in urban settings, and 27 (75%) studies included cohorts living in both rural and urban settings. The most common definition of elevated blood pressure, used in 30 (83%) studies, was derived from the guidelines of the American Academy of Pediatrics.[12] Overall, 28 (78%) studies provided specific information on the prevalence of elevated blood pressure based on normative sex, age, and height-adjusted blood pressure levels. All 36 studies applied (and reported data for) the 95th percentile threshold or higher for participants younger than 13 years, and an absolute threshold of 120/80 mm Hg or higher for those aged 13–19 years.

The specific methods used to measure blood pressure were heterogeneous with varying intervals that were often not reported and repeated measurements applied, with nine (25%) studies reporting the use of an automated digital sphygmomanometer.

Applying different methodologies, all 36 studies sought to identify the independent correlates of elevated blood pressure, with a particular focus on demographic, anthropometric and socioeconomic correlates. Overall, 20 (56%) of the 36 included studies were from countries where English is not the primary language spoken. In nine (25%) of 36 studies there was a positive correlation between age and hypertension, whereas two (6%) studies found a negative correlation. 14 (39%) of 36 studies found a higher prevalence of elevated blood pressure in female participants than in male participants, but 11 (31%) found the opposite. A positive correlation between BMI and elevated blood pressure was found in 23 (64%) of 36 studies; no such correlation was found in the 13 (36%) remaining studies. Other potential correlates of elevated blood pressure included education level (positive in four [11%] studies and negative in two [6%] studies), family history and alcohol use (positive in three [8%] studies), living in an urban area (higher than living in a rural area in five [14%] studies), and increased economic status (positive in two [6%] studies).

Among 29 696 adolescents, the reported prevalence of elevated blood pressure ranged from 4 (0·2%) of 1727 to 1755 (25·1%) of 6980, and the pooled prevalence of elevated blood pressure was estimated to be 9·9% (95% CI 7·3–12·5; $p_{heterogeneity}$<0·0001; figure 3). The I^2 value was 99·2%, indicating high heterogeneity. Therefore, a sex-specific meta-analysis was done.

	Summary data
Number of participants	37 926
Sex of participants	
Male	17 466 (46·0%)
Female	20 480 (54·0%)
Age of participants, years	15 (1·54)
Number of included studies	36
Timing of data collection	
Cross-sectional	36 (100%)
Risk of bias	
Low	35 (97%)
Low–medium	1 (3%)
Type of participant selection	
Random	36 (100%)
Representativeness	
National	4 (11%)
Subnational	32 (89%)
Study cohort type	
Population-based	4 (11%)
Community-based	32 (89%)
Range of publication years	2010–21
Setting	
Rural	4 (11%)
Urban	5 (14%)
Both	27 (75%)

Table: **Summary statistics and methodological quality of included studies**

Findings from 26 818 adolescents showed that there was no significant difference in the percentage of male participants with elevated blood pressure (13·4%, 95% CI 12·9–13·9; p<0·0001) compared with female participants (11·9%, 11·3–12·4; p<0·0001; OR 1·04, 95% CI 0·81–1·34; p<0·0001; appendix p 20). The I^2 value was 85·8%, indicating moderate-to-high heterogeneity.

Among 27 155 adolescents, the pooled SBP was 111 mm Hg (95% CI 108–114; $p_{heterogeneity}$<0·0001) and the pooled DBP was 68 mm Hg (66–70; $p_{heterogeneity}$<0·0001; figure 4). The I^2 value was 99·8%, indicating high heterogeneity. For every unit increase in age (year), SBP increased by 3·5 mm Hg (95% CI 2·0–5·0) and DBP increased by 1·7 mm Hg (0·3–3·1); for every unit increase in BMI (kg/m²), SBP and DBP increased by 1·9 mm Hg (0·7–3·1).

Among 23 777 adolescents with sex-specific data, the pooled SBP was 112 mm Hg (95% CI 109 to 115) and the pooled DBP was 67 mm Hg (65 to 68) in male participants versus a pooled SBP of 111 mm Hg (109 to 113) and a pooled DBP of 68 mm Hg (67 to 69) in female participants. The mean difference in SBP levels between male adolescents and female adolescents was 1·13 mm Hg (95% CI –0·56 to 2·82; p<0·0001) and the mean difference in DBP levels between male adolescents and female adolescents was –1·21 mm Hg (–1·71 to –0·71; p<0·0001; appendix pp 21–22). The I^2 values were 97·78% in male

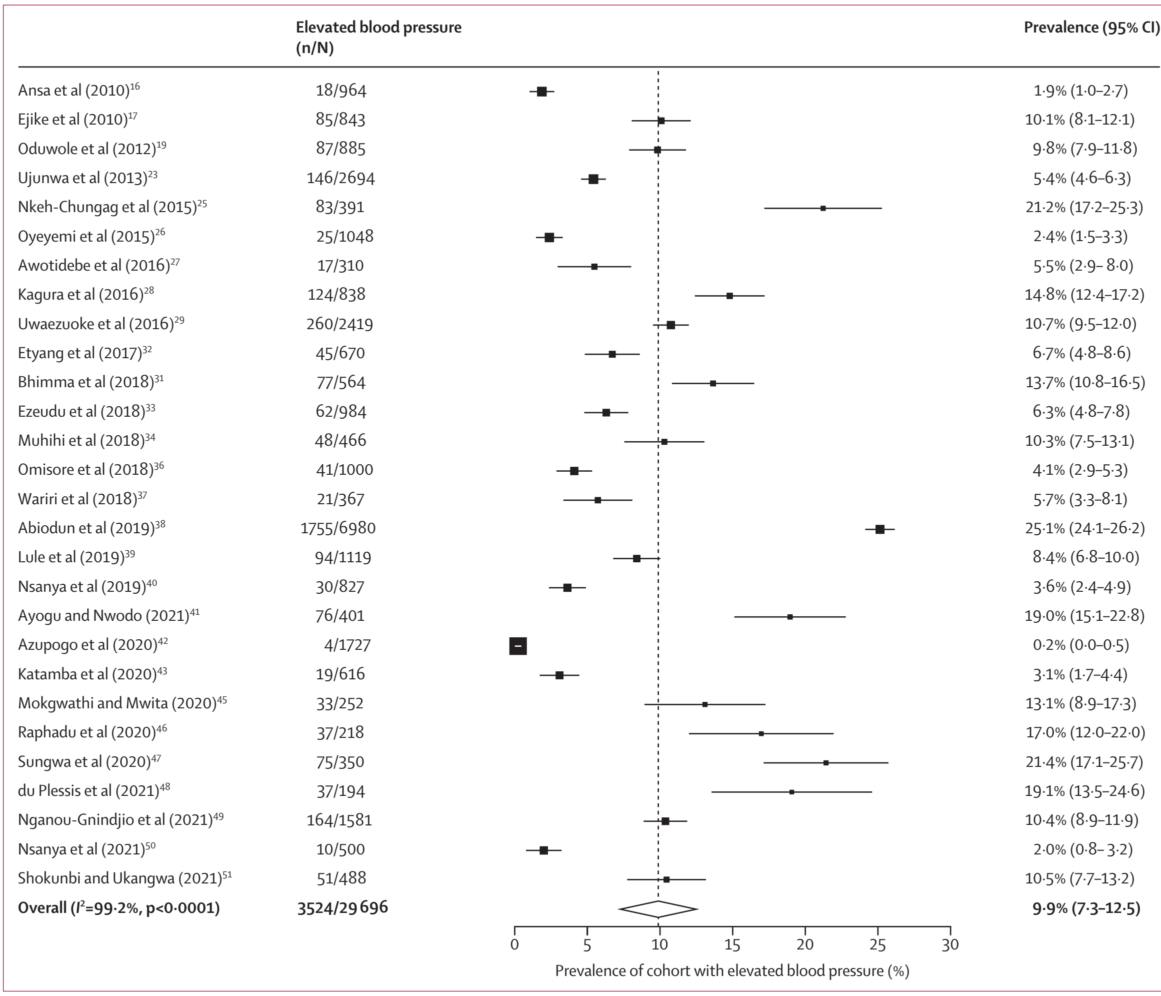

Figure 3: **Pooled prevalence of elevated blood pressure**

adolescents and 83·16% in female adolescents, indicating high heterogeneity. Subgroup and sensitivity analyses are presented in the appendix (p 30). Our sensitivity analysis showed that only one study[38] exerted a large influence on pooled analyses (appendix p 29). Two studies[31,40] with data including participants aged 19–24 years showed an estimated prevalence of elevated blood pressure of 10·0% (95% CI 7·3 to 12·6). When data were reported in 26 studies, there was a positive correlation between age and BMI of participants and their SBP and DBP levels (appendix p 31).

Discussion

To our knowledge, this is the first systematic review and meta-analysis to specifically examine the reported pattern of elevated blood pressure levels, including sex-specific analyses, among adolescents aged 10–19 years living across sub-Saharan Africa. Combining contemporary blood pressure surveillance data from 36 studies with 37 926 adolescent participants living in ten different sub-Saharan African countries, our findings suggest that approximately one in ten individuals aged 10–19 years have elevated blood pressure. Consequently, they are already prone to developing premature cardiovascular disease due to underlying hypertension. Overall, study methodology varied; not all studies provided sex-specific data or actual blood pressure measurements. Despite consistent reports that women in sub-Saharan Africa are more likely to have hypertension than men,[5] we were unable to identify definitive sex-specific differences in blood pressure levels within adolescents living in sub-Saharan Africa that could explain the difference later in life. However, increasing age and BMI positively correlated with both increasing SBP and DBP levels. Overall, our findings reinforce the need for more systematic and granular reporting of blood pressure data (eg, applying minimum standards) against important factors such as age, sex, anthropometric profile, and socioeconomic status. Crucially, a high proportion of the population across sub-Saharan Africa, including many low-income countries, were not represented in our analyses.

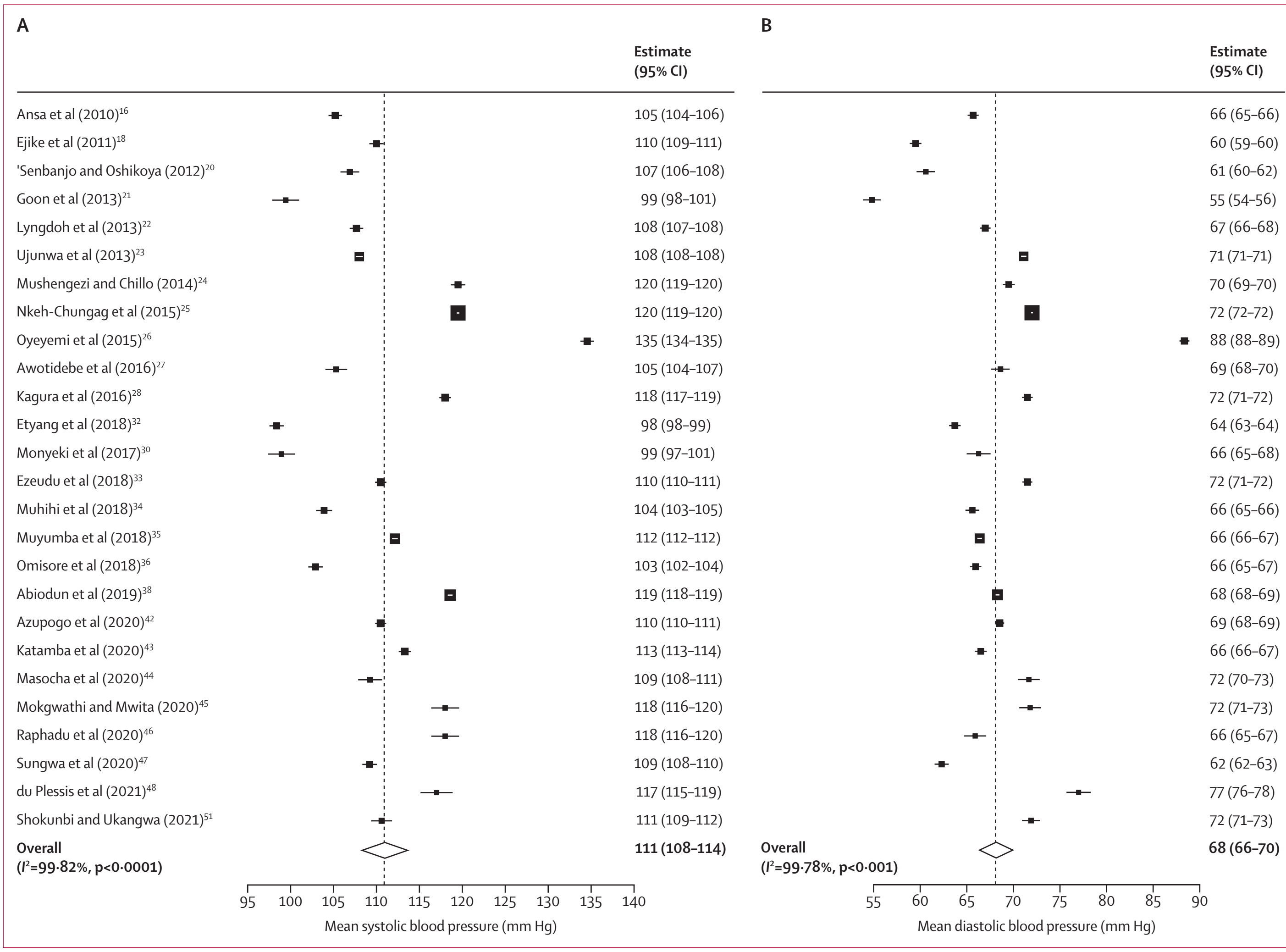

Figure 4: **Mean systolic and diastolic blood pressure**
(A) Mean systolic blood pressure. (B) Mean diastolic blood pressure.

In a previous international study with little data from Africa, the reported prevalence of elevated blood pressure and hypertension among adolescents in north and sub-Saharan Africa combined was 25·5% (95% CI 10·1–39·1).[10] This finding can be compared with an estimate of 5·5% (4·2–6·9) from a more recent and substantive meta-analysis of 54196 children and adolescents in Africa.[11] These contrasting findings might be explained by the periods in which data were collected, the methods, an over-representation of specific countries or populations, a reliance on non-African normative blood pressure data, and, perhaps most importantly, the mixed age and sex distribution of study cohorts. Consequently, focusing on large, contemporary surveillance studies (ie, including >100 participants and published from 2010 onwards), we considered which sub-Saharan African countries were represented, whether adolescent data were specifically reported, whether sex-specific data were provided, and the actual blood pressure levels of studied participants. Subsequently, based on a geographically limited number of studies from ten sub-Saharan African countries, our estimated prevalence of adolescents with hypertension in sub-Saharan Africa (9·9%, 7·3–12·5) falls between the two previous estimates just mentioned. This estimated prevalence is consistent with a global estimate of adolescents with hypertension (11·2%).[10] Our leave-one-out sensitivity analysis revealed that study findings were robust, with only one study exerting a large influence on our pooled prevalence estimates. Nevertheless, heterogeneity in reported blood pressure levels among adolescents is a consistent feature of data derived from the region. Two studies conducted in Ghana, both published in 2022, are consistent with the range of estimates of elevated blood pressure among adolescents living in sub-Saharan Africa (8·5% and 19·1%),[52,53] shown by our more contemporary and adolescent-focused study.

Overall, the natural history of hypertension and subsequent end-organ damage across the lifespan in

Africa remains poorly understood.[54] Reflecting a combination of poverty, communicable disease, urbanisation, and epidemiological transition altering traditional lifestyles,[7,55] as well as potentially high sensitivity to salt intake and susceptibility to small-vessel disease triggered by hypertension,[56] men and women from Africa typically present with stroke and advanced forms of hypertensive heart disease or heart failure[8] at a relatively young age compared with men and women living in high-income countries. For example, in an epidemiological study of 651 incident stroke cases in individuals with a mean age of 59·1 years (SD 13·2) living in Maputo, Mozambique, 91% had a history of hypertension.[57] Large surveillance studies of people predominantly living in urban areas of Nigeria and South Africa have also shown a pattern of advanced forms of hypertensive heart disease[58,59] affecting a greater proportion of women and younger adults than were observed in high-income countries. As shown by our meta-regression analyses of age and BMI, increasing obesity levels[7] and life expectancy[8] have the potential to markedly increase the burden of disease imposed by hypertension. From a treatment perspective, outcomes from landmark antihypertensive trials suggest that Black African adults have a greater reduction in their SBP in response to amlodipine and diuretics than people of non-African ancestry.[60] The pivotal pan-African CREOLE trial subsequently showed that drug combinations based on calcium-channel blockers are more effective in reducing both ambulatory and office blood pressures than a combination of an angiotensin-converting enzyme inhibitor and a thiazide diuretic in men and women in sub-Saharan Africa with hypertension.[61]

The unique context of hypertension and consequent end-organ damage in people living in sub-Saharan Africa reinforces the need for locally relevant hypertension guidelines.[62] Establishing these guidelines requires a more robust evidence base around prevention, early detection, and optimal management of hypertension. The scarcity of surveillance data in young people in sub-Saharan Africa necessitates pooled analyses such as ours. Pooling male and female participants is problematic considering that there are substantial differences in the cardiovascular risk profile, behaviours, and disease trajectory of men (eg, more smokers) and women (eg, higher BMI) of African descent.[63] In the CREOLE trial, women with hypertension appeared to have larger reductions in their SBP in response to calcium channel blocker-based combination therapy than men.[64] As shown by our indeterminate, sex-specific analyses, the ways potential sex-specific differences[65] and differences between living in urban or rural communities[66] influence the future pattern of cardiovascular disease among young people in Africa are yet to be fully elucidated. Regardless of the mechanisms, we know that increased cardiovascular risk, including hypertension,[10] early in life contributes to cardiovascular disease later in life.[67] However, why people in sub-Saharan Africa present earlier in life with more advanced end-organ damage or disease than people living in other regions of the world is still unknown. Acquiring and comparing equivalent data on the evolving cardiovascular risk profile of adolescents in every part of sub-Saharan Africa would be ideal. In the meantime, there is a crucial need to develop and support regional-specific strategies to promote healthier lifestyles among young people in sub-Saharan Africa, with a specific focus on increasing activity levels and reducing salt and sugar intake.[8] A range of initiatives to screen adolescents in the region for other important conditions, such as rheumatic heart disease, could readily incorporate blood-pressure monitoring.[5] Blood-pressure monitoring could also be conducted in those aged 10–12 years as part of enrolment before secondary school in the region. Concurrently, initiatives to prompt health workers in sub-Saharan Africa to actively screen for and optimally manage hypertension in young individuals are urgently needed.

There are several limitations when considering the veracity of our data and interpreting the clinical and public health implications, including the location and distribution of source data. Despite an increasing number of cardiovascular-related research reports,[8] many low-income countries throughout the region were under-represented in our study. Accordingly, we recommend a concerted effort by international agencies to address this deficit. Despite the high quality of studies overall, most studies focused on adolescents who were attending school. However, a substantial proportion of adolescents with low socioeconomic status in Africa cannot attend school (eg, 73–78% of children in the lowest socio-economic groups in Mali, Niger, Nigeria, and Guinea were found to not attend school).[68] Furthermore, application of standardised surveillance and reporting methods in the included studies was problematic. Although most studies included in this systematic review and meta-analysis applied three separate blood pressure measurements with an automated sphygmomanometer, establishing whether the high heterogeneity observed in our meta-analyses was due to the cohort being studied or the method of blood pressure measurement is difficult. This issue is substantial for several reasons, including that the commonly applied definition of elevated blood pressure by the American Academy of Physicians is percentile-based for people younger than 13 years.[12] Overall, studies were not consistent in applying standardised criteria for identifying elevated blood pressure and then providing blood pressure levels on an age-specific and sex-specific basis. Accordingly, via the Pan-African Cardiac Society's Hypertension Taskforce, we will be recommending that minimum standards for collating and reporting such data be developed and then systematically applied in the future. Supporting standardised protocols, such as the WHO STEPwise approach to surveillance,[69] to derive comparable data on an age-specific and sex-specific basis is a priority in reducing the future burden on non-communicable forms of cardiovascular disease, including hypertensive heart disease and stroke, in sub-Saharan Africa. By predominantly focusing on the published English literature and full study reports, we might not have included potentially important data; overall, 20 (56%) of the 36 included studies were from countries where English is not the primary language spoken. We acknowledge that by selecting studies with a primary rather than a secondary focus on blood pressure levels in adolescents across sub-Saharan Africa we have not collated all the available data on blood pressure levels within this age cohort. However, because of the limitations (including the heterogeneity of study protocols and reporting standards), we believed that focusing on studies in which blood pressure levels and the ways they were acquired were the focus was important. Moreover, we acknowledge that the current WHO definition of adolescence (age 10–19 years)[70] does not include individuals aged 20–24 years, who might be considered to be adolescents by some.[71] We plan to focus on this specific age group in future analyses.

Our systematic review and meta-analysis of contemporary observation data from ten sub-Saharan African countries suggests that approximately one in ten adolescents across these ten countries have elevated blood pressure. This finding is consistent with a high burden of stroke and hypertensive heart disease at a relatively young age in the region.[8] To support our findings, a wider geographical distribution of methodologically standardised studies in this potentially vulnerable and pivotal age group should be conducted. In the meantime, there is sufficient evidence to prompt urgent efforts to proactively detect and optimally treat elevated blood pressure and hypertension in young individuals living across sub-Saharan Africa.

Contributors

SS and AC conceptualised and designed the study in collaboration with AOM and DBO. AC and LW, with the help of an expert librarian, did a comprehensive search of PubMed and Google Scholar according to the study protocol. AC and LW independently screened the titles and abstracts of articles retrieved from the literature search. Full-text screening was independently conducted by AC, LW, and SS. AC did the meta-analyses and generated all forest plots in consultation with SS and Y-KC. AC, LW, and SS generated the flow-chart and table. AC and SS drafted the first version of the manuscript. All authors reviewed, edited, and commented on the interpretation of study findings. AC, Y-KC, and SS had access to and verified all the data. All authors had full access to all data in the study and had final responsibility for the decision to submit for publication.

Declaration of interests

SS is supported by the National Health and Medical Research Council of Australia (GNT1135894). All other authors declare no competing interests.

Data sharing

All data reported in this study were extracted from published studies and are currently available through the Institute of Health Research, University of Notre Dame (Fremantle, WA, Australia; https://www.notredame.edu.au/research/Institute-for-Health-Research/publications). Details of how to access the PROSPERO protocol are available in the appendix (p 2).

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