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Non-pharmacological interventions to achieve blood pressure control in African patients: a systematic review

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Abstract

Objectives: This systematic review aims to evaluate the evidence of non-pharmacological strategies to improve blood pressure (BP) control in hypertensive patients from African countries.

Design: We performed a systematic review and searched Medline, Central, CINAHL, and study registers until June 2020 for randomized studies on interventions to decrease BP of patients with hypertension in African countries. We assessed the study quality using the Cochrane risk of bias tool and narratively described studies on non-pharmacological hypertension interventions.

Setting: We included studies conducted in African countries in primary and secondary care settings.

Participants: Adult African patients with a hypertension diagnosis.

Interventions: Studies on non-pharmacological interventions aiming to improve BP control and treatment adherence.

Outcomes: Main outcomes were BP and treatment adherence. We removed the planned outcomes NYHA stage, hospital admission and death, since we decided to focus this review from cardiovascular diseases in general to hypertension due to the amount of search results.

Results: We identified 5564 references, included 23 with altogether 18,153 participants from six African countries. The studies investigated educational strategies to improve adherence (11 studies) and treatment by health care professionals (5 studies), individualized treatment strategies (2 studies), strategies on lifestyle including physical activity (4 studies) and modified nutrition (1 study). Nearly all studies on educational strategies stated improved adherence, but only three studies showed a clinically relevant benefit on BP control. All studies on individualized strategies and lifestyle changes resulted in clinically relevant effects on BP.

Conclusions: The identified studies offer a wide range of effective low-cost interventions including educative and task shifting strategies, individualized treatment, as well as lifestyle modifications to improve BP control. All strategies were trialed in African countries and can be used for recommendations in evidence-based guidelines on hypertension in African settings.

Review registration: A protocol was registered on PROSPERO (CRD42018075062).

Strength and limitations of this study

- This systematic review summarizes evidence on a wide range of different non-pharmacological interventions, adding a comprehensive overview to the literature that can support physicians and health care policy makers in the African setting.

- Most of the included studies were conducted in urban areas of few Western and Southern African countries leading to a lack of generalizability to other African regions and showing a need of future research in rural areas.

- A main limitation of this systematic review occurs through deviations from the protocol. Due to the amount of search results for the initially planned more general scope on cardiovascular diseases we decided to focus on hypertension.

- Nevertheless, this review was limited to studies with the highest level of evidence to investigate the benefits and harms of non-pharmacological interventions on blood pressure control in African patients with hypertension.

- This review adds to the scope of a recently published a systematic review on the efficacy of common pharmacological treatment for hypertensive patients in Sub-Saharan Africa.

Keywords:

systematic review, Africa, hypertension, raised blood pressure, non-pharmacological interventions, randomized controlled trials

Background

Hypertension is a major public health problem and affects the lives of about 1.13 billion people (1). The highest blood pressure levels shifted from high to low-income countries in South Asia and Sub-Saharan Africa (SSA) (2) with a prevalence of 57 % in older adults in African countries (3, 4). The estimated number of adults with raised blood pressure in SSA rose from 30 million in 1975 to over 100 million in 2016 due to population growth, aging, and westernization of lifestyle (2). Hypertension is a leading risk factor of cardiovascular disease, chronic kidney disease, and diabetes (1). Studies show that black people suffer from more severe forms of hypertension associated with more frequent treatment failure and more severe and earlier target organ damage, all resulting in higher morbidity and mortality (5, 6). Hypertension is a major contributor to devastating health events like stroke or heart failure (7-9), which can be catastrophic to both individuals and healthcare systems in which resources are scarce.

Tackling and reducing the burden of premature mortality due to non-communicable diseases (NCDs) through prevention and treatment has been a designated goal within the UN 2030 Agenda (10). The Pan-African Society of Cardiology developed an algorithm including recommendations on screening, diagnosis, and treatment to achieve 25 % hypertension control in Africa by 2025 with a treatment target value of less than 140/90 mmHg. Screening programs are proposed to be carried out in health care facilities as well as public places like markets and churches. The treatment starts with lifestyle modifications, is intensified through a monotherapy and a subsequent combination of two or three medications in higher stages and resistant forms of hypertension. In some cases, the assessment of secondary causes by specialists is recommended (9).

However, the awareness of hypertension remains relatively low in many parts of Africa, hindering adequate screening, treatment, and control to lower the long-term risks (11-13). Extensive counseling and education of patients and health-care providers on the importance of adherence to medications and lifestyle modifications is necessary in order to improve hypertension control (14, 15). Especially patients with multiple medications benefit from the support of their health care providers to understand the treatment's purpose (16).

Evidence is needed detailing regional differences in hypertension incidences, risk factors, and, as subject of this review, treatment strategies in different, transitioning populations on the African continent. Seeley et al. recently published a systematic review on the efficacy of common pharmacological treatment for hypertensive patients in SSA (17). These interventions do not include treatment strategies like lifestyle modifications (e.g., nutritional modifications, physical activity) or educational strategies, which can be summarized as non-pharmacological interventions (18). Hence,

the main aim of this systematic review is to add the best available evidence on the effectiveness of non-pharmacological strategies on blood pressure control in African patients with hypertension.

Main Text

Methods

A protocol of this systematic review was prospectively registered on PROSPERO (CRD42018075062) following the PRISMA guideline (19) (see Checklist S1). We initially planned to include randomized controlled trials (RCTs) on all cardiovascular diseases (CVDs). Due to the high number and heterogeneity of eligible studies, we decided to focus this review on patients with hypertension as one of the main risk factors for other CVDs. We aim to describe all non-pharmacological hypertension interventions in detail in order to broaden the scope of the existing evidence.

Patient and public involvement

The conception of this systematic review was discussed in detail with members and students at the Addis Ababa School of Public Health in order to consider the priorities in the African context. Consensus was to gather evidence on hypertension treatment as a measure of tackling the burden of non-communicable diseases which is part of the UN 2030 Agenda (10). No patients were involved.

Inclusion and exclusion criteria

We included full-text publications on RCTs (20) including cross-over RCTs and cluster RCTs on non-pharmacological interventions with adult hypertensive patients in African countries and reported results on BP. The study aims were improvement of prevention, diagnoses, and treatment of hypertension in African countries. Studies on primary prevention were excluded due to the high variety of possible participants and interventions. International multi-center studies were included if more than 50 % of centers were set in African countries. For detailed inclusion criteria see Table 1.

>>>> Table 1

Literature search and study selection

Two electronic databases (Medline Ovid, Central) and registers of ongoing and completed studies (International Clinical Trials Registry Platform) were searched to identify all relevant studies (see Additional file 1). We added a search in CINAHL to cover nursing interventions. The main keywords of the search strategy included hypertension, high blood pressure, blood pressure control, Africa, a list

of all African countries, and randomized controlled trials. The first searches in 2017 included all CVDs, while updated strategies were limited to hypertension. The last search was conducted in June 2020. All searches were done without time frame constrictions. The study selection process was described in a flow chart according to the PRISMA statement (19). We exported articles retrieved from the literature search into a reference manager software (EndNote (21)). Duplicate references were identified in case of congruence of authors, title, year, and journal and deleted.

Titles, abstracts, and full texts of potentially eligible articles were independently screened by three authors (MC, ESK and SU). Disagreements were resolved through consensus.

Interventions

This systematic review compares non-pharmacological interventions to improve adequate diagnoses, prevention, and treatment of patients with hypertension with standard care, no intervention or another, less intensive or frequent intervention (Table 1).

Outcomes

The main outcomes of the primary planned systematic review on CVD were blood pressure, NYHA, hospital admission, and death within the longest follow-up period. Costs were planned as an additional outcome. The main goal of non-pharmacological interventions for patients with hypertension is to improve blood-pressure control through the implementation of recommended lifestyle changes, attendance to follow-up visits, and interventions promoting adherence to take hypertensive medications. We therefore report results on blood pressure and adherence (Table 1).

Data extraction and management

One author (MC or SU) extracted and a second author (SU or ESK) checked all information on study design and setting, participants, interventions, and main results by using an assessment form in Excel. The form was especially designed for this systematic review and piloted for the first five studies.

We extracted information on the publication (study name consisting of the name of first author and year of the first publication of final results, registration, and additional publications), study characteristics (design, country and region in which the study was conducted, duration, pre-planned outcomes), participants (with inclusion/exclusion criteria, randomized sample size, prevention level, grade of hypertension, mean age, baseline blood pressure), a short description of the intervention and control groups, and the main results on blood pressure and adherence within the longest follow-up periods. The grade of hypertension was described as mild (grade 1, 140-159/90-99 mmHg),

moderate (grade 2, 160-179/100-109 mmHg) or severe (grade 3, ≥ 180/≥ 110 mmHg) (15). If BP was reported in standing and supine position, we extracted results for supine position.

All effect sizes were reported with their corresponding confidence intervals (CI). They were calculated either on the basis of mean and standard deviation for metric outcomes or by comparing the frequencies of better adherence or BP control. Positive mean differences (MDs) describe a positive treatment effect on BP with lower mean values or higher decrease in the intervention group. Relative risks (RR), hazard ratios (HR) and odds ratios (OR) compare the frequency of good adherence or BP control. Effect measures greater than 1 describe a better adherence or BP control in the intervention group.

Quality assessment and risk of bias

Risk of bias was evaluated for all studies based on the Cochrane risk of bias tool (22). Two investigators (MC or ESK and SU) independently assessed the risk of bias in seven domains (sequence generation, allocation concealment, blinding of personal and participants, blinding of outcome assessors, incomplete outcome data, selective outcome reporting, and other sources of bias). Risk of bias due to selective outcome reporting was judged as low, when the study protocol was available and results on all pre-planned outcomes were reported. Incomplete outcome data was judged as high, when more than 10 % of randomized participants dropped out. Other sources of bias were reported to be high in cases of missing sample size calculation, no definition of the primary endpoint, or no reporting of baseline values.

Data synthesis

The main aim of this review is a narrative synthesis of studies with their participants, different types of interventions, and resulting outcomes. We added a figure visualizing the effect sizes on BP of different types of interventions in forest plots using RevMan (23). Due to the high clinical heterogeneity between included studies with their different settings, interventions, control groups, and lengths of follow-up, we did not pool any results.

Treatment effects were described as statistically significant or clinically relevant. Statistically significant results on BP with MD over 5 mmHg were defined as clinically relevant.

Results

We identified a total of 5564 references from electronic databases and 18 references from the International Clinical Trials registry platform. 340 articles were potentially eligible and full texts were assessed for the inclusion and exclusion criteria. Of those, 298 articles were excluded including 13 articles on studies to treat heart failure, 7 articles on coronary heart diseases, and 76 articles on pharmacotherapy for hypertension. Twenty-three studies (reported in 42 articles) (24-66) on non-pharmacological strategies to treat patients with hypertension matched the inclusion criteria and were included in this systematic review (Figure 1 and list of included studies in the appendix). The characteristics and main results of these studies were summarized in Table 2.

>>>>> Figure 1

Study characteristics

We identified 15 studies with two or more independent parallel groups and individual randomization of patients and eight cluster-RCTs with randomization of different observation units, such as independent villages, health-care facilities, or different geographical regions (Table 2). Most of the included studies were conducted in Nigeria (11 studies) and South Africa (8 studies), others in Ghana, Kenya, Cameroon and Egypt. One of the studies (25) recruited patients in three countries (South Africa, Nigeria and Kenya). Seven studies (30 %) were at least partly conducted in rurally located health-care facilities (Figure 2). The included studies were published between 1991 and 2019. Only three of the studies, all conducted South Africa, were published before 2010.

>>>>> Figure 2

Participants

The total sample size ranged from 30 to 4722 participants with a total number of 18,153 participants (Table 2). Eighteen studies (78 %) randomized more than 100 participants. The mean age was between 45 and 63 years. Most studies (19 studies) included more females. Two studies to enhance physical activity included women (63) or men (37) only. Mean systolic blood pressure (SBP) at baseline was between 128 and 175 mmHg, mean diastolic blood pressure (DBP) between 76 and 117 mmHg. Most studies included patients in secondary prevention with mild to moderate hypertension. Three studies (56, 58, 66) included hypertensive patients post stroke.

Intervention

Studies investigated educational strategies to improve adherence of patients and treatment by health care professionals (16 studies), to individualize treatment (2 studies), and to change lifestyle via enhanced physical activity (4 studies) or modified nutrition (1 study) (Table 2).

>>>> Table 2

Educational strategies to improve adherence

Sixteen studies (17,090 participants), with follow-up periods from two weeks in a short-term feasibility study (66) up to 18 months (34), were published between 1991 and 2019.

The main aim of eleven studies was the improvement of patients' knowledge on hypertension and adherence to self-monitoring of BP, recommendations on medication, lifestyle changes, and regular attendance at health-care facilities (24, 27-29, 36, 56, 58, 60, 61, 64, 66). Five studies investigated strategies to improve adequate treatment of hypertensive patients by clinicians, nurses, and health-care workers (32, 34, 35, 52, 62).

Eight studies (27, 28, 36, 56, 58, 60, 61, 64) investigated the efficacy of adherence-promotion via counselling and phone or letter-based interventions. Seven studies (24, 29, 32, 34, 35, 52, 66) investigated the efficacy of interventions on the basis of training measures with subsequent task-shifting to nurses or health workers for home visits and patient education. One study (Steyn 2013 (62)) tested a multi-faced intervention to implement national South-African guidelines into primary care of patients with hypertension or diabetes. Another two studies investigated the efficacy of financial incentives as an additional health insurance coverage (Gyamfi 2017 (35)) or free treatment (Labhardt 2011 (36)), respectively.

Nearly all studies stated improved medication adherence (Adeyemo 2013, Bobrow 2016, Bolarinwa 2019, Labhardt 2011, Saunders 1991, Stewart 2005), implementation of lifestyle recommendations (Ayodapo 2019, Mendis 2010), linkage to care (Labhardt 2011, Mendis 2010, Vedanthan 2019), or knowledge and practical skills of healthcare professionals (Fairall 2016, Gyamfi 2017). In only three studies (Ayodapo 2019, Bobrow 2016, Borarinwa 2019) (27-29), these improvements resulted in modest benefits on BP (Table 2 and Figure 3C). In the study by Ayodapo 2019 (27), counseling had a positive impact on lifestyle behavior and resulted in a clinically relevant decrease of mean arterial BP (-9.8 mmHg; 95 %CI -11.5 to -8.1). (Bobrow 2016 (28)) assessed the effect of automated treatment adherence support delivered via mobile phone short messages. (Bolarinwa 2019 (29)) trialed home-based follow-up care with education and counseling of patients and modifications of environmental characteristics. Both studies achieved a 12 % higher BP control with SBP<140 mmHg and

DBP< 90 mmHg in participants of the intervention compared to the control groups (RR: 1.12; 95 % CI 1.01 to 1.23 and 1.12; 95 % CI 1.00 to 1.25) (Figure 3).

>>>>> Figure 3

Individualized treatment strategies

Two studies (286 participants) with follow-up periods of 3 and 12 months were published in 2011 and 2017. Both investigated strategies on the efficacy of an individualized therapy. Therapy individualization based on the patients' renin/aldosterone profile (Akintunde 2017 (25)) resulted in more appropriate prescriptions and a relevant decrease of SBP (MD: -13.2 mmHg; 95 % CI -19.4 to -7.0) and DBP (MD: -5.6; 95 % CI -9.4 to -1.8) in patients with uncontrolled hypertension. The second study (Okeahialam 2011 (55)) showed a higher reduction of DBP in patients using their anti-hypertensives at night compared to a morning intake (MD: -6.9 mmHg; 95 % CI -10.4 to -3.4), but stated no change in SBP (Table 2).

Strategies with physical activity

Four studies (685 participants), published between 2010 and 2016, investigated the BP-lowering effect of different aerobic training strategies over 4 to 12 weeks. Enhanced physical activities were performed two or three times a week and included dance training (26, 51) and exercise training on an ergometer (37) or treadmill (63).

All studies stated a clinically relevant benefit with mean reductions of SBP between 21 and 7.1 mmHg and DBP between 10 and 1.4 mmHg (Figure 4). The highest BP decrease was achieved in a study on the effect of moderate aerobic exercise training by walking on a treadmill in postmenopausal hypertensive women (Turky 2013 (63)) (MD: -21 mmHg; 95 %-CI 25.8 to -16.2).

>>>>> Figure 4

Modified nutrition strategies

Charlton 2008 tested a food-based dietary strategy (reduced salt consumption) in 92 mildly to moderately hypertensive patients from a low socio-economic background (31), stating a clinically relevant decrease in SBP after two months (MD: -6.2 mmHg; 95 % CI -11.4 to -0.9), but no effect on DBP (Table 2).

Potential biases

The greatest restriction of study quality was a high risk of bias in the blinding of staff and study participants in 19 studies. Especially educational strategies were not examined in double-blinded studies, however three of these studies (Goudge 2018, Owolabi 2019, Sarfo 2019) (34, 56, 58) reported a quality assurance against detection bias with blinded measurement of blood pressure. Two studies on physical activity enhancement in comparison to usual care (37, 51) (Lamina 2010, Maruf 2016) were described as double-blinded without reporting further details. Only the study on modified nutrition (31) (Charlton 2008) adequately reported detailed methods to ensure blinding of participants and fieldworkers. Another frequent problem was incomplete outcome data in 14 studies with loss to follow-up over 10 % of randomized participants or per-protocol analyses. Selective reporting was checked in all 13 studies with a published protocol. Of those, five studies (Bolarinwa 2019, Gyamfi 2017, Labhardt 2011, Owolabi 2019, Maruf 2016) (29, 35, 36, 51, 56) did not report all pre-planned outcomes. Problems concerning randomization were identified in three studies with a non-random component in sequence generation or allocation concealment (25, 37, 52) (Akintunde 2017, Lamina 2010, Mendis 2010). Other sources of bias include missing sample-size calculations, reporting of intermediate results only, and relevant differences at baseline in nine studies (Table 3, Figure 5).

>>>>> Table 3

>>>>> Figure 5

Discussion

This systematic review describes interventions and treatment effects of 23 studies with a total of 18,153 participants with hypertension from six African countries. Most of the studies investigated successful low-cost concepts to improve BP control through improved adherence to medical treatment and lifestyle changes.

While lower- and middle-income countries' CVD-mortality remained unchanged over the last decades, high-income countries have reduced the CVD-mortality by more than 50 % since 1990 (67), largely by using country-specific guidelines, evidence-based policy interventions to reduce risk-factor levels, strengthening the health system at the primary-care level, and improving acute care with attention to early initiation of treatment. However, policies to reduce population-wide risk factors of hypertension have not been widely adopted in low- and middle-income countries (68).

Pharmacotherapy with the well-established anti-hypertensive medications is the mainstay of hypertension management (15, 69). Nevertheless, treatment recommendations on adherence to medication and changed lifestyle habits are often only incompletely applied in practice (70-72). Patients are frequently unwilling to take drugs due to possible side effects. They may benefit from adequate knowledge as well as a higher motivation to take their prescribed medications and to implement sustainable lifestyle changes (73-75). Despite the frequent lack of acute symptoms, uncontrolled BP may result in severe long-term outcome and increased mortality. The risk increases in cases of inadequate treatment and low patient adherence as well as inconsistent follow-up on BP control (7). Therefore, all strategies with the aim to increase knowledge, awareness, and adherence are essential to lowering BP levels and improving the prognoses of patients (69, 76). Due to the short-term follow-up, no study reported long-term outcomes on mortality, and we interpreted available results on BP changes and treatment adherence.

Several strategies to improve health related behavior concerning hypertension with convincing results were examined. We identified eight studies that investigated the efficacy of phone or letter-based interventions (e.g., via short message service) to improve knowledge on hypertension, with adherence support or reminder letters for follow-up (27, 28, 36, 56, 58, 60, 61, 64). All these studies showed strong effects of the intervention concerning self-reported behavioral changes, but only two of these studies showed improved BP during follow-up (27-28). Three studies (29, 35, 52) reported improved adherence and two of those a decreased BP level through nurse-led interventions (29, 52). These studies demonstrated the efficacy of task-shifting interventions in a low-resource setting. Furthermore, low-cost interventions suited to the environment, including financial incentives for adherent patients with minimal additional resources, can significantly improve the adherence of patients (36) and thus potentially influence BP control.

Even though cost-effective interventions are globally available, there are major gaps in their implementation, particularly in limited resource settings (68). Two large multi-level studies that combined phone or letter-based interventions with task-shifting to nurses or health workers were not successful in achieving a relevant improvement in adherence and BP control (32, 34). On the other hand, no harm was observed after the expansion of the nurses' roles (32). Thus, the intervention might be a practical and acceptable tool to expand the scope of non-physician clinicians into primary care of patients with common NCDs. There is a generally good access to essential medications in four countries where the included studies have been conducted (South Africa, Egypt, Kenya and Ghana). The access is not as widespread in Cameroon and Nigeria (77). Nevertheless, one study conducted in rural parts of South Africa between 2014 to 2015 (34) reported insufficient or unavailable equipment and medication shortage. Moreover, increasing numbers of NCD patients require an adequate number of nursing personnel as well as health care facilities. Similar factors contributed to the poor results of the implementation of national guidelines in resource-scarce primary health care settings in South Africa (62), which did not show improved outcomes in hypertension and diabetes patients. In studies with follow-up-periods of less than one year, the time frame might have been too short to reach a clinically relevant BP control through improved knowledge and awareness, since lifestyle changes are oftentimes challenging and should be applied over a long time (24, 61, 66). Generally, the results of the systematic review are consistent with existing evidence on the importance of long-acting patient centered interventions. Unfortunately, these interventions do not reach all patients and often, a full benefit of medical treatment on clinically important outcomes cannot be achieved (78).

Most studies in this review included participants in secondary prevention with mild to moderate hypertension. In contrast, observational studies and conclusions from a systematic review on pharmacological treatment generally concerned participants with higher grades of hypertension (5, 7, 79). Interventions for patients with severe or uncontrolled hypertension and potentially target-organ damage are underrepresented. Interventions for high-risk patients are especially necessary due to the high frequency of late first diagnosis (7) and high prevalence of severe forms of hypertension at an early age in African patients (6). A multi-center study on patients with uncontrolled hypertension in clinics in Nigeria, Kenya, and South Africa stated the efficacy of an individualized therapy based on phenotyping with plasma renin and aldosterone to improve BP control (25). The researchers suggest testing this approach in African Americans and patients of any race with therapy-resistant hypertension. Three studies (56, 58, 66) investigated the implementation of multi-level approaches including educational, telephone-based, nurse-led, self-management supporting interventions, as well as BP monitoring for stroke survivors. These studies were not successful in sufficiently improving BP control, possibly due to short follow-up periods.

Regarding the different grades of hypertension, low risk patients with grade 1 hypertension benefit from lifestyle modifications including regular physical activity, sodium restriction, weight reduction, smoking cessation, moderation of alcohol consumption, and other dietary changes. These are recommended as initial strategies to reduce BP levels in order to prevent or delay the use of pharmacotherapy (14, 15). Nevertheless, even for patients with higher grades of hypertension, lifestyle modifications remain important in addition to pharmacotherapy (14, 15, 69, 80). The clinically accepted relevant BP lowering effect of medium-to high-intensity physical activity as a single or additive treatment for hypertension (81) was demonstrated in four of the included studies (26, 37, 51, 63). Only one study from South Africa investigated the effect of a modified nutrition strategy (reduction of salt intake) and stated a clinically relevant effect on SBP (31). To the authors' knowledge, no randomized study investigated the efficacy of other recommended lifestyle interventions, like smoking cessation or weight reduction, in hypertensive patients in an African country.

Strengths and Limitations of this Review

We were able to generate evidence on a wide range of different non-pharmacological interventions, adding a comprehensive overview to the literature that can support physicians and health care policy makers in the African setting.

A main limitation occurs through deviations from the protocol. We planned a comprehensive summary of all RCTs to prevent, diagnose, and treat patients with cardiovascular diseases in African countries. Due to a high number of eligible studies in the first systematic search, we decided to focus on published studies on hypertension. We therefore had to change the pre-planned outcomes and instead focus on BP and additionally describe results on medication adherence and lifestyle changes. The pre-planned outcomes mortality, NYHA, and hospital admission were dropped. Due to the recently published systematic review by Seeley et al. (17), this publication describes non-pharmacological strategies. The complete results, including pharmacological interventions, were summarized in a doctoral thesis paper (82).

Nevertheless, this review was limited to studies with the highest level of evidence to investigate the benefits and harms of non-pharmacological interventions for hypertension. The randomized allocation ensures the comparability of participants across intervention groups. However, the unfeasibility of double-blinding might restrict the internal validity of results.

The external validity might be limited by our restriction to studies published in the English language and the disproportionally high number of studies conducted in urban areas in some Western and Southern African countries. According to the United Nations, there are currently 54 African countries. RCTs have been conducted in only six of those countries. Inhabitants of these countries (approximately

480 million) represent only a fraction of the African population of about 1.34 billion (83). Especially Central and Northern Africa were underrepresented. There are high levels of diversity within and between African populations. Subpopulations with genetic variants are living in geographically distant areas with specific local lifestyle or environmental conditions, which may be associated with a susceptibility to specific NCDs (84). Therefore, it is uncertain whether our results can be extrapolated to patients living in other areas than those studied. A significant amount of the African population lives in rural areas while the majority of studies was conducted in urban settings. However, it is crucial to make health service available as close as possible to the population in order to achieve the most comprehensive care. Thus, research on non-pharmacological interventions such as educational strategies to improve adherence and lifestyle modification should be expanded across all parts of Africa. Research must be conducted especially in rural areas to ensure a higher generalizability, quality of services, and resulting improvement of the African peoples' health.

Conclusion

This systematic review shows that even though hypertension is a critical health problem, there are still very few randomized studies on non-pharmacological treatment of hypertension conducted on the African continent. Available studies are not representative of all Africans and were conducted in only a few countries. It is therefore advisable to plan and implement studies on patients with hypertension and health-care professionals in rural areas as well as Northern and Central African countries.

An improvement in the prognosis of patients with high BP in Africa requires the implementation of comprehensive diagnostics, education to enhance adherence to recommended medical treatment, lifestyle changes, and subsequent regular checks. The identified studies describe effective approaches tested in African countries that can be used to generate specific African evidence-based guidelines. The approaches include low-cost interventions including task shifting, education, individualized treatment and lifestyle modifications to improve BP control.

List of abbreviations

BP	Blood pressure
CI	Confidence interval
CVD	Cardiovascular disease
DBP	Diastolic blood pressure
HR	Hazard ratio
MD	Mean difference
NCD	Non-communicable disease
OR	Odds ratio
RCT	Randomized controlled trial
RR	Relative Risk
SBP	Systolic blood pressure
SSA	Sub-Saharan Africa

Declarations

Ethics approval and consent to participate

No ethics approval and consent to participate was necessary.

Consent for publication

Not applicable.

Availability of data and materials

Please find the search strategy and a list of included studies in the supplementary material.

Competing interests

The authors declare that they have no competing interests.

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Author contributions

MC
Involved in all steps to plan this systematic review including the protocol; wrote the draft of this manuscript; screening of titles, abstracts, and full texts, data extraction, quality assessment.

ESK
Wrote the draft of this manuscript; screening of titles, abstracts and full texts, data extraction, quality assessment of the last update; submission of the manuscript.

TD
Involved in all steps to plan this systematic review including the protocol; provided expertise and discussed the results in the African context, commented on the manuscript.

TF
Provided expertise on primary care aspects of hypertension treatment, discussed the results, commented on the manuscript.

SG
Provided expertise on CVD epidemiology and public health, discussed the results in the African context, commented on the manuscript.

EJK
Involved in all steps to plan this systematic review including the protocol; provided expertise on the needs of evidence in the African context, commented on the manuscript.

SU
Involved in all steps to plan this systematic review including the protocol; wrote the draft of this manuscript, systematic search, screening of titles, abstracts and full texts, data extraction, quality assessment, submission of the manuscript

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Table 1: Inclusion and exclusion criteria

Design	RCTs conducted in African countries, in international studies with at least 50 % African countries
Population	African adult patients in secondary and tertiary prevention, diagnosis and treatment of hypertension Exclusion of patients with gestational diabetes, Pre-eclampsia or eclampsia
Intervention	All non-pharmacological strategies to improve adequate diagnoses, prevention and treatment of hypertension
Control	- No intervention - Standard care - Another intervention
Outcome	blood pressure (SBP, DBP, MAP), adherence to recommendations (medications and lifestyle changes) and costs within longest follow-up
Publication	Full-text publications according to CONSORT in English or German
CONSORT: Consolidated Standards of Reporting Trials; DBP: Diastolic blood pressure; MAP: Mean arterial pressure; SBP: Systolic blood pressure, RCT: Randomized controlled trial	

Table 1: Study characteristics

		Participants			Intervention (IG) vs. Control (CG)		Results on adherence and blood pressure
Name (design)	**Country**	**n**	**Age (years) / Females**	**hypertension; SBP /DBP (mmHg)**	**Description**	**Follow-up (months)**	IG vs. CG; treatment effect (95 %-CI)
Educational strategies for patients (11 RCTs)							
Adeyemo 2013 RCT	Nigeria (mixed)	668	62.7±10.0 / 66 %	mild to moderate 167.4±19.2 / 91.8 ±12.3	home visits by nurses and clinic management (community based, nurse-led treatment program with physician backup; facilitation of clinic visits and health education; use of diuretics and a beta blocker as needed) vs. clinic management	6	excellent adherence (missed ≤2 pills per month): worse in IG: 72.5% vs. 79.0%; OR_a 0.524 (0.30; 0.75) BP control: no difference 65.0 vs. 66.3%; RR 0.98 (0.87;1.11)
Ayodapo 2019 RCT	Nigeria (mixed)	322	60.9±10.0 / 51 %	MAP: 106.4±8.3	Counselling on lifestyle behaviors (physical activity, fruit and vegetable consumption, alcohol consumption, smoking) over 30-45 minutes, reminders (telephone calls/SMS) vs. usual care	3	Met recommendations on: Physical activity: better in IG: 22.4 vs. 6.2 %; RR 3.60 (1.85;7.00) fruit and vegetable consumption: better in IG: 71.4 vs. 66 %; RR 1.74 (1.41;2.15) alcohol consumption: better in IG: 100 vs. 87.6 %; RR 1.14 (1.08; 1.21) smoking: no difference: 83.9 vs. 78.5 %; RR 1.05 (0.95; 1.17) blood pressure: MAP: lower in IG: 94.6±8.1 vs. 106.2±7.6 mmHg; MD -9.8 (-11.5; -8.1)
Bobrow 2016 (PACTR2014 11000724141) RCT	South Africa (urban)	1372	54.3±11.5 / 72 %	mild to moderate 135.4±17.5 83.4±12.1	mobile phone text messages on behavior change techniques (IG2: interactive with information and possibility to response vs. IG1: only information on hypertension, motivation to take medications and reminders) vs. usual care	12	adherence (days with medication ≥ 80 %): higher with IG: 59.7 vs. 62.8 vs. 49.4 %; RR 1.12 (1.01;1.23) IG2 vs. CG: OR_a 1.86 (1.39;2.49) IG1 vs. CG: OR_a 1.60 (1.20;2.16) blood pressure: slightly lower with IG1

		Participants			Intervention (IG) vs. Control (CG)		Results on adherence and blood pressure
Name (design)	**Country**	**n**	**Age (years) / Females**	**hypertension; SBP /DBP (mmHg)**	**Description**	**Follow-up (months)**	IG vs. CG; treatment effect (95 %-CI)
							SBP: 132.7±17.5 vs. 132.1±16.6 vs. 134.3±17.3 mmHg IG2 vs. CG: MD_a-1.6 mmHg (-3.7; 0.6) IG1 vs. CG: MD_a -2.2mmHg (-4.4; -0.04) BP control: slightly better with IG: 65 vs. 65 vs. 58 % IG1 vs. CG: OR_a 1.42 (1.03; 1.95) IG2 vs. CG: OR_a 1.41 (1.02; 1.95)
Bolarinwa 2019 (PACTR2016 06001671335) RCT	Nigeria (urban)	299	61.1±10.8 / 77 %	140.0 ± 22.9 86.9 ±11.9	task-shifting (driven by trained and professionally competent nurses) home-based follow-up care (BP and BMI monitoring, medical advice and counselling at home) vs. usual care	12	medical <u>adherence</u>: better with IG: low: 4 vs. 16.6%, medium: 17.5 vs. 34.7%, high: 78.5% vs. 48.7% <u>BP control</u>: better with IG: 85.9% vs. 76.7%; RR 1.12 (1.00; 1.25)
Labhardt 2011 cluster RCT	Cameroon (rural)	187	59.9± 12.5/ 64 %	mild to moderate 175.8 / 100.7	reminder letters in case of missing follow-up (IG2) vs. financial incentive (one month free treatment for regular attenders) (IG1) vs. usual care in nurse-led facilities	12	<u>adherence</u>: retention rate: 60 vs. 65 vs. 29%; lower risk of loss to follow up from the program and better adherence in IG IG2 vs. CG: HR_a: 0.38 (0.24; 0.61) IG1 vs. CG: HR_a: 0.44 (0.27; 0.72) adherence (≥ 80 %): 38 vs. 35 vs. 10 % IG2 vs. CG: MD_a: 28 % (14; 42) IG1 vs. CG: MD_a: 25 % (13; 37) <u>blood pressure:</u> no differences in SBP in retained patients <u>Costs:</u> In IG1: average monthly cost per patient for antihypertensive medication: 1.1±0.9 €, transport: 1.1±1.0 €

		Participants			Intervention (IG) vs. Control (CG)		Results on adherence and blood pressure
Name (design)	**Country**	**n**	**Age (years) / Females**	**hypertension; SBP /DBP (mmHg)**	**Description**	**Follow-up (months)**	IG vs. CG; treatment effect (95 %-CI)
Owolabi 2019 (NCT01900756) RCT	Nigeria (mixed)	400#	57.2 ± 11.7/ 37 %	All stroke (n=400); 138.3 ± 23.6 83.0 ± 15.2 stroke and uncontrolled hypertension (SBP/DBP>140 /90 mmHg) (n=168) 158.7 ± 21.7 92.5 ± 15.6	chronic care model components of delivery system redesign (increased follow-up visits, pre-appointment phone texts), self-management support (patient report card, post-clinic follow-up phone texts, waiting room educational video) and clinical information systems (patient report card as part of medical chart, hospital registry) vs. standardized usual care (risk factor identification and control) and phone contact information	12	Blood pressure: No difference for all patients after stroke: SBP: 136.5±22.3 vs. 136.2±21.2 mmHg patients with uncontrolled hypertension: SBP: 145.1±22.6 vs. 148.5±22.8 mmHg
Sarfo 2019 (NCT02568137) cluster-RCT	Ghana (urban)	60#	55 ± 13/ 35 %	stroke and uncontrolled hypertension; 143.8 ± 26.7 90.5 ± 15.7	Nurse-led, multilevel approach with m-Health technology for monitoring and reporting BP measurement and tailored motivational text messages vs. usual care	9	adherence: modified MMA score: no difference: 13±1.5 vs. 13±1.7 Blood pressure: BP control: no difference: 47 vs. 40 %; OR_a: 1.24 (0.83; 1.84) SBP<140 mmHg: better in IG: 73 vs. 43 % DBP<90 mmHg: better in CG: 47 vs. 77 %
Saunders 1991 RCT	South Africa (urban)	224	65 % between 40-50 / 73 %	mild to moderate; n.r. 116.6	Reminder letters and home visits by fieldworkers and patient-retained records for self-monitoring of medication compliance and BP control vs. usual care (appointment system and health education)	6	adherence (treatment received) over 6 months: higher for newly treated (135.5±48.9 vs. 95.0±60.0 days) and infrequent attenders (168.4±16.4 vs.116.7±56.9 days) of 180 days >80 % of treatment: better for newly treated (59 vs. 29 %; p< 0.001) and

		Participants			Intervention (IG) vs. Control (CG)		Results on adherence and blood pressure
Name (design)	**Country**	**n**	**Age (years) / Females**	**hypertension; SBP /DBP (mmHg)**	**Description**	**Follow-up (months)**	IG vs. CG; treatment effect (95 %-CI)
							infrequent attenders (87 vs. 42 %; p< 0.001) blood pressure: DBP: lower for newly treated patients (93.4 vs. 100.5 mmHg; MD: 7.1 mmHg (0.5-13.7), no difference for infrequent attenders: 97.5 vs. 94.7 mmHg; MD: -2.8 mmHg (-6.9; 1.3)
Stewart 2005 RCT	South Africa (urban)	83	late middle aged/ n.r.	all hypertensives; 146.4±18.5 93.5±11.1	telephonic intervention (educational and home-based exercise program + support of a healthcare practitioner and a family member) vs. control group (educational and home-based exercise program only)	6	adherence: better with IG: 62.8 ±34.5% vs. 39.3± 42.8 %; p=0.007 blood pressure: no difference: SBP: 142±16 vs. 144±20 mmHg; MD: -2 mmHg (-10.3 - 6.3) DBP: 92±12 vs. 91±10 mmHg, change: MD: 1 mmHg (-4.0 - 6.0)
Vedanthan 2019 (NCT01844596) cluster-RCT	Kenya (rural)	1460	54.2±16.4/ 58 %	all hypertensives; 159.4±19.5 89.7 ±12	tailored behavioral communication (smartphone (IG2) or paper-based (IG1)) vs. usual care	12	adherence (Linkage to care): best results with IG2, worse with IG1: IG2 vs. CG: OR_a: 1.21 (0.70; 2.01) IG1 vs. CG: OR_a: 0.64 (0.43; 0.91) IG2 vs. IG1: OR_a: 1.95 (1.23; 3.01) blood pressure: no difference SBP: 149.4±20.8 vs. 150.2±21.6 vs. 150.0±22.9 mmHg, change: -13.1±20.5 vs. -8.4±24.0 vs. -9.7±25.1 mmHg IG2 vs. CG: MD_a: -2.13 mmHg (-4.89;0.42) IG1 vs. CG: MD_a: -0.06 mmHg (-3.61; 3.20)

		Participants			Intervention (IG) vs. Control (CG)		Results on adherence and blood pressure
Name (design)	**Country**	**n**	**Age (years) / Females**	**hypertension; SBP /DBP (mmHg)**	**Description**	**Follow-up (months)**	IG vs. CG; treatment effect (95 %-CI)
							IG2 vs. IG1: MD_a: -2.07 mmHg (-5.14;1.12) DBP: no difference: 91.3±12.7 vs. 91.0±14.1 vs. 90.1±13.7 mmHg, change: 1.5±12.7 vs. 0.4±15.2 vs. 0.1±14.7 mmHg BP control: no difference: IG2 vs. CG: OR_a: 0.95 (0.61; 1.38) IG1 vs. CG: OR_a: 0.97 (0.63; 1.42) IG2 vs. IG1: OR_a: 1.00 (0.69; 1.40)
Wahab 2017 RCT	Nigeria (urban)	35#	58.1 ±10.5/ 34 %	all patients with stroke; 138.3 ± 24.2 85.0 ±12.4	feasibility of a nurse-led Intervention (education and skill building, BP monitor with review, phone calls) vs. usual care	0.5	adherence: no difference, but improvement in both groups: MMA Score: 7.32±0.93 vs. 7.03±1.36 Blood pressure: no difference SBP: 137.5±23.0 vs.133.1±18.2 mmHG; MD: 4.40 mmHg (-9.4; 18.2) DBP: 84.1±9.7 vs. 84.2±13.1 mmHg; MD -0.1 mmHg (-7.7; 7.5)
Educational strategies for health-care professionals (5 RCTs)							
Fairall 2016 (ISRCTN20283604) cluster-RCT	South Africa (rural)	4393	52 (IQR 43-62)/ 73 %	mild to moderate 139±23.6[a] 90±13.2[a]	Education of nurses on NCD care (nurse training in educational outreach sessions with a primary care program to expand their role in NCD care, authorization to prescribe an expanded range of drugs on NCDs) vs. usual training	14	adherence: no difference Blood pressure: BP controlled: no difference: 33 vs. 32 %; RR 1.01 (0.2-1.8)
Goudge 2018 (ISRCTN12128227) cluster-RCT	South Africa (rural)	4722	56.6±19.4 / 56 %	hypertension: 46.6 %, of them: 53.4%,	Support of nurses by health workers (e.g. assistance with booking appointments, retrieve and fill patient files, health education,	18	No hypertension: 50.9% vs. 52.9% adherence and blood pressure: no difference

		Participants			Intervention (IG) vs. Control (CG)		Results on adherence and blood pressure
Name (design)	**Country**	**n**	**Age (years) / Females**	**hypertension; SBP /DBP (mmHg)**	**Description**	**Follow-up (months)**	IG vs. CG; treatment effect (95 %-CI)
				on treatment and controlled: 8.6%, on treatment and uncontrolled: 9 %, not on treatment 29 %	measurements in the vital signs queue, prepacking of medications, reminders to appointment for patients) to provide chronic disease care vs. usual care		on treatment and controlled: 11.3 vs. 11.2 % on treatment and uncontrolled 13.0 vs. 13.2 % not on treatment 24.9% vs. 22.7% undiagnosed: 24.1 vs. 22.2 % taking medication: 24.3 vs. 24.4 %
Gyamfi 2017 (NCT01802372) cluster-RCT	Ghana (mixed)	757	58.0±12.4 / 60 %	mild to moderate 155.9 ± 12.1 / 89.6 ± 10.8	Training of nurses in task shifting for hypertension control + health insurance coverage vs. health coverage	12	blood pressure: improvement in both groups, but no difference between groups: SBP: 137.1±27.5 vs. 138.4±27.3 mmHg; change: -19.5±18.0 vs. -16.6±17.9 mmHg; MD: -2.9 mmHg (-6.9; 1.0) DBP: 79.8±22.9 vs.81.8±22.8 mmHg; change -9,3±11.5 vs. 8.7±18.7 mmHg; MD -0.6 mmHg (-2.9; 1.7) BP control: 55.2 vs. 49.9 % (MD 5.2 % (-1.8; 12.4)
Mendis 2010 cluster-RCT	Nigeria (mixed)	1188	55 ± 4.7 / 58 %	mild to moderate 153.2±12.4 94 ± 9.7	Education of health-care workers and patients with a simple cardiovascular risk management package vs. usual care	12	adherence: higher with IG Attended visits: 90.1 vs. 74.5 % quit smoking: 100 vs. 74.4 % (p=0.023) Increased fruit consumption: 93.4 vs. 18.8 % (p< 0.0001) increased vegetable consumption: 14.2 vs. 7.0 % (p=0.0002) blood pressure: higher decrease in IG

		Participants			Intervention (IG) vs. Control (CG)		Results on adherence and blood pressure
Name (design)	**Country**	**n**	**Age (years) / Females**	**hypertension; SBP /DBP (mmHg)**	**Description**	**Follow-up (months)**	IG vs. CG; treatment effect (95 %-CI)
							SBP: -11.0±15.4 vs. -6.6±20.6 mmHg; MD -4.4 mmHg (-6.7; -2.1) DBP: -5.4±10.0 vs. -2.0±13.2 mmHg; MD -3.4 mmHg (-4.9; -1.9)
Steyn 2013 (PACTR2013 03000493351) cluster-RCT	South Africa (urban)	920	60.3±11.1 / 79 %	all hypertensives1 51.2 ±26.7 / 87.1 ± 12.4	multi-faced intervention to implement national guidelines (structured record of national guidelines and visits to train clinicians) vs. usual care (passive dissemination) at primary care level	12	Blood pressure: no difference SBP: 161±28.9 vs. 158.2±29.5 mmHg; MD 2.8 mmHg (-1.2; 6.8) DBP: 88.1±13 vs. 87.1±12.6 mmHg; MD 1.00 mmHg (-0.73; 2.73) controlled BP: 23.1 vs. 26 %
Individualized treatment (3 RCTs)							
Akintunde 2017 (ISRCTN69440037) RCT {Akintunde, 2017 #4980} (ISRCTN69440037)	Nigeria, Kenya, South Africa (urban)	105	56.6±14.3 / 53 %	uncontrolled 170.9 ± 19.2 / 85.6 ± 21.8	physiologically individualized care (guided by their physiological phenotype, based on plasma renin and aldosterone) vs. usual care	12	blood pressure: lower in IG SBP: 139.4±17.4 vs. 152.6±12.3 mmHg; MD -13.2 mmHg (-19.4; -7.0) DBP: 84.0±11.0 vs. 89.6±7.0 mmHg; MD -5.6 mmHg (-9.4; -1.8) BP control: 50.0 vs. 11.1 % (p=0.0001)
Okeahialam 2011 RCT	Nigeria (urban)	181	49.7±14.2 / 61 %	mild to moderate 150.3 ± 14.8 / 93.7 ± 9.6	chronotherapy: drug intake in the night (10 pm) vs. drug intake in the morning (10 am)	3	blood pressure: higher decrease in IG SBP: . -18.1±17.9 vs.-14.1±14.7 mmHg; MD -4.0 mmHg (-9.0;1.0) DBP-15.6±12.2 vs.-8.7±10.2 mmHg; MD -6.9 mmHg (-10.4; -3.4)
Physical activity (4 RCTs)							
Aweto 2012 RCT	Nigeria (urban)	50	45±12.3 / 58 %	mild to moderate 138.7±10.9 /	dance movement therapy (50 minutes) vs. educational sessions, both 2x/week over 4 wks	1	blood pressure: lower in IG SBP: 119.9±8.3 vs. 135.5±11.6 mmHg; MD -15.6 mmHg (-22.4; -8.8)

		Participants			Intervention (IG) vs. Control (CG)		Results on adherence and blood pressure
Name (design)	**Country**	**n**	**Age (years) / Females**	**hypertension; SBP /DBP (mmHg)**	**Description**	**Follow-up (months)**	IG vs. CG; treatment effect (95 %-CI)
				79.9±9.3			DBP: 70.9±7.2 vs. 74.1±7.7 mmHg; MD -3.2 mmHg (-8.1; 1.7)
Lamina 2010 RCT	Nigeria (urban)	485	58.5 ±6.8 / 0 %	mild to moderate, stable 165.4±13.2 / 98.1 ± 4.6	training programs on bicycle ergometer, 3x/wk, 45-60 minutes: Interval training (IG2) vs. continuous training (IG1) vs. usual care over 8 wks	2	blood pressure: lower in IG SBP: 150.4±16.7 vs. 154.4±12.6 vs.163.5±14.9 mmHg; MD -11.1 mmHg (-14.8: -7.4) DBP: 95±5 vs. 94.4±8.8 vs. 96.1±2.7 mmHg; MD -1.4 mmHg (-2.6; -0.2)
Maruf 2016 (ISRCTN81952488) RCT	Nigeria (urban)	120	52.8±8.4 (range 38-65) / 71 %	mild to moderate, 155.7±11.4 / 93±10	aerobic dance training (3x/wk, 45 minutes) vs. usual care over 12 wks	3	blood pressure: lower in IG SBP: 135.3±5.6 vs. 142.4±4.7 mmHg; MD: -7.1 mmHg (-9.3; -4.9) DBP: 82.2±3.4 vs. 83.9±2.8 mmHg; MD: -1.7 mmHg (-3.0; -0.4)
Turky 2013 RCT	Egypt (urban)	30	52.8±2.4, 40-50 / 100 %	postmeno-pausal hypertensives 151±6.2 / 94.5±4.2	moderate aerobic exercise training (40 minutes, 3x/wk) by walking on a treadmill vs. usual care over 8 wks	2	blood pressure: lower in IG SBP: 124±5.6 vs. 145±6.7 mmHg; MD: -21.0 mmHg (-25.8; -16.2) DBP: 85±5.4 vs. 95±3.7 mmHg; MD: -10.0 mmHg (-13.7; -6.3)
Modified nutrition (1 RCT)							
Charlton 2008 RCT	South Africa (urban)	92	61.1±7/ 84 %	mild to moderate 134.6±15.7 / 81.1±8.1	food-based dietary strategy (modified food, salt replacement, + 500 ml of maas (fermented milk) vs. control (same quantities of the targeted foods of standard commercial composition, 500 ml/d artificially sweetened cooldrink)	2	blood pressure: lower in IG SBP: 132.5±15.8 vs. 127.5±15.8 mmHg; MD_a:-6.2 mmHg (-11.4; -0.9) DBP: 82.2±9.5 vs. 79.2±11.4 mmHg; MD_a: -0.6 mmHg (-3.0; 1.8)

		Participants			Intervention (IG) vs. Control (CG)		Results on adherence and blood pressure
Name (design)	**Country**	**n**	**Age (years) / Females**	**hypertension; SBP /DBP (mmHg)**	**Description**	**Follow-up (months)**	IG vs. CG; treatment effect (95 %-CI)
# tertiary prevention BMI: body mass index; BP: blood pressure; CG: Control group; DBP: diastolic blood pressureIG: Intervention group; MD: mean difference; MD_a: adjusted mean difference; n: number of randomized participants; MMA: Morisky medication adherence; NCD: non-communicable disease; n.r. not reported; ; OR_a: adjusted odds ratio; RCT: randomized controlled trial; RR: relative risk; SBP: systolic blood pressure; wk: week							

Table 2: Risk of bias assessment

Study	Sequence generation	Allocation concealment	Blinding of		Incomplete outcome data	Selective reporting	Other sources
			personnel / participants	outcome assessors			
Educational strategies							
Adeyemo 2013	😐	😐	☹	😐	☹	😐	☹
Ayodapo 2019	😐	☺	☹	☹	☺	😐	😐
Bobrow 2016	☺	☺	☹	😐	☹	☺	☺
Bolarinwa 2019	☺	☺	☹	☹	☹	☹	☹
Fairall 2016	☺	☺	☹	😐	☺	☺	☺
Goudge 2018	☺	☺	☹	☺	☹	☺	☺
Gyamfi 2017	☺	☺	☹	😐	☹	☹	☺
Labhardt 2011	☺	☺	☹	☹	☹	☹	☺
Mendis 2010	☹	☹	☹	☹	☹	😐	☺
Owolabi 2019	☺	😐	☹	☺	☺	☹	☺
Sarfo 2019	☺	☺	☹	☺	☺	☺	☺
Saunders 1991	😐	😐	☹	☹	☺	😐	☺
Stewart 2005	😐	😐	☹	☹	☹	😐	☺
Steyn 2013	☺	☺	☹	☹	☺	☺	☺
Vedanthan 2019	😐	☺	☹	☹	☹	☺	☹
Wahab 2017	☺	☺	☹	☹	☺	😐	☹
Standardized treatment							
Akintunde 2017	☹	😐	😐	😐	☹	☺	☹
Okeahialam 2011	☺	☺	☹	😐	☹	😐	☹
Physical activity							
Aweto 2012	😐	😐	☹	☹	☹	😐	☹

Study	Sequence generation	Allocation concealment	Blinding of		Incomplete outcome data	Selective reporting	Other sources
			personnel / participants	outcome assessors			
Lamina 2010	☹	😐	😐	☺	☹	😐	☺
Maruf 2016	☺	☺	😐	☺	☺	☹	☹
Turky 2013	☺	☺	☹	☹	☹	😐	☹
Modified nutrition							
Charlton 2008	😐	😐	☺	☺	☺	😐	☺
☺: low; 😐: unclear; ☹: high risk of bias							

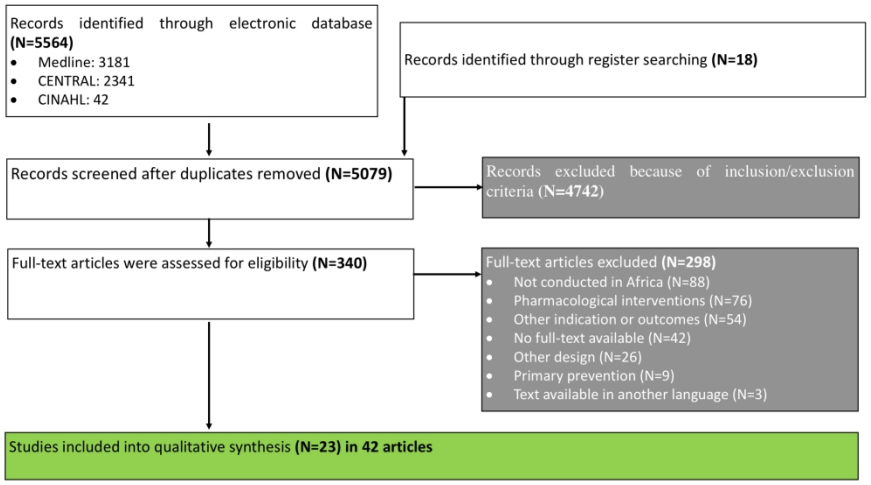

Figure 1: PRISMA flow chart describing the process of study selection

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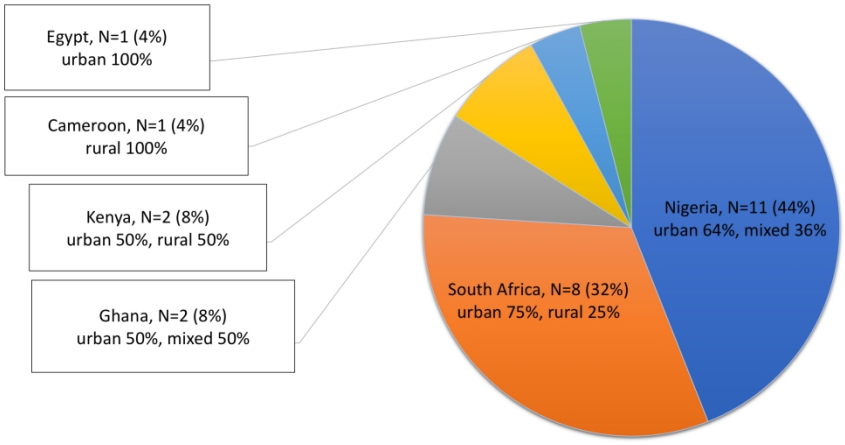

Figure 2: Spatial distribution of countries in which randomized studies were conducted

338x190mm (225 x 225 DPI)

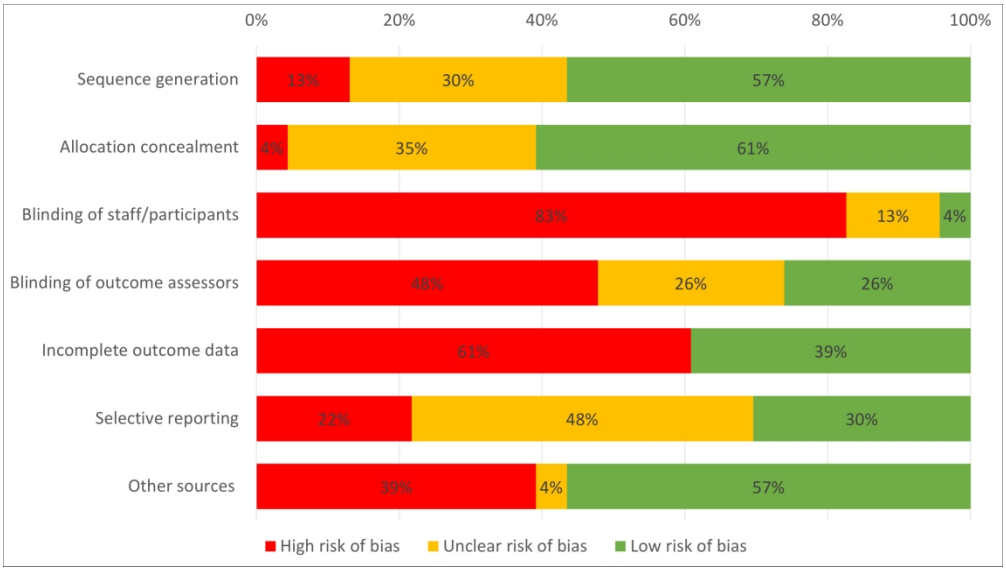

Figure 5: Summary of risk of bias

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PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	4
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	4,5
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	2,6
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	6
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	6
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	6, supplementary file
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	6
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	6,7
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	7
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	8
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	8

PRISMA 2009 Checklist

Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	8

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	8
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	8
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	9
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	9
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	12, Table 3
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	10,11
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	None done, narrative synthesis
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	12, Figure 5
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	None done
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	13,14, 15
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	15, 16
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	17

PRISMA 2009 Checklist

FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	19

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit: **www.prisma-statement.org**.

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Search strategies

Medline (Ovid): Search on CVDs

Nr.	Searches (24th July 2017)	Results
Indication		
1.	exp heart diseases/	
2.	exp vascular diseases/	
3.	cerebrovascular disorders/	
4.	exp brain ischemia/	
5.	exp carotid artery diseases/	
6.	exp dementia, vascular/	
7.	exp intracranial arterial diseases/	
8.	exp intracranial embolism/ and thrombosis/	
9.	exp intracranial hemorrhages/	
10.	exp stroke/	
11.	exp hyperlipidemias/	
12.	Exp hypercholesteremia/	
13.	exp Myocardial Ischemia/	
14.	angina.tw	
15.	(heart adj3 disease$).tw.	
16.	(coronary adj3 disease$).tw.	
17.	(peripheral adj3 disease$).tw.	
18.	(cerebrovascular disease).tw	
19.	Renal artery stenosis.tw	
20.	(Aortic aneurism or Aneurysm$).tw	
21.	myocardial infarct$.tw.	
22.	exp Myocardial Revascularization/	
23.	(coronary adj3 bypass$).tw.	
24.	(coronary adj3 angioplast$).tw.	
25.	(heart adj3 infarct$).tw.	
26.	postmyocardial infarct$.tw.	
27.	cardiovascular diseases/	
28.	Hypertens$.tw	
29.	(high adj2 blood pressure).tw	
30.	(blood pressure control).tw	
31.	Hypertensive heart disease.tw.	
32.	Cardiomyopath$.tw.	
33.	Heart failure.tw.	

Nr.	Searches (24th July 2017)	Results
34.	(Pulmonary heart disease).tw	
35.	Cardiac dysrhythmia*.tw.	
36.	Inflammatory heart disease.tw.	
37.	Endocarditis.tw.	
38.	Cardiomegaly.tw	
39.	Valvular heart disease.tw.	
40.	Rheumatic heart disease.tw	
41.	Myocarditis.tw	
42.	Arrhythmi$.tw	
43.	Vasculitis.tw	
44.	**or/1-43**	**2 498 192**
Africa and African countries		
45.	Africa.tw	
46.	Exp Africa/	
47.	Algeria$.tw or exp Algeria/	
48.	Angol$.tw or exp Angola/	
49.	Benin$.tw or exp Benin/	
50.	Botswan$.tw or exp Botswana/	
51.	Burkina Faso.tw or exp Burkina Faso/	
52.	Burund$.tw or exp Burundi/	
53.	Cameroon$.tw or exp Cameroon/	
54.	Cape Verde.tw or exp Cape Verde/	
55.	Central African Republic$.tw or exp Central African Republic/	
56.	Chad$.tw or exp Chad/	
57.	Comoros$.tw or exp Comoros/	
58.	Cote d'Ivoire.tw or exp Cote d'Ivoire/	
59.	Democratic Republic of Congo.tw or exp Democratic Republic of Congo	
60.	Djibout$.tw or exp Djibouti/	
61.	Egypt$.tw or exp Egypt/	
62.	Equatorial Guinea$.tw or exp Equatorial Guinea/	
63.	Eritrea$.tw or exp Eritrea/	
64.	Ethiop$.tw or exp Ethiopia/	
65.	Gabon$.tw or exp Gabon/	
66.	Gambia$.tw or exp Gambia/	
67.	Ghana$.tw or exp Ghana/	
68.	Guinea$.tw or exp Guinea/	
69.	Guinea-Bissau.tw or exp Guinea-Bissau/	

Nr.	Searches (24th July 2017)	Results
70.	Kenya$.tw or exp Kenya/	
71.	Lesoth$.tw or exp Lesotho/	
72.	Liberia$.tw or exp Liberia/	
73.	Libya$.tw or exp Libya/	
74.	Madagascar$.tw or exp Madagascar/	
75.	Malawi$.tw or exp Malawi/	
76.	Mali.tw or exp Mali/	
77.	Mauritania$.tw or exp Mauritania/	
78.	Mauritius$.tw or exp Mauritius/	
79.	Morocc$.tw or exp Morocco/	
80.	Mozambique$.tw or exp Mozambique/	
81.	Namibia$.tw or exp Namibia/	
82.	Niger.tw or exp Niger/	
83.	Nigeria$.tw or exp Nigeria/	
84.	Rwanda$.tw or exp Rwanda/	
85.	(Sao Tome and Principe).tw	
86.	Senegal$.tw or exp Senegal/	
87.	Seychell$.tw	
88.	Sierra Leone.tw or exp Sierra Leone/	
89.	Somalia$.tw or exp Somalia/	
90.	South Africa$.tw or exp South Africa.de	
91.	South Sudan.tw or exp South Sudan/	
92.	Sudan$.tw or exp Sudan/	
93.	Swaziland$.tw or exp Swaziland/	
94.	Tanzania$.tw or exp Tanzania/	
95.	Togo$.tw or exp Togo/	
96.	Tunisia$.tw or exp Tunisia/	
97.	Uganda$.tw or exp Uganda/	
98.	Zambia$.tw or exp Zambia/	
99.	Zimbabwe$.tw or exp Zimbabwe/	
100.	Somaliland$.tw or exp Somaliland/	
101.	#1.tw	
102.	or/45-101	436 084
103.	44 and 102	19 017
Study design		
104.	randomized controlled trial.pt.	
105.	controlled clinical trial.pt.	

Nr.	Searches (24th July 2017)	Results
106.	randomized.ab.	
107.	placebo.ab.	
108.	randomly.ab.	
109.	trial.ab.	
110.	groups.ab.	
111.	or/104-110	2 535 560
112.	exp animals/ not humans.sh.	
113.	111 not 112	2 133 129
114.	103 and 113	**2643**

Medline (Ovid): Update on hypertension

Nr.	Searches (23th June 2020)	Results
Indication		
1.	Exp hypertension	
2.	Hypertens$.ti,ab	
3.	(high adj2 blood pressure).ti,ab	
4.	(blood pressure control).ti,ab	
5.	**or/1-4**	464 555
Africa and African countries		
6.	Africa.tw	
7.	Exp Africa/	
8.	Algeria$.tw or exp Algeria/	
9.	Angol$.tw or exp Angola/	
10.	Benin$.tw or exp Benin/	
11.	Botswan$.tw or exp Botswana/	
12.	Burkina Faso.tw or exp Burkina Faso/	
13.	Burund$.tw or exp Burundi/	
14.	Cameroon$.tw or exp Cameroon/	
15.	Cape Verde.tw or exp Cape Verde/	
16.	Central African Republic$.tw or exp Central African Republic/	
17.	Chad$.tw or exp Chad/	
18.	Comoros$.tw or exp Comoros/	
19.	Cote d'Ivoire.tw or exp Cote d'Ivoire/	
20.	Democratic Republic of Congo.tw or exp Democratic Republic of Congo	
21.	Djibout$.tw or exp Djibouti/	

Nr.	Searches (23th June 2020)	Results
22.	Egypt$.tw or exp Egypt/	
23.	Equatorial Guinea$.tw or exp Equatorial Guinea/	
24.	Eritrea$.tw or exp Eritrea/	
25.	Ethiop$.tw or exp Ethiopia/	
26.	Gabon$.tw or exp Gabon/	
27.	Gambia$.tw or exp Gambia/	
28.	Ghana$.tw or exp Ghana/	
29.	Guinea$.tw or exp Guinea/	
30.	Guinea-Bissau.tw or exp Guinea-Bissau/	
31.	Kenya$.tw or exp Kenya/	
32.	Lesoth$.tw or exp Lesotho/	
33.	Liberia$.tw or exp Liberia/	
34.	Libya$.tw or exp Libya/	
35.	Madagascar$.tw or exp Madagascar/	
36.	Malawi$.tw or exp Malawi/	
37.	Mali.tw or exp Mali/	
38.	Mauritania$.tw or exp Mauritania/	
39.	Mauritius$.tw or exp Mauritius/	
40.	Morocc$.tw or exp Morocco/	
41.	Mozambique$.tw or exp Mozambique/	
42.	Namibia$.tw or exp Namibia/	
43.	Niger.tw or exp Niger/	
44.	Nigeria$.tw or exp Nigeria/	
45.	Rwanda$.tw or exp Rwanda/	
46.	(Sao Tome and Principe).tw	
47.	Senegal$.tw or exp Senegal/	
48.	Seychell$.tw	
49.	Sierra Leone.tw or exp Sierra Leone/	
50.	Somalia$.tw or exp Somalia/	
51.	South Africa$.tw or exp South Africa.de	
52.	South Sudan.tw or exp South Sudan/	
53.	Sudan$.tw or exp Sudan/	
54.	Swaziland$.tw or exp Swaziland/	
55.	Tanzania$.tw or exp Tanzania/	
56.	Togo$.tw or exp Togo/	
57.	Tunisia$.tw or exp Tunisia/	
58.	Uganda$.tw or exp Uganda/	

Nr.	Searches (23th June 2020)	Results
59.	Zambia$.tw or exp Zambia/	
60.	Zimbabwe$.tw or exp Zimbabwe/	
61.	Somaliland$.tw or exp Somaliland/	
62.	Sahrawi Arab Democratic Republic.tw.	
63.	or/6-62	530 370
Study design		
64.	randomized controlled trial.pt.	
65.	controlled clinical trial.pt.	
66.	(randomized or randomised or randomly).ti,ab	
67.	placebo.ab.	
68.	trial.ab.	
69.	groups.ab.	
70.	or/64-69	2 757 989
71.	5 and 63 and 70	3036
72.	exp animals/ not humans.sh.	
73.	71 not 72	
74.	73 not (comment or editorial).pt	2964
75.	Limit 74 to yr= “2017-Current”	**538**

CENTRAL: Search on CVDs

Nr.	Searches (14th August 2017)	Results
1	Africa, explode all trees	
2	Algeria* or Angol* or Benin* or Botswan*	
3	(Burkina Faso) or Burund* or Cameroon* or (Cape Verde) or (Central African Republic)	
4	Chad* or Comoros* or Cote d'Ivoire or Congo*	
5	Djibout* or Egypt* or (Equatorial Guinea*) or Eritrea*	
6	Ethiop* or Gabon* or Gambia* or Ghana* or Guinea* or Guinea-Bissau	
7	Kenya* or Lesoth* or Liberia* or Libya* or Madagascar* or Malawi*	
8	Mali* or Mauritania* or Mauritius* or Morocc* or Mozambique* or Namibia* or Niger*	
9	Nigeria* or Rwanda* or (Sao Tome and Principe) or Senegal* or Seychell*	
10	Sierra Leone or Somalia* or (South Africa) or (South Sudan*) or Sudan* or Swasiland	
11	Tanzania* or Togo* or Tunisia* or Uganda* or Zambia* or Zimbabwe* or Somaliland or (Sahrawi Arab Democratic Republic)	
12	#1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10 or #11	39 610
13	MeSH descriptor Cardiovascular Diseases, this term only	
14	MeSH descriptor Heart Diseases explode all trees	
15	MeSH descriptor Vascular Diseases explode all trees	
16	MeSH descriptor Cerebrovascular Disorders, this term only	
17	MeSH descriptor Brain Ischemia explode all trees	
18	MeSH descriptor Carotid Artery Diseases explode all trees	
19	MeSH descriptor Dementia, Vascular explode all trees	
20	MeSH descriptor Intracranial Arterial Diseases explode all trees	
21	MeSH descriptor Intracranial Embolism and Thrombosis explode all trees	
22	MeSH descriptor Intracranial Hemorrhages explode all trees	
23	MeSH descriptor Stroke explode all trees	
24	MeSH descriptor Hyperlipidemias explode all trees (4197)	
25	(coronar* or heart or peripheral* or cerebrovascular* or myocardial) near 3 (disease or infarct*)	
26	myocardi* near 3 (infarct* or revascular* or ischaem* or ischem*)	
27	vascular* near 3 (peripheral* or disease* or complication*))	
28	hypertensi* or (high near 2 blood pressure)	
29	(heart near 2 failure) or stroke	
30	Endocarditis or myocarditis or Cardiomegaly or arrythmi*	
31	#13 or #14 or #15 or #16 or #17 or #18 or #19 or #20 or #21 or #22 or #23 or #24 or #25 or #26 or #27 or #28 or #29 or #30	101 472
32	#12 and #31	4139
32	Trials	**2008**

CENTRAL, Update on hypertension

Nr.	Searches (23th June 2020)	Results
1	Africa, explode all trees	
2	Algeria* or Angol* or Benin* or Botswan*	
3	(Burkina Faso) or Burund* or Cameroon* or (Cape Verde) or (Central African Republic)	
4	Chad* or Comoros* or Cote d'Ivoire or Congo*	
5	Djibout* or Egypt* or (Equatorial Guinea*) or Eritrea*	
6	Ethiop* or Gabon* or Gambia* or Ghana* or Guinea* or Guinea-Bissau	
7	Kenya* or Lesoth* or Liberia* or Libya* or Madagascar* or Malawi*	
8	Mali* or Mauritania* or Mauritius* or Morocc* or Mozambique* or Namibia* or Niger*	
9	Nigeria* or Rwanda* or (Sao Tome and Principe) or Senegal* or Seychell*	

Nr.	Searches (23th June 2020)	Results
10	Sierra Leone or Somalia* or (South Africa) or (South Sudan*) or Sudan* or Swasiland	
11	Tanzania* or Togo* or Tunisia* or Uganda* or Zambia* or Zimbabwe* or Somaliland or (Sahrawi Arab Democratic Republic)	
12	#1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10 or #11	60 623
13	MeSH descriptor: [Hypertension] explode all trees	
14	hypertensi* or (high near 2 blood pressure)	
15	#13 or #14	67 954
16	#12 and #15	2929
	Trials, 2017-Current	**333**

CINAHL, Search on 23.06.2020

(Africa$ or Africa$ or Algeria$ or Angol$ or Benin$ or Botswan$ or (Burkina Faso) or Burund$ or Cameroon$ or (Cape Verde) or (Central African Republic) or Chad$ or Comoros$ or Cote d'Ivoire or Congo$ Djibout$ or Egypt$ or (Equatorial Guinea$) or Eritrea$ or Ethiop$ or Gabon$ or Gambia$ or Ghana$ or Guinea$ or Guinea-Bissau or Kenya$ or Lesoth$ or Liberia$ or Libya$ or Madagascar$ or Malawi$ or Mali$ or Mauritania$ or Mauritius$ or Morocc$ or Mozambique$ or Namibia$ or Niger$ or Nigeria$ or Rwanda$ or (Sao Tome and Principe) or Senegal$ or Seychell$ or Sierra Leone or Somalia$ or (South Africa) or (South Sudan$) or Sudan$ or Swasiland or Tanzania$ or Togo$ or Tunisia$ or Uganda$ or Zambia$ or Zimbabwe$ or Somaliland or (Sahrawi Arab Democratic Republic)) in Abstract
AND
hypertension or high blood pressure or elevated blood pressure or htn or hypertensive in Abstract
AND
randomized or rct or randomised in Abstract
AND
In English
AND
Peer-reviewed
And
Humans
Total: 42 results

International Clinical Trials Registry Platform (http://apps.who.int/trialsearch/AdvSearch.aspx), Search on 22 October 2019

hypertension or (blood pressure control) or (high blood pressure) in the condition,

Recruitment status: all

Countries of recruitment:

- Africa or African in the title: 90 trials
- Algeria or Angola or Behin or Burkina Faso or Botswana or Burundi or Cameroon or Central Africa Republic or Chad or Congo or Cabo Verde or Cite D'Ivoire: 13 trials
- Democratic Republic of Congo or Djibouti or Egypt or Equatorial Guinea or Eritrea or Ethiopia or Gabon or Gambia or Ghana or Guinea or Guinea-Bissau or Kenya: 78 trials
- Lesotho or Liberia or Libya or Madagascar or Malawi or Mali or Mauritius or Morocco or Mozambique: 14 trials
- Namibia or Niger or Nigeria or Rwanda or Sao Tome andPrincipe or Senegal or Seychelles or Sierra Leone or Somalia or Sudan or South Sudan or Swaziland: 23 trials
- Togo or Tunezia or United Republic of Tanzania or Uganda or Zambia or Zimbabwe: 25 trials

Total: 18 results

Table 1 : Inclusion and exclusion criteria

Design	RCTs conducted in African countries, in international studies with at least 50 % African countries
Population	African adult patients in secondary and tertiary prevention, diagnosis and treatment of hypertension Exclusion of patients with gestational diabetes, Pre-eclampsia or eclampsia
Intervention	All non-pharmacological strategies to improve adequate diagnoses, prevention and treatment of hypertension
Control	- No intervention - Standard care - Another intervention
Outcome	blood pressure (SBP, DBP, MAP), adherence to recommendations (medications and lifestyle changes) and costs within longest follow-up
Publication	Full-text publications according to CONSORT in English or German
CONSORT: Consolidated Standards of Reporting Trials; DBP: Diastolic blood pressure; MAP: Mean arterial pressure; SBP: Systolic blood pressure, RCT: Randomized controlled trial	

Table 1: Study characteristics

		Participants			Intervention (IG) vs. Control (CG)		Results on adherence and blood pressure
Name (design)	**Country**	**n**	**Age (years) / Females**	**hypertension; SBP /DBP (mmHg)**	**Description**	**Follow-up (months)**	IG vs. CG; treatment effect (95 %-CI)
Educational strategies for patients (11 RCTs)							
Adeyemo 2013 RCT	Nigeria (mixed)	668	62.7±10.0 / 66 %	mild to moderate 167.4±19.2 / 91.8 ±12.3	home visits by nurses and clinic management (community based, nurse-led treatment program with physician backup; facilitation of clinic visits and health education; use of diuretics and a beta blocker as needed) vs. clinic management	6	excellent adherence (missed ≤2 pills per month): worse in IG: 72.5% vs. 79.0%; OR_a 0.524 (0.30; 0.75) BP control: no difference 65.0 vs. 66.3%; RR 0.98 (0.87;1.11)
Ayodapo 2019 RCT	Nigeria (mixed)	322	60.9±10.0 / 51 %	MAP: 106.4±8.3	Counselling on lifestyle behaviors (physical activity, fruit and vegetable consumption, alcohol consumption, smoking) over 30-45 minutes, reminders (telephone calls/SMS) vs. usual care	3	Met recommendations on: Physical activity: better in IG: 22.4 vs. 6.2 %; RR 3.60 (1.85;7.00) fruit and vegetable consumption: better in IG: 71.4 vs. 66 %; RR 1.74 (1.41;2.15) alcohol consumption: better in IG: 100 vs. 87.6 %; RR 1.14 (1.08; 1.21) smoking: no difference: 83.9 vs. 78.5 %; RR 1.05 (0.95; 1.17) blood pressure: MAP: lower in IG: 94.6±8.1 vs. 106.2±7.6 mmHg; MD -9.8 (-11.5; -8.1)
Bobrow 2016 (PACTR2014 11000724141) RCT	South Africa (urban)	1372	54.3±11.5 / 72 %	mild to moderate 135.4±17.5 83.4±12.1	mobile phone text messages on behavior change techniques (IG2: interactive with information and possibility to response vs. IG1: only information on hypertension, motivation to take medications and reminders) vs. usual care	12	adherence (days with medication ≥ 80 %): higher with IG: 59.7 vs. 62.8 vs. 49.4 %; RR 1.12 (1.01;1.23) IG2 vs. CG: OR_a 1.86 (1.39;2.49) IG1 vs. CG: OR_a 1.60 (1.20;2.16) blood pressure: slightly lower with IG1

		Participants			Intervention (IG) vs. Control (CG)		Results on adherence and blood pressure
Name (design)	**Country**	**n**	**Age (years) / Females**	**hypertension; SBP /DBP (mmHg)**	**Description**	**Follow-up (months)**	IG vs. CG; treatment effect (95 %-CI)
							SBP: 132.7±17.5 vs. 132.1±16.6 vs. 134.3±17.3 mmHg IG2 vs. CG: MD_a-1.6 mmHg (-3.7; 0.6) IG1 vs. CG: MD_a -2.2mmHg (-4.4; -0.04) BP control: slightly better with IG: 65 vs. 65 vs. 58 % IG1 vs. CG: OR_a 1.42 (1.03; 1.95) IG2 vs. CG: OR_a 1.41 (1.02; 1.95)
Bolarinwa 2019 (PACTR2016 06001671335) RCT	Nigeria (urban)	299	61.1±10.8 / 77 %	140.0 ± 22.9 86.9 ±11.9	task-shifting (driven by trained and professionally competent nurses) home-based follow-up care (BP and BMI monitoring, medical advice and counselling at home) vs. usual care	12	medical adherence: better with IG: low: 4 vs. 16.6%, medium: 17.5 vs. 34.7%, high: 78.5% vs. 48.7% BP control: better with IG: 85.9% vs. 76.7%; RR 1.12 (1.00; 1.25)
Labhardt 2011 cluster RCT	Cameroon (rural)	187	59.9± 12.5/ 64 %	mild to moderate 175.8 / 100.7	reminder letters in case of missing follow-up (IG2) vs. financial incentive (one month free treatment for regular attenders) (IG1) vs. usual care in nurse-led facilities	12	adherence: retention rate: 60 vs. 65 vs. 29%; lower risk of loss to follow up from the program and better adherence in IG IG2 vs. CG: HR_a: 0.38 (0.24; 0.61) IG1 vs. CG: HR_a: 0.44 (0.27; 0.72) adherence (≥ 80 %): 38 vs. 35 vs. 10 % IG2 vs. CG: MD_a: 28 % (14; 42) IG1 vs. CG: MD_a: 25 % (13; 37) blood pressure: no differences in SBP in retained patients Costs:

Commented [US1]: Müssen wir laut Einschlusskriterien ausschließen, da keine Ergebnisse zu Bluthochdruck

		Participants			Intervention (IG) vs. Control (CG)		Results on adherence and blood pressure
Name (design)	**Country**	**n**	**Age (years) / Females**	**hypertension; SBP /DBP (mmHg)**	**Description**	**Follow-up (months)**	IG vs. CG; treatment effect (95 %-CI)
							In IG1: average monthly cost per patient for antihypertensive medication: 1.1±0.9 €, transport: 1.1±1.0 €
Owolabi 2019 (NCT01900756) RCT	Nigeria (mixed)	400#	57.2 ± 11.7/ 37 %	All stroke (n=400); 138.3 ± 23.6 83.0 ± 15.2 stroke and uncontrolled hypertension (SBP/DBP>140 /90 mmHg) (n=168) 158.7 ± 21.7 92.5 ± 15.6	chronic care model components of delivery system redesign (increased follow-up visits, pre-appointment phone texts), self-management support (patient report card, post-clinic follow-up phone texts, waiting room educational video) and clinical information systems (patient report card as part of medical chart, hospital registry) vs. standardized usual care (risk factor identification and control) and phone contact information	12	Blood pressure: No difference for all patients after stroke: SBP: 136.5±22.3 vs. 136.2±21.2 mmHg patients with uncontrolled hypertension: SBP: 145.1±22.6 vs. 148.5±22.8 mmHg
Sarfo 2019 (NCT02568137) cluster-RCT	Ghana (urban)	60#	55 ± 13/ 35 %	stroke and uncontrolled hypertension; 143.8 ± 26.7 90.5 ± 15.7	Nurse-led, multilevel approach with m-Health technology for monitoring and reporting BP measurement and tailored motivational text messages vs. usual care	9	adherence: modified MMA score: no difference: 13±1.5 vs. 13±1.7 Blood pressure: BP control: no difference: 47 vs. 40 %; OR_a: 1.24 (0.83; 1.84) SBP<140 mmHg: better in IG: 73 vs. 43 % DBP<90 mmHg: better in CG: 47 vs. 77 %
Saunders 1991 RCT	South Africa (urban)	224	65 % between 40-50 / 73 %	mild to moderate; n.r. 116.6	Reminder letters and home visits by fieldworkers and patient-retained records for self-monitoring of medication compliance and BP control vs. usual care (appointment system and health education)	6	adherence (treatment received) over 6 months: higher for newly treated (135.5±48.9 vs. 95.0±60.0 days) and infrequent

		Participants			Intervention (IG) vs. Control (CG)		Results on adherence and blood pressure
Name (design)	**Country**	**n**	**Age (years) / Females**	**hypertension; SBP /DBP (mmHg)**	**Description**	**Follow-up (months)**	IG vs. CG; treatment effect (95 %-CI)
							attenders (168.4±16.4 vs.116.7±56.9 days) of 180 days >80 % of treatment: better for newly treated (59 vs. 29 %; p< 0.001) and infrequent attenders (87 vs. 42 %; p< 0.001) blood pressure: DBP: lower for newly treated patients (93.4 vs. 100.5 mmHg; MD: 7.1 mmHg (0.5-13.7), no difference for infrequent attenders: 97.5 vs. 94.7 mmHg; MD: -2.8 mmHg (-6.9; 1.3)
Stewart 2005 RCT	South Africa (urban)	83	late middle aged/ n.r.	all hypertensives; 146.4±18.5 93.5±11.1	telephonic intervention (educational and home-based exercise program + support of a healthcare practitioner and a family member) vs. control group (educational and home-based exercise program only)	6	adherence: better with IG: 62.8 ±34.5% vs. 39.3± 42.8 %; p=0.007 blood pressure: no difference: SBP: 142±16 vs. 144±20 mmHg; MD: -2 mmHg (-10.3 - 6.3) DBP: 92±12 vs. 91±10 mmHg, change: MD: 1 mmHg (-4.0 - 6.0)
Vedanthan 2019 (NCT01844596) cluster-RCT	Kenya (rural)	1460	54.2±16.4/ 58 %	all hypertensives; 159.4±19.5 89.7 ±12	tailored behavioral communication (smartphone (IG2) or paper-based (IG1)) vs. usual care	12	adherence (Linkage to care): best results with IG2, worse with IG1: IG2 vs. CG: OR_a: 1.21 (0.70; 2.01) IG1 vs. CG: OR_a: 0.64 (0.43; 0.91) IG2 vs. IG1: OR_a: 1.95 (1.23; 3.01) blood pressure: no difference SBP: 149.4±20.8 vs. 150.2±21.6 vs. 150.0±22.9 mmHg, change: -13.1±20.5 vs. -8.4±24.0 vs. -9.7±25.1 mmHg

		Participants			Intervention (IG) vs. Control (CG)		Results on adherence and blood pressure
Name (design)	**Country**	**n**	**Age (years) / Females**	**hypertension; SBP /DBP (mmHg)**	**Description**	**Follow-up (months)**	IG vs. CG; treatment effect (95 %-CI)
							IG2 vs. CG: MD_a: -2.13 mmHg (-4.89;0.42) IG1 vs. CG: MD_a: -0.06 mmHg (-3.61; 3.20) IG2 vs. IG1: MD_a: -2.07 mmHg (-5.14;1.12) DBP: no difference: 91.3±12.7 vs. 91.0±14.1 vs. 90.1±13.7 mmHg, change: 1.5±12.7 vs. 0.4±15.2 vs. 0.1±14.7 mmHg BP control: no difference: IG2 vs. CG: OR_a: 0.95 (0.61; 1.38) IG1 vs. CG: OR_a: 0.97 (0.63; 1.42) IG2 vs. IG1: OR_a: 1.00 (0.69; 1.40)
Wahab 2017 RCT	Nigeria (urban)	35#	58.1 ±10.5/ 34 %	all patients with stroke; 138.3 ± 24.2 85.0 ±12.4	feasibility of a nurse-led Intervention (education and skill building, BP monitor with review, phone calls) vs. usual care	0.5	adherence: no difference, but improvement in both groups: MMA Score: 7.32±0.93 vs. 7.03±1.36 Blood pressure: no difference SBP: 137.5±23.0 vs.133.1±18.2 mmHG; MD: 4.40 mmHg (-9.4; 18.2) DBP: 84.1±9.7 vs. 84.2±13.1 mmHg; MD -0.1 mmHg (-7.7; 7.5)
Educational strategies for health-care professionals (5 RCTs)							
Fairall 2016 (ISRCTN20283604) cluster-RCT	South Africa (rural)	4393	52 (IQR 43-62)/ 73 %	mild to moderate 139±23.6[a] 90±13.2[a]	Education of nurses on NCD care (nurse training in educational outreach sessions with a primary care program to expand their role in NCD care, authorization to prescribe an expanded range of drugs on NCDs) vs. usual training	14	adherence: no difference Blood pressure: BP controlled: no difference: 33 vs. 32 %; RR 1.01 (0.2-1.8)

		Participants			Intervention (IG) vs. Control (CG)		Results on adherence and blood pressure
Name (design)	**Country**	**n**	**Age (years) / Females**	**hypertension; SBP /DBP (mmHg)**	**Description**	**Follow-up (months)**	IG vs. CG; treatment effect (95 %-CI)
Goudge 2018 (ISRCTN12128227) cluster-RCT	South Africa (rural)	4722	56.6±19.4 / 56 %	hypertension: 46.6 %, of them: 53.4%, on treatment and controlled: 8.6%, on treatment and uncontrolled: 9 %, not on treatment 29 %	Support of nurses by health workers (e.g. assistance with booking appointments, retrieve and fill patient files, health education, measurements in the vital signs queue, prepacking of medications, reminders to appointment for patients) to provide chronic disease care vs. usual care	18	No hypertension: 50.9% vs. 52.9% adherence and blood pressure: no difference on treatment and controlled: 11.3 vs. 11.2 % on treatment and uncontrolled 13.0 vs. 13.2 % not on treatment 24.9% vs. 22.7% undiagnosed: 24.1 vs. 22.2 % taking medication: 24.3 vs. 24.4 %
Gyamfi 2017 (NCT01802372) cluster-RCT	Ghana (mixed)	757	58.0±12.4 / 60 %	mild to moderate 155.9 ± 12.1 / 89.6 ± 10.8	Training of nurses in task shifting for hypertension control + health insurance coverage vs. health coverage	12	blood pressure: improvement in both groups, but no difference between groups: SBP: 137.1±27.5 vs. 138.4±27.3 mmHg; change: -19.5±18.0 vs. -16.6±17.9 mmHg; MD: -2.9 mmHg (-6.9; 1.0) DBP: 79.8±22.9 vs.81.8±22.8 mmHg; change -9,3±11.5 vs. 8.7±18.7 mmHg; MD -0.6 mmHg (-2.9; 1.7) BP control: 55.2 vs. 49.9 % (MD 5.2 % (-1.8; 12.4)
Mendis 2010 cluster-RCT	Nigeria (mixed)	1188	55 ± 4.7 / 58 %	mild to moderate 153.2±12.4 94 ± 9.7	Education of health-care workers and patients with a simple cardiovascular risk management package vs. usual care	12	adherence: higher with IG Attended visits: 90.1 vs. 74.5 % quit smoking: 100 vs. 74.4 % (p=0.023) Increased fruit consumption: 93.4 vs. 18.8 % (p< 0.0001)

		Participants			Intervention (IG) vs. Control (CG)		Results on adherence and blood pressure
Name (design)	**Country**	**n**	**Age (years) / Females**	**hypertension; SBP /DBP (mmHg)**	**Description**	**Follow-up (months)**	IG vs. CG; treatment effect (95 %-CI)
							increased vegetable consumption: 14.2 vs. 7.0 % (p=0.0002) blood pressure: higher decrease in IG SBP: -11.0±15.4 vs. -6.6±20.6 mmHg; MD -4.4 mmHg (-6.7; -2.1) DBP: -5.4±10.0 vs. -2.0±13.2 mmHg; MD -3.4 mmHg (-4.9; -1.9)
Steyn 2013 (PACTR2013 03000493351) cluster-RCT	South Africa (urban)	920	60.3±11.1 / 79 %	all hypertensives1 51.2 ±26.7 / 87.1 ± 12.4	multi-faced intervention to implement national guidelines (structured record of national guidelines and visits to train clinicians) vs. usual care (passive dissemination) at primary care level	12	Blood pressure: no difference SBP: 161±28.9 vs. 158.2±29.5 mmHg; MD 2.8 mmHg (-1.2; 6.8) DBP: 88.1±13 vs. 87.1±12.6 mmHg; MD 1.00 mmHg (-0.73; 2.73) controlled BP: 23.1 vs. 26 %
Individualized treatment (3 RCTs)							
Akintunde 2017 (ISRCTN69440037) RCT {Akintunde, 2017 #4980} (ISRCTN69440037)	Nigeria, Kenya, South Africa (urban)	105	56.6±14.3 / 53 %	uncontrolled 170.9 ± 19.2 / 85.6 ± 21.8	physiologically individualized care (guided by their physiological phenotype, based on plasma renin and aldosterone) vs. usual care	12	blood pressure: lower in IG SBP: 139.4±17.4 vs. 152.6±12.3 mmHg; MD -13.2 mmHg (-19.4; -7.0) DBP: 84.0±11.0 vs. 89.6±7.0 mmHg; MD -5.6 mmHg (-9.4; -1.8) BP control: 50.0 vs. 11.1 % (p=0.0001)
Okeahialam 2011 RCT	Nigeria (urban)	181	49.7±14.2 / 61 %	mild to moderate 150.3 ± 14.8 / 93.7 ± 9.6	chronotherapy: drug intake in the night (10 pm) vs. drug intake in the morning (10 am)	3	blood pressure: higher decrease in IG SBP: . -18.1±17.9 vs.-14.1±14.7 mmHg; MD -4.0 mmHg (-9.0;1.0) DBP-15.6±12.2 vs.-8.7±10.2 mmHg; MD -6.9 mmHg (-10.4; -3.4)
Physical activity (4 RCTs)							

		Participants			Intervention (IG) vs. Control (CG)		Results on adherence and blood pressure
Name (design)	**Country**	**n**	**Age (years) / Females**	**hypertension; SBP /DBP (mmHg)**	**Description**	**Follow-up (months)**	IG vs. CG; treatment effect (95 %-CI)
Aweto 2012 RCT	Nigeria (urban)	50	45±12.3 / 58 %	mild to moderate 138.7±10.9 / 79.9±9.3	dance movement therapy (50 minutes) vs. educational sessions, both 2x/week over 4 wks	1	blood pressure: lower in IG SBP: 119.9±8.3 vs. 135.5±11.6 mmHg; MD -15.6 mmHg (-22.4; -8.8) DBP: 70.9±7.2 vs. 74.1±7.7 mmHg; MD -3.2 mmHg (-8.1; 1.7)
Lamina 2010 RCT	Nigeria (urban)	485	58.5 ±6.8 / 0 %	mild to moderate, stable 165.4±13.2 / 98.1 ± 4.6	training programs on bicycle ergometer, 3x/wk, 45-60 minutes: Interval training (IG2) vs. continuous training (IG1) vs. usual care over 8 wks	2	blood pressure: lower in IG SBP: 150.4±16.7 vs. 154.4±12.6 vs.163.5±14.9 mmHg; MD -11.1 mmHg (-14.8: -7.4) DBP: 95±5 vs. 94.4±8.8 vs. 96.1±2.7 mmHg; MD -1.4 mmHg (-2.6; -0.2)
Maruf 2016 (ISRCTN81952488) RCT	Nigeria (urban)	120	52.8±8.4 (range 38-65) / 71 %	mild to moderate, 155.7±11.4 / 93±10	aerobic dance training (3x/wk, 45 minutes) vs. usual care over 12 wks	3	blood pressure: lower in IG SBP: 135.3±5.6 vs. 142.4±4.7 mmHg; MD: -7.1 mmHg (-9.3; -4.9) DBP: 82.2±3.4 vs. 83.9±2.8 mmHg; MD: -1.7 mmHg (-3.0; -0.4)
Turky 2013 RCT	Egypt (urban)	30	52.8±2.4, 40-50 / 100 %	postmeno-pausal hypertensives 151±6.2 / 94.5±4.2	moderate aerobic exercise training (40 minutes, 3x/wk) by walking on a treadmill vs. usual care over 8 wks	2	blood pressure: lower in IG SBP: 124±5.6 vs. 145±6.7 mmHg; MD: -21.0 mmHg (-25.8; -16.2) DBP: 85±5.4 vs. 95±3.7 mmHg; MD: -10.0 mmHg (-13.7; -6.3)
Modified nutrition (1 RCT)							
Charlton 2008 RCT	South Africa (urban)	92	61.1±7/ 84 %	mild to moderate 134.6±15.7 / 81.1±8.1	food-based dietary strategy (modified food, salt replacement, + 500 ml of maas (fermented milk) vs. control (same quantities of the targeted foods	2	blood pressure: lower in IG SBP: 132.5±15.8 vs. 127.5±15.8 mmHg; MD_a:-6.2 mmHg (-11.4; -0.9)

		Participants			Intervention (IG) vs. Control (CG)		Results on adherence and blood pressure
Name (design)	**Country**	**n**	**Age (years) / Females**	**hypertension; SBP /DBP (mmHg)**	**Description**	**Follow-up (months)**	IG vs. CG; treatment effect (95 %-CI)
					of standard commercial composition, 500 ml/d artificially sweetened cooldrink)		DBP: 82.2±9.5 vs. 79.2±11.4 mmHg; MD_a: -0.6 mmHg (-3.0; 1.8)

tertiary prevention
BMI: body mass index; BP: blood pressure; CG: Control group; DBP: diastolic blood pressureIG: Intervention group; MD: mean difference; MD_a: adjusted mean difference; n: number of randomized participants; MMA: Morisky medication adherence; NCD: non-communicable disease; n.r. not reported; ; OR_a: adjusted odds ratio; RCT: randomized controlled trial; RR: relative risk; SBP: systolic blood pressure; wk: week

Table 2: Risk of bias assessment

Study	Sequence generation	Allocation concealment	Blinding of		Incomplete outcome data	Selective reporting	Other sources
			personnel / participants	outcome assessors			
Educational strategies							
Adeyemo 2013	😐	😐	☹	😐	☹	😐	☹
Ayodapo 2019	😐	☺	☹	☹	☺	😐	😐
Bobrow 2016	☺	☺	☹	😐	☹	☺	☺
Bolarinwa 2019	☺	☺	☹	☹	☹	☹	☹
Fairall 2016	☺	☺	☹	😐	☺	☺	☺
Goudge 2018	☺	☺	☹	☺	☹	☺	☺
Gyamfi 2017	☺	☺	☹	😐	☹	☹	☺
Labhardt 2011	☺	☺	☹	☹	☹	☹	☺
Mendis 2010	☹	☹	☹	☹	☹	😐	☺
Owolabi 2019	☺	😐	☹	☺	☺	☹	☺
Sarfo 2019	☺	☺	☹	☺	☺	☺	☺
Saunders 1991	😐	😐	☹	☹	☺	😐	☺
Stewart 2005	😐	😐	☹	☹	☹	😐	☺
Steyn 2013	☺	☺	☹	☹	☺	☺	☺
Vedanthan 2019	😐	☺	☹	☹	☹	☺	☹
Wahab 2017	☺	☺	☹	☹	☺	😐	☹
Standardized treatment							
Akintunde 2017	☹	😐	😐	😐	☹	☺	☹
Okeahialam 2011	☺	☺	☹	😐	☹	😐	☹
Physical activity							

Study	Sequence generation	Allocation concealment	Blinding of		Incomplete outcome data	Selective reporting	Other sources
			personnel / participants	outcome assessors			
Aweto 2012	😐	😐	☹	☹	☹	😐	☹
Lamina 2010	☹	😐	😐	☺	☹	😐	☺
Maruf 2016	☺	☺	😐	☺	☺	☹	☹
Turky 2013	☺	☺	☹	☹	☹	😐	☹
Modified nutrition							
Charlton 2008	😐	😐	☺	☺	☺	😐	☺
☺: low; 😐: unclear; ☹: high risk of bias							

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Non-pharmacological interventions to achieve blood pressure control in African patients: a systematic review

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Non-pharmacological interventions to achieve blood pressure control in African patients: a systematic review

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Abstract

Objectives: This systematic review aims to evaluate the evidence of non-pharmacological strategies to improve blood pressure (BP) control in hypertensive patients from African countries.

Design: We performed a systematic review and searched Medline, Central, CINAHL, and study registers until June 2020 for randomized studies on interventions to decrease BP of patients with hypertension in African countries. We assessed the study quality using the Cochrane risk of bias tool and narratively synthesized studies on non-pharmacological hypertension interventions.

Setting: We included studies conducted in African countries.

Participants: Adult African patients with a hypertension diagnosis.

Interventions: Studies on non-pharmacological interventions aiming to improve BP control and treatment adherence.

Outcomes: Main outcomes were BP and treatment adherence.

Results: We identified 5564 references, included 23 with altogether 18,153 participants from six African countries. The studies investigated educational strategies to improve adherence (11 studies) and treatment by health care professionals (5 studies), individualized treatment strategies (2 studies), strategies on lifestyle including physical activity (4 studies) and modified nutrition (1 study). Nearly all studies on educational strategies stated improved adherence, but only three studies showed a clinically relevant improvement of BP control. All studies on individualized strategies and lifestyle changes resulted in clinically relevant effects on BP. Due to the type of interventions studied, risk of bias in domain blinding of staff/ participants was frequent (83%). Though incomplete outcome data in 61% of the studies is critical, the general study quality was reasonable.

Conclusions: The identified studies offer diverse low-cost interventions including educative and task shifting strategies, individualized treatment, and lifestyle modifications to improve BP control. Especially trialed physical activity interventions show clinically relevant BP changes. All strategies were trialed in African countries and may be used for recommendations in evidence-based guidelines on hypertension in African settings.

Review registration: A protocol was registered on PROSPERO (CRD42018075062).

Strength and limitations of this study

- This systematic review summarizes evidence on a wide range of different non-pharmacological interventions, adding a comprehensive overview to the literature that can support physicians and health care policy makers in the African setting.

- Most of the included studies were conducted in urban areas of few Western and Southern African countries leading to a lack of generalizability to other African regions and showing a need of future research in rural areas.

- A main limitation of this systematic review occurs through deviations from the protocol. Due to the amount of search results for the initially planned more general scope on cardiovascular diseases we decided to focus on hypertension.

- Nevertheless, this review was limited to studies with the highest level of evidence to investigate the benefits and harms of non-pharmacological interventions on blood pressure control in African patients with hypertension.

- This review adds to the scope of a recently published a systematic review on the efficacy of common pharmacological treatment for hypertensive patients in Sub-Saharan Africa.

Keywords:

systematic review, Africa, hypertension, raised blood pressure, non-pharmacological interventions, randomized controlled trials

Background

Hypertension is a major public health problem and affects the lives of about 1.13 billion people (1). The highest blood pressure levels shifted from high to low-income countries in South Asia and Sub-Saharan Africa (SSA) (2) with a prevalence of 57 % in older adults in African countries (3, 4). The estimated number of adults with raised blood pressure in SSA rose from 30 million in 1975 to over 100 million in 2016 due to population growth, aging, and westernization of lifestyle (2). Hypertension is a leading risk factor of cardiovascular disease, chronic kidney disease, and diabetes (1). Studies show that black people suffer from more severe forms of hypertension associated with more frequent treatment failure and more severe and earlier target organ damage, all resulting in higher morbidity and mortality (5, 6). Hypertension is a major contributor to devastating health events like stroke or heart failure (7-9), which can be catastrophic to both individuals and healthcare systems in which resources are scarce.

Tackling and reducing the burden of premature mortality due to non-communicable diseases (NCDs) through prevention and treatment has been a designated goal within the UN 2030 Agenda (10). The Pan-African Society of Cardiology developed an algorithm including recommendations on screening, diagnosis, and treatment to achieve 25 % hypertension control in Africa by 2025 with a treatment target value of less than 140/90 mmHg. Screening programs are proposed to be carried out in health care facilities as well as public places like markets and churches. The treatment starts with lifestyle modifications, is intensified through a monotherapy and a subsequent combination of two or three medications in higher stages and resistant forms of hypertension. In some cases, the assessment of secondary causes by specialists is recommended (9).

However, the awareness of hypertension remains relatively low in many parts of Africa, hindering adequate screening, treatment, and control to lower the long-term risks (11-13). Extensive counseling and education of patients and health-care providers on the importance of adherence to medications and lifestyle modifications is necessary in order to improve hypertension control (14, 15). Especially patients with multiple medications benefit from the support of their health care providers to understand the treatment's purpose (16).

Evidence is needed detailing regional differences in hypertension incidences, risk factors, and, as subject of this review, treatment strategies in different, transitioning populations on the African continent. Seeley et al. recently published a systematic review on the efficacy of common pharmacological treatment for hypertensive patients in SSA (17). These interventions do not include treatment strategies like lifestyle modifications (e.g., nutritional modifications, physical activity) or educational strategies, which can be summarized as non-pharmacological interventions (18). The main

aim of this systematic review is to summarize the best available evidence on the effectiveness of non-pharmacological strategies on blood pressure control in African patients with hypertension.

Main Text

Methods

A protocol of this systematic review was prospectively registered on PROSPERO (CRD42018075062) following the PRISMA guideline (19) (see Checklist S1). We initially planned to include randomized controlled trials (RCTs) on all cardiovascular diseases (CVDs). Due to the high number and heterogeneity of eligible studies, we decided to focus this review on patients with hypertension as one of the main risk factors for other CVDs. We aim to describe all non-pharmacological hypertension interventions in detail in order to broaden the scope of the existing evidence.

Patient and public involvement

The conception of this systematic review was discussed in detail with members and students at the Addis Ababa School of Public Health in order to consider the priorities in the African context. Consensus was to gather evidence on hypertension treatment as a measure of tackling the burden of non-communicable diseases which is part of the UN 2030 Agenda (10). No patients were involved.

Inclusion and exclusion criteria

We included full-text publications on RCTs (20) including cross-over RCTs and cluster RCTs on non-pharmacological interventions with adult hypertensive patients in African countries and reported results on BP. The study aims were improvement of prevention, diagnoses, and treatment of hypertension in African countries. Studies on primary prevention were excluded due to the high variety of possible participants and interventions. International multi-center studies were included if more than 50 % of centers were set in African countries. For detailed inclusion criteria see Table 1.

>>>> Table 1

Literature search and study selection

Two electronic databases (Medline Ovid, Central) and registers of ongoing and completed studies (International Clinical Trials Registry Platform) were searched to identify all relevant studies (see Additional file 1). We added a search in CINAHL to cover nursing interventions. The main keywords of the search strategy included hypertension, high blood pressure, blood pressure control, Africa, a list

of all African countries, and randomized controlled trials. The first searches in 2017 included all CVDs, while updated strategies were limited to hypertension. The last search was conducted in June 2020. All searches were done without time frame constrictions. The study selection process was described in a flow chart according to the PRISMA statement (19). We exported articles retrieved from the literature search into a reference manager software (EndNote (21)). Duplicate references were identified in case of congruence of authors, title, year, and journal and deleted.

Titles, abstracts, and full texts of potentially eligible articles were independently screened by three authors (MC, ESK and SU). Disagreements were resolved through consensus.

Interventions

This systematic review compares non-pharmacological interventions to improve adequate diagnoses, prevention, and treatment of patients with hypertension with standard care, no intervention or another, less intensive or frequent intervention (Table 1). Non-pharmacological interventions are considered non-medication treatment strategies such as educational programs for patients or health professionals, individualized treatment, physical activity or nutrition modification strategies (18).

Outcomes

The main goal of non-pharmacological interventions for patients with hypertension is to improve blood-pressure control through the implementation of recommended lifestyle changes, attendance to follow-up visits, and interventions promoting adherence to take hypertensive medications. We therefore report results on blood pressure and adherence (Table 1).

Data extraction and management

One author (MC or SU) extracted and a second author (SU or ESK) checked all information on study design and setting, participants, interventions, and main results by using an assessment form in Excel. The form was especially designed for this systematic review and piloted for the first five studies.

We extracted information on the publication (study name consisting of the name of first author and year of the first publication of final results, registration, and additional publications), study characteristics (design, country and region in which the study was conducted, duration, pre-planned outcomes), participants (with inclusion/exclusion criteria, randomized sample size, prevention level, grade of hypertension, mean age, baseline blood pressure), a short description of the intervention and control groups, and the main results on blood pressure and adherence within the longest follow-up periods. The grade of hypertension was described as mild (grade 1, 140-159/90-99 mmHg),

moderate (grade 2, 160-179/100-109 mmHg) or severe (grade 3, ≥ 180/≥ 110 mmHg) (15). If BP was reported in standing and supine position, we extracted results for supine position.

All effect sizes were reported with their corresponding confidence intervals (CI). They were calculated either on the basis of mean and standard deviation for metric outcomes or by comparing the frequencies of better adherence or BP control. Positive mean differences (MDs) describe a positive treatment effect on BP with lower mean values or higher decrease in the intervention group. Relative risks (RR), hazard ratios (HR) and odds ratios (OR) compare the frequency of good adherence or BP control. Effect measures greater than 1 describe a better adherence or BP control in the intervention group.

Quality assessment and risk of bias

Risk of bias was evaluated for all studies based on the Cochrane risk of bias tool (22). Two investigators (MC or ESK and SU) independently assessed the risk of bias in seven domains (sequence generation, allocation concealment, blinding of personal and participants, blinding of outcome assessors, incomplete outcome data, selective outcome reporting, and other sources of bias). Risk of bias due to selective outcome reporting was judged as low, when the study protocol was available and results on all pre-planned outcomes were reported. Incomplete outcome data was judged as high, when more than 10 % of randomized participants dropped out. Other sources of bias were reported to be high in cases of missing sample size calculation, no definition of the primary endpoint, or no reporting of baseline values.

Data synthesis

The main aim of this review is a narrative synthesis of studies with their participants, different types of interventions, and resulting outcomes. We added a figure visualizing the effect sizes on BP of different types of interventions in forest plots using RevMan (23). Due to the high clinical heterogeneity between included studies with their different settings, interventions, control groups, and lengths of follow-up, we did not pool any results.

Treatment effects were described as statistically significant or clinically relevant. Statistically significant results on BP with MD over 5 mmHg were defined as clinically relevant.

Results

We identified a total of 5564 references from electronic databases and 18 references from the International Clinical Trials registry platform. 340 articles were potentially eligible and full texts were assessed for the inclusion and exclusion criteria. Of those, 298 articles were excluded including 13 articles on studies to treat heart failure, 7 articles on coronary heart diseases, and 76 articles on pharmacotherapy for hypertension (see list of excluded studies in the supplemental material). Twenty-three studies (reported in 42 articles) (24-66) on non-pharmacological strategies to treat patients with hypertension matched the inclusion criteria and were included in this systematic review (Figure 1 and list of included studies in the supplemental material). The characteristics and main results of these studies were summarized in Table 2.

>>>>> Figure 1

Study characteristics

We identified 15 studies with two or more independent parallel groups and individual randomization of patients and eight cluster-RCTs with randomization of different observation units, such as independent villages, health-care facilities, or different geographical regions (Table 2). Most of the included studies were conducted in Nigeria (11 studies) and South Africa (8 studies), others in Ghana, Kenya, Cameroon and Egypt. One of the studies (Akintunde 2017) (25) recruited patients in three countries (South Africa, Nigeria and Kenya). Nine studies (39 %) were at least partly conducted in rurally located health-care facilities (Figure 2) (24, 27, 32, 34, 35, 36, 52, 56, 64). The included studies were published between 1991 and 2019. Only three of the studies, all conducted South Africa, were published before 2010 (31, 60, 61).

>>>>> Figure 2

Participants

The total sample size ranged from 30 to 4722 participants with a total number of 18,153 participants (Table 2). Eighteen studies (78 %) randomized more than 100 participants. The mean age was between 45 and 63 years. Most studies (n=19) included more females. Two studies to enhance physical activity included women (Turky 2013) (63) or men (Lamina 2010) (37) only. Mean systolic blood pressure (SBP) at baseline was between 128 and 175 mmHg, mean diastolic blood pressure (DBP) between 76 and

117 mmHg. Most studies included patients in secondary prevention with mild to moderate hypertension. Three studies (56, 58, 66) included hypertensive patients post stroke.

Intervention

Studies investigated educational strategies to improve adherence of patients and treatment by health care professionals (16 studies), to individualize treatment (2 studies), and to change lifestyle via enhanced physical activity (4 studies) or modified nutrition (1 study) (Table 2).

>>>> Table 2

Educational strategies to improve adherence

Sixteen studies (17,090 participants), with follow-up periods from two weeks in a short-term feasibility study (Wahab 2017) (66) up to 18 months (Goudge 2018) (34), were published between 1991 and 2019.

The main aim of eleven studies was the improvement of patients' knowledge on hypertension and adherence to self-monitoring of BP, recommendations on medication, lifestyle changes, and regular attendance at health-care facilities (24, 27-29, 36, 56, 58, 60, 61, 64, 66). Five studies investigated strategies to improve adequate treatment of hypertensive patients by clinicians, nurses, and health-care workers (32, 34, 35, 52, 62).

Eight studies (27, 28, 36, 56, 58, 60, 61, 64) investigated the efficacy of adherence-promotion via counselling and phone or letter-based interventions. Seven studies (24, 29, 32, 34, 35, 52, 66) investigated the efficacy of interventions on the basis of training measures with subsequent task-shifting to nurses or health workers for home visits and patient education. One study (Steyn 2013) (62) tested a multi-faced intervention to implement national South-African guidelines into primary care of patients with hypertension or diabetes. Another two studies investigated the efficacy of financial incentives as an additional health insurance coverage (Gyamfi 2017) (35) or free treatment (Labhardt 2011) (36), respectively.

Nearly all studies stated improved medication adherence (24, 28, 29, 36, 60, 61), implementation of lifestyle recommendations (Ayodapo 2019, Mendis 2010) (27, 52), linkage to care (36, 52, 64), or knowledge and practical skills of healthcare professionals (Fairall 2016, Gyamfi 2017) (32, 35). In only three studies (27-29), these improvements resulted in modest benefits on BP (Table 2 and Figure 3A to 3C). In the study by Ayodapo 2019 (27), counseling had a positive impact on lifestyle behavior and resulted in a clinically relevant decrease of mean arterial BP (-9.8 mmHg; 95 %CI -11.5 to -8.1). (Bobrow 2016) (28) assessed the effect of automated treatment adherence support delivered via mobile phone

short messages. Bolarinwa 2019 (29) trialed home-based follow-up care with education and counseling of patients and modifications of environmental characteristics. Both studies achieved a 12 % higher BP control with SBP<140 mmHg and DBP< 90 mmHg in participants of the intervention compared to the control groups (RR: 1.12; 95 % CI 1.01 to 1.23 and 1.12; 95 % CI 1.00 to 1.25) (Figure 3).

>>>>> Figure 3

Individualized treatment strategies

Two studies (286 participants) with follow-up periods of 3 and 12 months were published in 2011 and 2017 (Akintunde 2017, Okeahialam 2011) (25, 55). Both investigated strategies on the efficacy of an individualized therapy. Therapy individualization based on the patients' renin/aldosterone profile (Akintunde 2017) (25) resulted in more appropriate prescriptions and a relevant decrease of SBP (MD: -13.2 mmHg; 95 % CI -19.4 to -7.0) and DBP (MD: -5.6; 95 % CI -9.4 to -1.8) in patients with uncontrolled hypertension. The second study (Okeahialam 2011) (55) showed a higher reduction of DBP in patients using their anti-hypertensives at night compared to a morning intake (MD: -6.9 mmHg; 95 % CI -10.4 to -3.4) but stated no change in SBP (Table 2).

Strategies with physical activity

Four studies (26, 37, 51, 63) (685 participants), published between 2010 and 2016, investigated the BP-lowering effect of different aerobic training strategies over 4 to 12 weeks. Enhanced physical activities were performed two or three times a week and included dance training (Aweto 2012, Maruf 2016) (26, 51) and exercise training on an ergometer (Lamina 2010) (37) or treadmill (Turky 2013) (63). All studies stated a clinically relevant benefit with mean reductions of SBP between 21 and 7.1 mmHg and DBP between 10 and 1.4 mmHg (Figure 4). The highest BP decrease was achieved in a study on the effect of moderate aerobic exercise training by walking on a treadmill in postmenopausal hypertensive women (Turky 2013) (63) (MD: -21 mmHg; 95 %-CI 25.8 to -16.2).

>>>>> Figure 4

Modified nutrition strategies

Charlton 2008 (31) tested a food-based dietary strategy (reduced salt consumption) in 92 mildly to moderately hypertensive patients from a low socio-economic background, stating a clinically relevant decrease in SBP after two months (MD: -6.2 mmHg; 95 % CI -11.4 to -0.9), but no effect on DBP (Table 2).

Potential biases

The greatest restriction of study quality was a high risk of bias in the blinding of staff and study participants in 19 studies. Especially educational strategies were not examined in double-blinded studies, however three of these studies (34, 56, 58) reported a quality assurance against detection bias with blinded measurement of blood pressure. Two studies on physical activity enhancement in comparison to usual care (Lamina 2010, Maruf 2016) (37, 51) were described as double-blinded without reporting further details. Only the study on modified nutrition (Charlton 2008) (31) adequately reported detailed methods to ensure blinding of participants and fieldworkers. Another frequent problem was incomplete outcome data in 14 studies with loss to follow-up over 10 % of randomized participants or per-protocol analyses. Selective reporting was checked in all 13 studies with a published protocol. Of those, five studies (29, 35, 36, 51, 56) did not report all pre-planned outcomes. Problems concerning randomization were identified in three studies with a non-random component in sequence generation or allocation concealment (25, 37, 52). Other sources of bias include missing sample-size calculations, reporting of intermediate results only, and relevant differences at baseline in nine studies (Table 3, Figure 5) (24, 25, 26, 29, 51, 55, 63, 64, 66).

>>>>> Table 3

>>>>> Figure 5

Discussion

This systematic review describes interventions and treatment effects of 23 studies with a total of 18,153 participants with hypertension from six African countries. Most of the studies investigated successful low-cost concepts to improve BP control through improved adherence to medical treatment and lifestyle changes.

While lower- and middle-income countries' CVD-mortality remained unchanged over the last decades, high-income countries have reduced the CVD-mortality by more than 50 % since 1990 (67), largely by using country-specific guidelines, evidence-based policy interventions to reduce risk-factor levels, strengthening the health system at the primary-care level, and improving acute care with attention to early initiation of treatment. However, policies to reduce population-wide risk factors of hypertension have not been widely adopted in low- and middle-income countries (68).

Pharmacotherapy with the well-established anti-hypertensive medications is the mainstay of hypertension management (15, 69). Nevertheless, treatment recommendations on adherence to medication and changed lifestyle habits are often only incompletely applied in practice (70-72). Patients are frequently unwilling to take drugs due to possible side effects. They may benefit from adequate knowledge as well as a higher motivation to take their prescribed medications and to implement sustainable lifestyle changes (73-75). Despite the frequent lack of acute symptoms, uncontrolled BP may result in severe long-term outcome and increased mortality. The risk increases in cases of inadequate treatment and low patient adherence as well as inconsistent follow-up on BP control (7). Therefore, all strategies with the aim to increase knowledge, awareness, and adherence are essential to lowering BP levels and improving the prognoses of patients (69, 76). Due to the short-term follow-up, no study reported long-term outcomes on mortality, and we interpreted available results on BP changes and treatment adherence.

Several strategies to improve health related behavior concerning hypertension with convincing results were examined. We identified eight studies that investigated the efficacy of phone or letter-based interventions (e.g., via short message service) to improve knowledge on hypertension, with adherence support or reminder letters for follow-up (27, 28, 36, 56, 58, 60, 61, 64). All these studies showed strong effects of the intervention concerning self-reported behavioral changes, but only two of these studies showed improved BP during follow-up (Ayodapo 2019, Bobrow 2016) (27, 28). Three studies (29, 35, 52) reported improved adherence and two of those a decreased BP level through nurse-led interventions (Bolarinwa 2019, Mendis 2010) (29, 52). These studies demonstrated the efficacy of task-shifting interventions in a low-resource setting. Furthermore, low-cost interventions suited to the environment, including financial incentives for adherent patients with minimal additional resources,

can significantly improve the adherence of patients (Labhardt 2011) (36) and thus potentially influence BP control.

Even though cost-effective interventions are globally available, there are major gaps in their implementation, particularly in limited resource settings (68). Two large multi-level studies that combined phone or letter-based interventions with task-shifting to nurses or health workers were not successful in achieving a relevant improvement in adherence and BP control (Fairall 2016, Goudge 2018) (32, 34). On the other hand, no harm was observed after the expansion of the nurses' roles (Fairall 2016) (32). Thus, the intervention might be a practical and acceptable tool to expand the scope of non-physician clinicians into primary care of patients with common NCDs. There is a generally good access to essential medications in four countries where the included studies have been conducted (South Africa, Egypt, Kenya and Ghana). The access is not as widespread in Cameroon and Nigeria (77). Nevertheless, one study conducted in rural parts of South Africa between 2014 to 2015 (goudge 2018) (34) reported insufficient or unavailable equipment and medication shortage. Moreover, increasing numbers of NCD patients require an adequate number of nursing personnel as well as health care facilities. Similar factors contributed to the poor results of the implementation of national guidelines in resource-scarce primary health care settings in South Africa (62), which did not show improved outcomes in hypertension and diabetes patients. In studies with follow-up-periods of less than one year, the time frame might have been too short to reach a clinically relevant BP control through improved knowledge and awareness, since lifestyle changes are oftentimes challenging and should be applied over a long time (24, 61, 66). Generally, the results of the systematic review are consistent with existing evidence on the importance of long-acting patient centered interventions. Unfortunately, these interventions do not reach all patients and often, a full benefit of medical treatment on clinically important outcomes cannot be achieved (78).

Most studies in this review included participants in secondary prevention with mild to moderate hypertension. In contrast, observational studies and conclusions from a systematic review on pharmacological treatment generally concerned participants with higher grades of hypertension (5, 7, 79). Interventions for patients with severe or uncontrolled hypertension and potentially target-organ damage are underrepresented. Interventions for high-risk patients are especially necessary due to the high frequency of late first diagnosis (7) and high prevalence of severe forms of hypertension at an early age in African patients (6). A multi-center study on patients with uncontrolled hypertension in clinics in Nigeria, Kenya, and South Africa stated the efficacy of an individualized therapy based on phenotyping with plasma renin and aldosterone to improve BP control (Akintunde 2017) (25). The researchers suggest testing this approach in African Americans and patients of any race with therapy-resistant hypertension. Three studies (56, 58, 66) investigated the implementation of multi-level approaches including educational, telephone-based, nurse-led, self-management supporting

interventions, as well as BP monitoring for stroke survivors. These studies were not successful in sufficiently improving BP control, possibly due to short follow-up periods.

Regarding the different grades of hypertension, low risk patients with grade 1 hypertension benefit from lifestyle modifications including regular physical activity, sodium restriction, weight reduction, smoking cessation, moderation of alcohol consumption, and other dietary changes. These are recommended as initial strategies to reduce BP levels in order to prevent or delay the use of pharmacotherapy (14, 15). Nevertheless, even for patients with higher grades of hypertension, lifestyle modifications remain important in addition to pharmacotherapy (14, 15, 69, 80). The clinically accepted relevant BP lowering effect of medium-to high-intensity physical activity as a single or additive treatment for hypertension (81) was demonstrated in four of the included studies (26, 37, 51, 63). Only one study from South Africa investigated the effect of a modified nutrition strategy (reduction of salt intake) and stated a clinically relevant effect on SBP (Charlton 2008) (31). To the authors' knowledge, no randomized study investigated the efficacy of other recommended lifestyle interventions, like smoking cessation or weight reduction, in hypertensive patients in an African country.

Strengths and Limitations of this Review

We were able to generate evidence on a wide range of different non-pharmacological interventions, adding a comprehensive overview to the literature that can support physicians and health care policy makers in the African setting.

A main limitation occurs through deviations from the protocol. We planned a comprehensive summary of all RCTs to prevent, diagnose, and treat patients with cardiovascular diseases in African countries. Due to a high number of eligible studies in the first systematic search, we decided to focus on published studies on hypertension. We therefore had to change the pre-planned outcomes and instead focus on BP and additionally describe results on medication adherence and lifestyle changes. The pre-planned outcomes mortality, NYHA, and hospital admission were dropped. Due to the recently published systematic review by Seeley et al. (17), this publication describes non-pharmacological strategies. The complete results, including pharmacological interventions, were summarized in a doctoral thesis paper (82).

Nevertheless, this review was limited to studies with the highest level of evidence to investigate the benefits and harms of non-pharmacological interventions for hypertension. The randomized allocation ensures the comparability of participants across intervention groups. However, the unfeasibility of double-blinding might restrict the internal validity of results.

The external validity might be limited by our restriction to studies published in the English language and the disproportionally high number of studies conducted in urban areas in some Western and Southern African countries. According to the United Nations, there are currently 54 African countries. RCTs have been conducted in only six of those countries. Inhabitants of these countries (approximately 480 million) represent only a fraction of the African population of about 1.34 billion (83). Especially Central and Northern Africa were underrepresented. There are high levels of diversity within and between African populations. Subpopulations with genetic variants are living in geographically distant areas with specific local lifestyle or environmental conditions, which may be associated with a susceptibility to specific NCDs (84). Therefore, it is uncertain whether our results can be extrapolated to patients living in other areas than those studied. A significant amount of the African population lives in rural areas while the majority of studies was conducted in urban settings. However, it is crucial to make health service available as close as possible to the population in order to achieve the most comprehensive care. Thus, research on non-pharmacological interventions such as educational strategies to improve adherence and lifestyle modification should be expanded across all parts of Africa. Research must be conducted especially in rural areas to ensure a higher generalizability, quality of services, and resulting improvement of the African peoples' health.

Conclusion

This systematic review shows that even though hypertension is a critical health problem, there are still few randomized studies on non-pharmacological treatment of hypertension conducted on the African continent. Available studies do not represent all Africans since they were conducted in only six countries, many in urban settings only. It is advisable to plan and implement studies on patients with hypertension and health-care professionals in rural areas as well as Northern and Central African countries.

An improvement in the prognosis of patients with high BP in Africa requires the implementation of practical and effective solutions to diagnose, treat and control hypertension in specific settings (9). The identified studies describe diverse approaches tested in African countries that may be used to generate local African evidence-based guidelines on hypertension treatment. Especially trialed physical activity interventions and individualized treatment strategies show clinically relevant BP changes. Educational strategies for patients and medical personnel show mixed results and offer a comprehensive insight into trialed approaches as well as a basis for future research opportunities. This review summarizes miscellaneous low-cost interventions including task shifting, education, individualized treatment and lifestyle modifications to improve BP control.

List of abbreviations

BP	Blood pressure
CI	Confidence interval
CVD	Cardiovascular disease
DBP	Diastolic blood pressure
HR	Hazard ratio
MD	Mean difference
NCD	Non-communicable disease
OR	Odds ratio
RCT	Randomized controlled trial
RR	Relative Risk
SBP	Systolic blood pressure
SSA	Sub-Saharan Africa

Declarations

Ethics approval and consent to participate

No ethics approval and consent to participate was necessary.

Consent for publication

Not applicable.

Availability of data and materials

Please find the search strategy and a list of included studies in the supplementary material.

Competing interests

The authors declare that they have no competing interests.

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Author contributions

MC
Involved in all steps to plan this systematic review including the protocol; wrote the draft of this manuscript; screening of titles, abstracts, and full texts, data extraction, quality assessment.

ESK
Wrote the draft of this manuscript; screening of titles, abstracts and full texts, data extraction, quality assessment of the last update; submission of the manuscript.

TD
Involved in all steps to plan this systematic review including the protocol; provided expertise and discussed the results in the African context, commented on the manuscript.

TF
Provided expertise on primary care aspects of hypertension treatment, discussed the results, commented on the manuscript.

SG
Provided expertise on CVD epidemiology and public health, discussed the results in the African context, commented on the manuscript.

EJK
Involved in all steps to plan this systematic review including the protocol; provided expertise on the needs of evidence in the African context, commented on the manuscript.

EN
Provided expertise on public health and African guideline work, discussed the results in the African context, commented on the manuscript, provided expertise and discussed the reviewer comments and supported the draft of the revised manuscript.

SU
Involved in all steps to plan this systematic review including the protocol; wrote the draft of this manuscript, systematic search, screening of titles, abstracts and full texts, data extraction, quality assessment, submission of the manuscript

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Table 1: Inclusion and exclusion criteria

Design	RCTs conducted in African countries, in international studies with at least 50 % African countries
Population	African adult patients in secondary and tertiary prevention, diagnosis and treatment of hypertension Exclusion of patients with gestational diabetes, Pre-eclampsia or eclampsia
Intervention	All non-pharmacological strategies to improve adequate diagnoses, prevention and treatment of hypertension
Control	- No intervention - Standard care - Another intervention
Outcome	blood pressure (SBP, DBP, MAP) and adherence to recommendations (medications and lifestyle changes) within longest follow-up
Publication	Full-text publications according to CONSORT in English or German
CONSORT: Consolidated Standards of Reporting Trials; DBP: Diastolic blood pressure; MAP: Mean arterial pressure; SBP: Systolic blood pressure, RCT: Randomized controlled trial	

Table 1: Study characteristics

		Participants			Intervention (IG) vs. Control (CG)		Results on adherence and blood pressure
Name (design)	**Country**	**n**	**Age (years) / Females**	**hypertension; SBP /DBP (mmHg)**	**Description**	**Follow-up (months)**	IG vs. CG; treatment effect (95 %-CI)
Educational strategies for patients (11 RCTs)							
Adeyemo 2013 (24) RCT	Nigeria (mixed)	668	62.7±10.0 / 66 %	mild to moderate 167.4±19.2 / 91.8 ±12.3	home visits by nurses and clinic management (community based, nurse-led treatment program with physician backup; facilitation of clinic visits and health education; use of diuretics and a beta blocker as needed) vs. clinic management	6	excellent adherence (missed ≤2 pills per month): worse in IG: 72.5% vs. 79.0%; OR_a 0.524 (0.30; 0.75) BP control: no difference 65.0 vs. 66.3%; RR 0.98 (0.87;1.11)
Ayodapo 2019 (27) RCT	Nigeria (mixed)	322	60.9±10.0 / 51 %	MAP: 106.4±8.3	Counselling on lifestyle behaviors (physical activity, fruit and vegetable consumption, alcohol consumption, smoking) over 30-45 minutes, reminders (telephone calls/SMS) vs. usual care	3	Met recommendations on: Physical activity: better in IG: 22.4 vs. 6.2 %; RR 3.60 (1.85;7.00) fruit and vegetable consumption: better in IG: 71.4 vs. 66 %; RR 1.74 (1.41;2.15) alcohol consumption: better in IG: 100 vs. 87.6 %; RR 1.14 (1.08; 1.21) smoking: no difference: 83.9 vs. 78.5 %; RR 1.05 (0.95; 1.17) blood pressure: MAP: lower in IG: 94.6±8.1 vs. 106.2±7.6 mmHg; MD -9.8 (-11.5; -8.1)
Bobrow 2016 (28) (PACTR2014 11000724141) RCT	South Africa (urban)	1372	54.3±11.5 / 72 %	mild to moderate 135.4±17.5 83.4±12.1	mobile phone text messages on behavior change techniques (IG2: interactive with information and possibility to response vs. IG1: only information on hypertension, motivation to take medications and reminders) vs. usual care	12	adherence (days with medication ≥ 80 %): higher with IG: 59.7 vs. 62.8 vs. 49.4 %; RR 1.12 (1.01;1.23) IG2 vs. CG: OR_a 1.86 (1.39;2.49) IG1 vs. CG: OR_a 1.60 (1.20;2.16) blood pressure: slightly lower with IG1

		Participants			Intervention (IG) vs. Control (CG)		Results on adherence and blood pressure
Name (design)	**Country**	**n**	**Age (years) / Females**	**hypertension; SBP /DBP (mmHg)**	**Description**	**Follow-up (months)**	IG vs. CG; treatment effect (95 %-CI)
							SBP: 132.7±17.5 vs. 132.1±16.6 vs. 134.3±17.3 mmHg IG2 vs. CG: MD_a-1.6 mmHg (-3.7; 0.6) IG1 vs. CG: MD_a -2.2mmHg (-4.4; -0.04) BP control: slightly better with IG: 65 vs. 65 vs. 58 % IG1 vs. CG: OR_a 1.42 (1.03; 1.95) IG2 vs. CG: OR_a 1.41 (1.02; 1.95)
Bolarinwa 2019 (29) (PACTR2016 06001671335) RCT	Nigeria (urban)	299	61.1±10.8 / 77 %	140.0 ± 22.9 86.9 ±11.9	task-shifting (driven by trained and professionally competent nurses) home-based follow-up care (BP and BMI monitoring, medical advice and counselling at home) vs. usual care	12	medical adherence: better with IG: low: 4 vs. 16.6%, medium: 17.5 vs. 34.7%, high: 78.5% vs. 48.7% BP control: better with IG: 85.9% vs. 76.7%; RR 1.12 (1.00; 1.25)
Labhardt 2011 (36) cluster RCT	Cameroon (rural)	187	59.9± 12.5/ 64 %	mild to moderate 175.8 / 100.7	reminder letters in case of missing follow-up (IG2) vs. financial incentive (one month free treatment for regular attenders) (IG1) vs. usual care in nurse-led facilities	12	adherence: retention rate: 60 vs. 65 vs. 29%; lower risk of loss to follow up from the program and better adherence in IG IG2 vs. CG: HR_a: 0.38 (0.24; 0.61) IG1 vs. CG: HR_a: 0.44 (0.27; 0.72) adherence (≥ 80 %): 38 vs. 35 vs. 10 % IG2 vs. CG: MD_a: 28 % (14; 42) IG1 vs. CG: MD_a: 25 % (13; 37) blood pressure: no differences in SBP in retained patients Costs: In IG1: average monthly cost per patient for antihypertensive medication: 1.1±0.9 €, transport: 1.1±1.0 €

		Participants			Intervention (IG) vs. Control (CG)		Results on adherence and blood pressure
Name (design)	**Country**	**n**	**Age (years) / Females**	**hypertension; SBP /DBP (mmHg)**	**Description**	**Follow-up (months)**	IG vs. CG; treatment effect (95 %-CI)
Owolabi 2019 (56) (NCT01900756) RCT	Nigeria (mixed)	400#	57.2 ± 11.7/ 37 %	All stroke (n=400); 138.3 ± 23.6 83.0 ± 15.2 stroke and uncontrolled hypertension (SBP/DBP>140 /90 mmHg) (n=168) 158.7 ± 21.7 92.5 ± 15.6	chronic care model components of delivery system redesign (increased follow-up visits, pre-appointment phone texts), self-management support (patient report card, post-clinic follow-up phone texts, waiting room educational video) and clinical information systems (patient report card as part of medical chart, hospital registry) vs. standardized usual care (risk factor identification and control) and phone contact information	12	Blood pressure: No difference for all patients after stroke: SBP: 136.5±22.3 vs. 136.2±21.2 mmHg patients with uncontrolled hypertension: SBP: 145.1±22.6 vs. 148.5±22.8 mmHg
Sarfo 2019 (58) (NCT02568137) cluster-RCT	Ghana (urban)	60#	55 ± 13/ 35 %	stroke and uncontrolled hypertension; 143.8 ± 26.7 90.5 ± 15.7	Nurse-led, multilevel approach with m-Health technology for monitoring and reporting BP measurement and tailored motivational text messages vs. usual care	9	adherence: modified MMA score: no difference: 13±1.5 vs. 13±1.7 Blood pressure: BP control: no difference: 47 vs. 40 %; OR_a: 1.24 (0.83; 1.84) SBP<140 mmHg: better in IG: 73 vs. 43 % DBP<90 mmHg: better in CG: 47 vs. 77 %
Saunders 1991 (60) RCT	South Africa (urban)	224	65 % between 40-50 / 73 %	mild to moderate; n.r. 116.6	Reminder letters and home visits by fieldworkers and patient-retained records for self-monitoring of medication compliance and BP control vs. usual care (appointment system and health education)	6	adherence (treatment received) over 6 months: higher for newly treated (135.5±48.9 vs. 95.0±60.0 days) and infrequent attenders (168.4±16.4 vs.116.7±56.9 days) of 180 days >80 % of treatment: better for newly treated (59 vs. 29 %; p< 0.001) and

		Participants			Intervention (IG) vs. Control (CG)		Results on adherence and blood pressure
Name (design)	**Country**	**n**	**Age (years) / Females**	**hypertension; SBP /DBP (mmHg)**	**Description**	**Follow-up (months)**	IG vs. CG; treatment effect (95 %-CI)
							infrequent attenders (87 vs. 42 %; p< 0.001) blood pressure: DBP: lower for newly treated patients (93.4 vs. 100.5 mmHg; MD: 7.1 mmHg (0.5-13.7), no difference for infrequent attenders: 97.5 vs. 94.7 mmHg; MD: -2.8 mmHg (-6.9; 1.3)
Stewart 2005(61) RCT	South Africa (urban)	83	late middle aged/ n.r.	all hypertensives; 146.4±18.5 93.5±11.1	telephonic intervention (educational and home-based exercise program + support of a healthcare practitioner and a family member) vs. control group (educational and home-based exercise program only)	6	adherence: better with IG: 62.8 ±34.5% vs. 39.3± 42.8 %; p=0.007 blood pressure: no difference: SBP: 142±16 vs. 144±20 mmHg; MD: -2 mmHg (-10.3 - 6.3) DBP: 92±12 vs. 91±10 mmHg, change: MD: 1 mmHg (-4.0 - 6.0)
Vedanthan 2019 (64) (NCT01844596) cluster-RCT	Kenya (rural)	1460	54.2±16.4/ 58 %	all hypertensives; 159.4±19.5 89.7 ±12	tailored behavioral communication (smartphone (IG2) or paper-based (IG1)) vs. usual care	12	adherence (Linkage to care): best results with IG2, worse with IG1: IG2 vs. CG: OR_a: 1.21 (0.70; 2.01) IG1 vs. CG: OR_a: 0.64 (0.43; 0.91) IG2 vs. IG1: OR_a: 1.95 (1.23; 3.01) blood pressure: no difference SBP: 149.4±20.8 vs. 150.2±21.6 vs. 150.0±22.9 mmHg, change: -13.1±20.5 vs. -8.4±24.0 vs. -9.7±25.1 mmHg IG2 vs. CG: MD_a: -2.13 mmHg (-4.89;0.42) IG1 vs. CG: MD_a: -0.06 mmHg (-3.61; 3.20)

		Participants			Intervention (IG) vs. Control (CG)		Results on adherence and blood pressure
Name (design)	**Country**	**n**	**Age (years) / Females**	**hypertension; SBP /DBP (mmHg)**	**Description**	**Follow-up (months)**	IG vs. CG; treatment effect (95 %-CI)
							IG2 vs. IG1: MD_a: -2.07 mmHg (-5.14;1.12) DBP: no difference: 91.3±12.7 vs. 91.0±14.1 vs. 90.1±13.7 mmHg, change: 1.5±12.7 vs. 0.4±15.2 vs. 0.1±14.7 mmHg BP control: no difference: IG2 vs. CG: OR_a: 0.95 (0.61; 1.38) IG1 vs. CG: OR_a: 0.97 (0.63; 1.42) IG2 vs. IG1: OR_a: 1.00 (0.69; 1.40)
Wahab 2017 (66) RCT	Nigeria (urban)	35#	58.1 ±10.5/ 34 %	all patients with stroke; 138.3 ± 24.2 85.0 ±12.4	feasibility of a nurse-led Intervention (education and skill building, BP monitor with review, phone calls) vs. usual care	0.5	adherence: no difference, but improvement in both groups: MMA Score: 7.32±0.93 vs. 7.03±1.36 Blood pressure: no difference SBP: 137.5±23.0 vs.133.1±18.2 mmHG; MD: 4.40 mmHg (-9.4; 18.2) DBP: 84.1±9.7 vs. 84.2±13.1 mmHg; MD -0.1 mmHg (-7.7; 7.5)
Educational strategies for health-care professionals (5 RCTs)							
Fairall 2016 (32) (ISRCTN20283604) cluster-RCT	South Africa (rural)	4393	52 (IQR 43-62)/ 73 %	mild to moderate 139±23.6[a] 90±13.2[a]	Education of nurses on NCD care (nurse training in educational outreach sessions with a primary care program to expand their role in NCD care, authorization to prescribe an expanded range of drugs on NCDs) vs. usual training	14	adherence: no difference Blood pressure: BP controlled: no difference: 33 vs. 32 %; RR 1.01 (0.2-1.8)
Goudge 2018 (34) (ISRCTN12128227) cluster-RCT	South Africa (rural)	4722	56.6±19.4 / 56 %	hypertension: 46.6 %, of them: 53.4%,	Support of nurses by health workers (e.g. assistance with booking appointments, retrieve and fill patient files, health education,	18	No hypertension: 50.9% vs. 52.9% adherence and blood pressure: no difference

		Participants			Intervention (IG) vs. Control (CG)		Results on adherence and blood pressure
Name (design)	**Country**	**n**	**Age (years) / Females**	**hypertension; SBP /DBP (mmHg)**	**Description**	**Follow-up (months)**	IG vs. CG; treatment effect (95 %-CI)
				on treatment and controlled: 8.6%, on treatment and uncontrolled: 9 %, not on treatment 29 %	measurements in the vital signs queue, prepacking of medications, reminders to appointment for patients) to provide chronic disease care vs. usual care		on treatment and controlled: 11.3 vs. 11.2 % on treatment and uncontrolled 13.0 vs. 13.2 % not on treatment 24.9% vs. 22.7% undiagnosed: 24.1 vs. 22.2 % taking medication: 24.3 vs. 24.4 %
Gyamfi 2017(35) (NCT01802372) cluster-RCT	Ghana (mixed)	757	58.0±12.4 / 60 %	mild to moderate 155.9 ± 12.1 / 89.6 ± 10.8	Training of nurses in task shifting for hypertension control + health insurance coverage vs. health coverage	12	blood pressure: improvement in both groups, but no difference between groups: SBP: 137.1±27.5 vs. 138.4±27.3 mmHg; change: -19.5±18.0 vs. -16.6±17.9 mmHg; MD: -2.9 mmHg (-6.9; 1.0) DBP: 79.8±22.9 vs.81.8±22.8 mmHg; change -9,3±11.5 vs. 8.7±18.7 mmHg; MD -0.6 mmHg (-2.9; 1.7) BP control: 55.2 vs. 49.9 % (MD 5.2 % (-1.8; 12.4)
Mendis 2010 (52) cluster-RCT	Nigeria (mixed)	1188	55 ± 4.7 / 58 %	mild to moderate 153.2±12.4 94 ± 9.7	Education of health-care workers and patients with a simple cardiovascular risk management package vs. usual care	12	adherence: higher with IG Attended visits: 90.1 vs. 74.5 % quit smoking: 100 vs. 74.4 % (p=0.023) Increased fruit consumption: 93.4 vs. 18.8 % (p< 0.0001) increased vegetable consumption: 14.2 vs. 7.0 % (p=0.0002) blood pressure: higher decrease in IG

		Participants			Intervention (IG) vs. Control (CG)		Results on adherence and blood pressure
Name (design)	**Country**	**n**	**Age (years) / Females**	**hypertension; SBP /DBP (mmHg)**	**Description**	**Follow-up (months)**	IG vs. CG; treatment effect (95 %-CI)
							SBP: -11.0±15.4 vs. -6.6±20.6 mmHg; MD -4.4 mmHg (-6.7; -2.1) DBP: -5.4±10.0 vs. -2.0±13.2 mmHg; MD -3.4 mmHg (-4.9; -1.9)
Steyn 2013 (62) (PACTR2013 03000493351) cluster-RCT	South Africa (urban)	920	60.3±11.1 / 79 %	all hypertensives1 51.2 ±26.7 / 87.1 ± 12.4	multi-faced intervention to implement national guidelines (structured record of national guidelines and visits to train clinicians) vs. usual care (passive dissemination) at primary care level	12	Blood pressure: no difference SBP: 161±28.9 vs. 158.2±29.5 mmHg; MD 2.8 mmHg (-1.2; 6.8) DBP: 88.1±13 vs. 87.1±12.6 mmHg; MD 1.00 mmHg (-0.73; 2.73) controlled BP: 23.1 vs. 26 %
Individualized treatment (3 RCTs)							
Akintunde 2017 (25) (ISRCTN69440037) RCT {Akintunde, 2017 #4980} (ISRCTN69440037)	Nigeria, Kenya, South Africa (urban)	105	56.6±14.3 / 53 %	uncontrolled 170.9 ± 19.2 / 85.6 ± 21.8	physiologically individualized care (guided by their physiological phenotype, based on plasma renin and aldosterone) vs. usual care	12	blood pressure: lower in IG SBP: 139.4±17.4 vs. 152.6±12.3 mmHg; MD -13.2 mmHg (-19.4; -7.0) DBP: 84.0±11.0 vs. 89.6±7.0 mmHg; MD -5.6 mmHg (-9.4; -1.8) BP control: 50.0 vs. 11.1 % (p=0.0001)
Okeahialam 2011 (55) RCT	Nigeria (urban)	181	49.7±14.2 / 61 %	mild to moderate 150.3 ± 14.8 / 93.7 ± 9.6	chronotherapy: drug intake in the night (10 pm) vs. drug intake in the morning (10 am)	3	blood pressure: higher decrease in IG SBP: . -18.1±17.9 vs.-14.1±14.7 mmHg; MD -4.0 mmHg (-9.0;1.0) DBP-15.6±12.2 vs.-8.7±10.2 mmHg; MD -6.9 mmHg (-10.4; -3.4)
Physical activity (4 RCTs)							

		Participants			Intervention (IG) vs. Control (CG)		Results on adherence and blood pressure
Name (design)	**Country**	**n**	**Age (years) / Females**	**hypertension; SBP /DBP (mmHg)**	**Description**	**Follow-up (months)**	IG vs. CG; treatment effect (95 %-CI)
Aweto 2012 (26) RCT	Nigeria (urban)	50	45±12.3 / 58 %	mild to moderate 138.7±10.9 / 79.9±9.3	dance movement therapy (50 minutes) vs. educational sessions, both 2x/week over 4 wks	1	blood pressure: lower in IG SBP: 119.9±8.3 vs. 135.5±11.6 mmHg; MD -15.6 mmHg (-22.4; -8.8) DBP: 70.9±7.2 vs. 74.1±7.7 mmHg; MD -3.2 mmHg (-8.1; 1.7)
Lamina 2010 (37) RCT	Nigeria (urban)	485	58.5 ±6.8 / 0 %	mild to moderate, stable 165.4±13.2 / 98.1 ± 4.6	training programs on bicycle ergometer, 3x/wk, 45-60 minutes: Interval training (IG2) vs. continuous training (IG1) vs. usual care over 8 wks	2	blood pressure: lower in IG SBP: 150.4±16.7 vs. 154.4±12.6 vs.163.5±14.9 mmHg; MD -11.1 mmHg (-14.8: -7.4) DBP: 95±5 vs. 94.4±8.8 vs. 96.1±2.7 mmHg; MD -1.4 mmHg (-2.6; -0.2)
Maruf 2016 (51) (ISRCTN81952488) RCT	Nigeria (urban)	120	52.8±8.4 (range 38-65) / 71 %	mild to moderate, 155.7±11.4 / 93±10	aerobic dance training (3x/wk, 45 minutes) vs. usual care over 12 wks	3	blood pressure: lower in IG SBP: 135.3±5.6 vs. 142.4±4.7 mmHg; MD: -7.1 mmHg (-9.3; -4.9) DBP: 82.2±3.4 vs. 83.9±2.8 mmHg; MD: -1.7 mmHg (-3.0; -0.4)
Turky 2013 (63) RCT	Egypt (urban)	30	52.8±2.4, 40-50 / 100 %	postmeno-pausal hypertensives 151±6.2 / 94.5±4.2	moderate aerobic exercise training (40 minutes, 3x/wk) by walking on a treadmill vs. usual care over 8 wks	2	blood pressure: lower in IG SBP: 124±5.6 vs. 145±6.7 mmHg; MD: -21.0 mmHg (-25.8; -16.2) DBP: 85±5.4 vs. 95±3.7 mmHg; MD: -10.0 mmHg (-13.7; -6.3)
Modified nutrition (1 RCT)							
Charlton 2008 (31) RCT	South Africa (urban)	92	61.1±7/ 84 %	mild to moderate 134.6±15.7 / 81.1±8.1	food-based dietary strategy (modified food, salt replacement, + 500 ml of maas (fermented milk) vs. control (same quantities of the targeted foods	2	blood pressure: lower in IG SBP: 132.5±15.8 vs. 127.5±15.8 mmHg; MD_a:-6.2 mmHg (-11.4; -0.9)

		Participants			Intervention (IG) vs. Control (CG)		Results on adherence and blood pressure
Name (design)	**Country**	**n**	**Age (years) / Females**	**hypertension; SBP /DBP (mmHg)**	**Description**	**Follow-up (months)**	IG vs. CG; treatment effect (95 %-CI)
					of standard commercial composition, 500 ml/d artificially sweetened cooldrink)		DBP: 82.2±9.5 vs. 79.2±11.4 mmHg; MD_a: -0.6 mmHg (-3.0; 1.8)

tertiary prevention
BMI: body mass index; BP: blood pressure; CG: Control group; DBP: diastolic blood pressureIG: Intervention group; MD: mean difference; MD_a: adjusted mean difference; n: number of randomized participants; MMA: Morisky medication adherence; NCD: non-communicable disease; n.r. not reported; ; OR_a: adjusted odds ratio; RCT: randomized controlled trial; RR: relative risk; SBP: systolic blood pressure; wk: week

Table 2: Risk of bias assessment

Study	Sequence generation	Allocation concealment	Blinding of		Incomplete outcome data	Selective reporting	Other sources
			personnel / participants	outcome assessors			
Educational strategies							
Adeyemo 2013 (24)	😐	😐	☹	😐	☹	😐	☹
Ayodapo 2019 (27)	😐	☺	☹	☹	☺	😐	😐
Bobrow 2016 (28)	☺	☺	☹	😐	☹	☺	☺
Bolarinwa 2019 (29)	☺	☺	☹	☹	☹	☹	☹
Fairall 2016 (32)	☺	☺	☹	😐	☺	☺	☺
Goudge 2018 (34)	☺	☺	☹	☺	☹	☺	☺
Gyamfi 2017 (35)	☺	☺	☹	😐	☹	☹	☺
Labhardt 2011 (36)	☺	☺	☹	☹	☹	☹	☺
Mendis 2010 (52)	☹	☹	☹	☹	☹	😐	☺
Owolabi 2019 (56)	☺	😐	☹	☺	☺	☹	☺
Sarfo 2019 (58)	☺	☺	☹	☺	☺	☺	☺
Saunders 1991 (60)	😐	😐	☹	☹	☺	😐	☺
Stewart 2005 (61)	😐	😐	☹	☹	☹	😐	☺
Steyn 2013 (62)	☺	☺	☹	☹	☺	☺	☺
Vedanthan 2019 (64)	😐	☺	☹	☹	☹	☺	☹
Wahab 2017 (66)	☺	☺	☹	☹	☺	😐	☹
Standardized treatment							
Akintunde 2017 (25)	☹	😐	😐	😐	☹	☺	☹

Study	Sequence generation	Allocation concealment	Blinding of		Incomplete outcome data	Selective reporting	Other sources
			personnel / participants	outcome assessors			
Okeahialam 2011 (55)	☺	☺	☹	😐	☹	😐	☹
Physical activity							
Aweto 2012 (26)	😐	😐	☹	☹	☹	😐	☹
Lamina 2010 (37)	☹	😐	😐	☺	☹	😐	☺
Maruf 2016 (51)	☺	☺	😐	☺	☺	☹	☹
Turky 2013 (63)	☺	☺	☹	☹	☹	😐	☹
Modified nutrition							
Charlton 2008 (31)	😐	😐	☺	☺	☺	😐	☺
☺: low; 😐: unclear; ☹: high risk of bias							

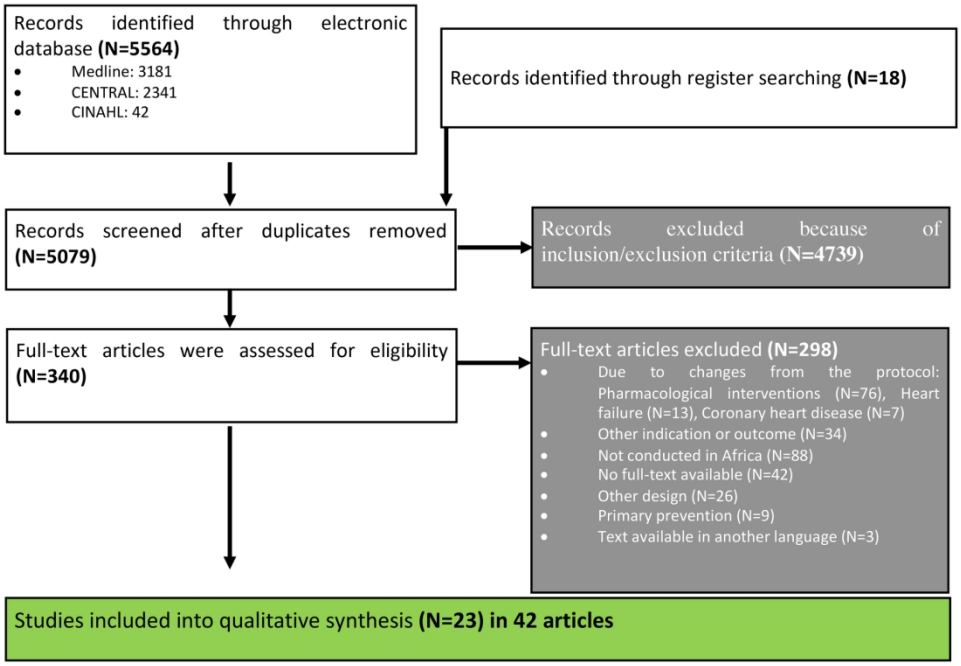


Figure 1: PRISMA flow chart describing the process of study selection

164x118mm (300 x 300 DPI)

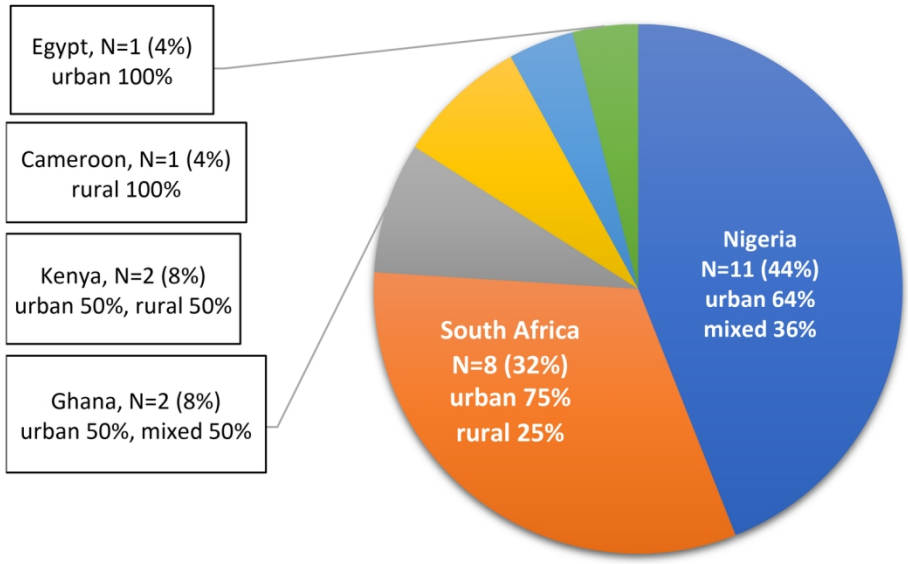
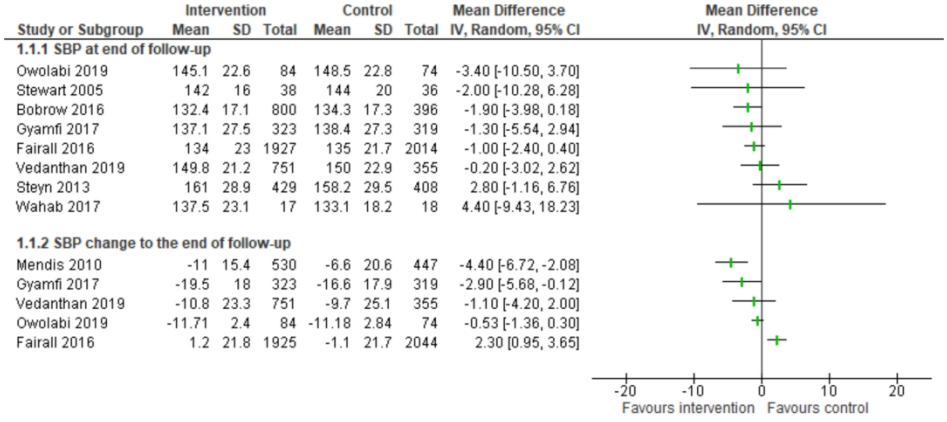


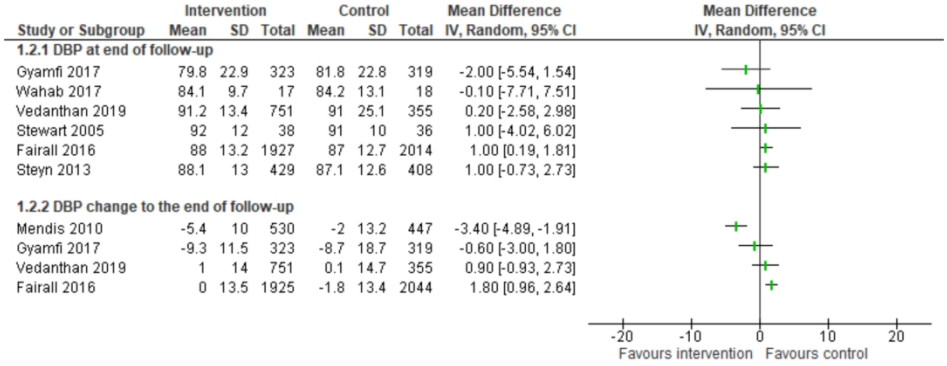
Figure 2: Spatial distribution of countries in which randomized studies were conducted

140x89mm (300 x 300 DPI)

A: Results on systolic blood pressure (SBP)



B: Results on diastolic blood pressure (DBP)



C: Results on Blood pressure (BP) control

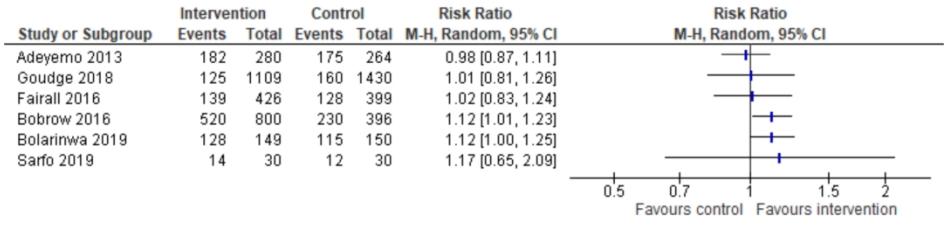
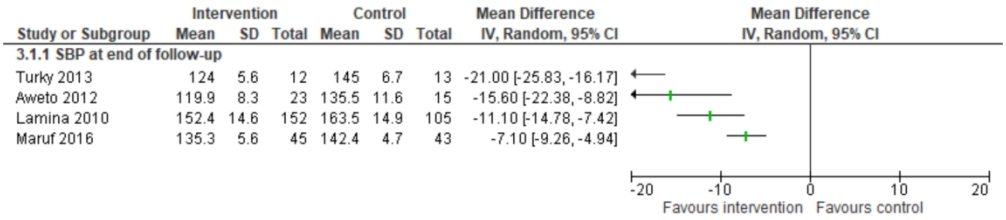


Figure 3: Results of educational strategies to improve adherence

160x204mm (300 x 300 DPI)

A: Results on systolic blood pressure (SBP)



B: Results on diastolic blood pressure (DBP)

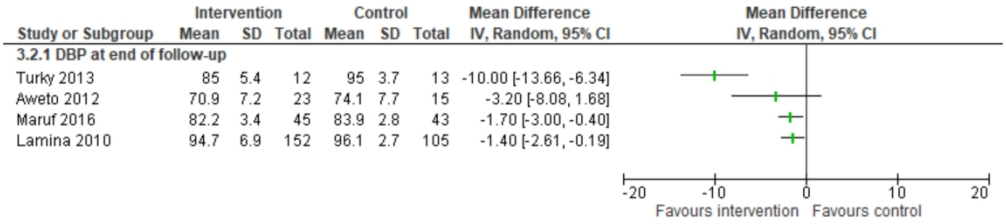


Figure 4: Results of strategies to enhance physical activity

160x96mm (300 x 300 DPI)

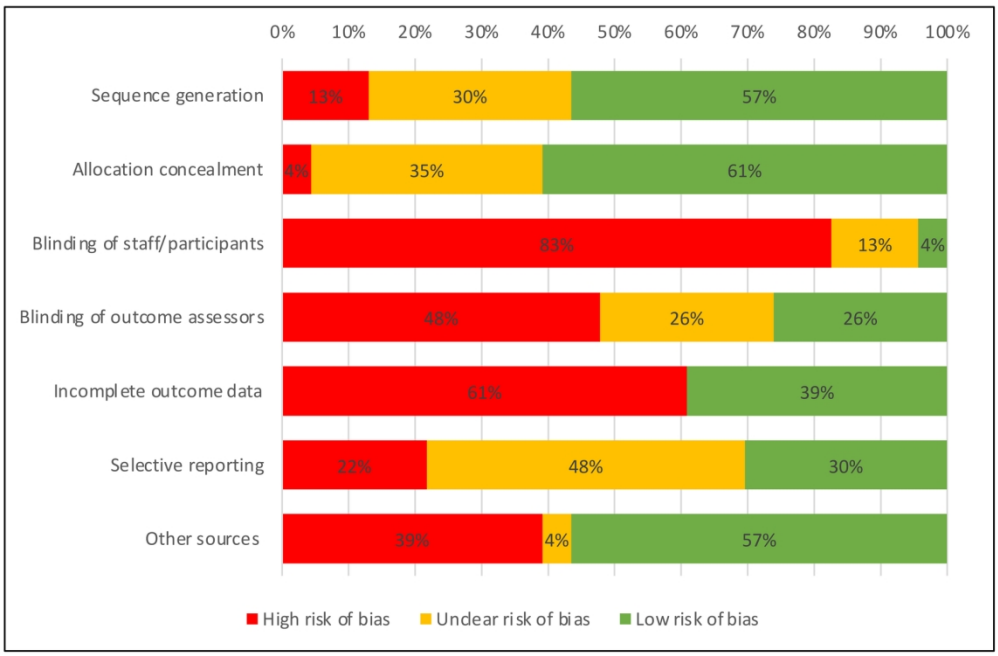


Figure 5: Summary of risk of bias

158x104mm (300 x 300 DPI)

Search strategies

Medline (Ovid): Search on CVDs

Nr.	Searches (24th July 2017)	Results
Indication		
1.	exp heart diseases/	
2.	exp vascular diseases/	
3.	cerebrovascular disorders/	
4.	exp brain ischemia/	
5.	exp carotid artery diseases/	
6.	exp dementia, vascular/	
7.	exp intracranial arterial diseases/	
8.	exp intracranial embolism/ and thrombosis/	
9.	exp intracranial hemorrhages/	
10.	exp stroke/	
11.	exp hyperlipidemias/	
12.	Exp hypercholesteremia/	
13.	exp Myocardial Ischemia/	
14.	angina.tw	
15.	(heart adj3 disease$).tw.	
16.	(coronary adj3 disease$).tw.	
17.	(peripheral adj3 disease$).tw.	
18.	(cerebrovascular disease).tw	
19.	Renal artery stenosis.tw	
20.	(Aortic aneurism or Aneurysm$).tw	
21.	myocardial infarct$.tw.	
22.	exp Myocardial Revascularization/	
23.	(coronary adj3 bypass$).tw.	
24.	(coronary adj3 angioplast$).tw.	
25.	(heart adj3 infarct$).tw.	
26.	postmyocardial infarct$.tw.	
27.	cardiovascular diseases/	
28.	Hypertens$.tw	
29.	(high adj2 blood pressure).tw	
30.	(blood pressure control).tw	
31.	Hypertensive heart disease.tw.	
32.	Cardiomyopath$.tw.	
33.	Heart failure.tw.	

Nr.	Searches (24th July 2017)	Results
34.	(Pulmonary heart disease).tw	
35.	Cardiac dysrhythmia*.tw.	
36.	Inflammatory heart disease.tw.	
37.	Endocarditis.tw.	
38.	Cardiomegaly.tw	
39.	Valvular heart disease.tw.	
40.	Rheumatic heart disease.tw	
41.	Myocarditis.tw	
42.	Arrhythmi$.tw	
43.	Vasculitis.tw	
44.	**or/1-43**	**2 498 192**
Africa and African countries		
45.	Africa.tw	
46.	Exp Africa/	
47.	Algeria$.tw or exp Algeria/	
48.	Angol$.tw or exp Angola/	
49.	Benin$.tw or exp Benin/	
50.	Botswan$.tw or exp Botswana/	
51.	Burkina Faso.tw or exp Burkina Faso/	
52.	Burund$.tw or exp Burundi/	
53.	Cameroon$.tw or exp Cameroon/	
54.	Cape Verde.tw or exp Cape Verde/	
55.	Central African Republic$.tw or exp Central African Republic/	
56.	Chad$.tw or exp Chad/	
57.	Comoros$.tw or exp Comoros/	
58.	Cote d'Ivoire.tw or exp Cote d'Ivoire/	
59.	Democratic Republic of Congo.tw or exp Democratic Republic of Congo	
60.	Djibout$.tw or exp Djibouti/	
61.	Egypt$.tw or exp Egypt/	
62.	Equatorial Guinea$.tw or exp Equatorial Guinea/	
63.	Eritrea$.tw or exp Eritrea/	
64.	Ethiop$.tw or exp Ethiopia/	
65.	Gabon$.tw or exp Gabon/	
66.	Gambia$.tw or exp Gambia/	
67.	Ghana$.tw or exp Ghana/	
68.	Guinea$.tw or exp Guinea/	
69.	Guinea-Bissau.tw or exp Guinea-Bissau/	

Nr.	Searches (24th July 2017)	Results
70.	Kenya$.tw or exp Kenya/	
71.	Lesoth$.tw or exp Lesotho/	
72.	Liberia$.tw or exp Liberia/	
73.	Libya$.tw or exp Libya/	
74.	Madagascar$.tw or exp Madagascar/	
75.	Malawi$.tw or exp Malawi/	
76.	Mali.tw or exp Mali/	
77.	Mauritania$.tw or exp Mauritania/	
78.	Mauritius$.tw or exp Mauritius/	
79.	Morocc$.tw or exp Morocco/	
80.	Mozambique$.tw or exp Mozambique/	
81.	Namibia$.tw or exp Namibia/	
82.	Niger.tw or exp Niger/	
83.	Nigeria$.tw or exp Nigeria/	
84.	Rwanda$.tw or exp Rwanda/	
85.	(Sao Tome and Principe).tw	
86.	Senegal$.tw or exp Senegal/	
87.	Seychell$.tw	
88.	Sierra Leone.tw or exp Sierra Leone/	
89.	Somalia$.tw or exp Somalia/	
90.	South Africa$.tw or exp South Africa.de	
91.	South Sudan.tw or exp South Sudan/	
92.	Sudan$.tw or exp Sudan/	
93.	Swaziland$.tw or exp Swaziland/	
94.	Tanzania$.tw or exp Tanzania/	
95.	Togo$.tw or exp Togo/	
96.	Tunisia$.tw or exp Tunisia/	
97.	Uganda$.tw or exp Uganda/	
98.	Zambia$.tw or exp Zambia/	
99.	Zimbabwe$.tw or exp Zimbabwe/	
100.	Somaliland$.tw or exp Somaliland/	
101.	#1.tw	
102.	or/45-101	436 084
103.	44 and 102	19 017
Study design		
104.	randomized controlled trial.pt.	
105.	controlled clinical trial.pt.	

Nr.	Searches (24th July 2017)	Results
106.	randomized.ab.	
107.	placebo.ab.	
108.	randomly.ab.	
109.	trial.ab.	
110.	groups.ab.	
111.	or/104-110	2 535 560
112.	exp animals/ not humans.sh.	
113.	111 not 112	2 133 129
114.	103 and 113	**2643**

Medline (Ovid): Update on hypertension

Nr.	Searches (23th June 2020)	Results
Indication		
1.	Exp hypertension	
2.	Hypertens$.ti,ab	
3.	(high adj2 blood pressure).ti,ab	
4.	(blood pressure control).ti,ab	
5.	**or/1-4**	464 555
Africa and African countries		
6.	Africa.tw	
7.	Exp Africa/	
8.	Algeria$.tw or exp Algeria/	
9.	Angol$.tw or exp Angola/	
10.	Benin$.tw or exp Benin/	
11.	Botswan$.tw or exp Botswana/	
12.	Burkina Faso.tw or exp Burkina Faso/	
13.	Burund$.tw or exp Burundi/	
14.	Cameroon$.tw or exp Cameroon/	
15.	Cape Verde.tw or exp Cape Verde/	
16.	Central African Republic$.tw or exp Central African Republic/	
17.	Chad$.tw or exp Chad/	
18.	Comoros$.tw or exp Comoros/	
19.	Cote d'Ivoire.tw or exp Cote d'Ivoire/	
20.	Democratic Republic of Congo.tw or exp Democratic Republic of Congo	
21.	Djibout$.tw or exp Djibouti/	

Nr.	Searches (23th June 2020)	Results
22.	Egypt$.tw or exp Egypt/	
23.	Equatorial Guinea$.tw or exp Equatorial Guinea/	
24.	Eritrea$.tw or exp Eritrea/	
25.	Ethiop$.tw or exp Ethiopia/	
26.	Gabon$.tw or exp Gabon/	
27.	Gambia$.tw or exp Gambia/	
28.	Ghana$.tw or exp Ghana/	
29.	Guinea$.tw or exp Guinea/	
30.	Guinea-Bissau.tw or exp Guinea-Bissau/	
31.	Kenya$.tw or exp Kenya/	
32.	Lesoth$.tw or exp Lesotho/	
33.	Liberia$.tw or exp Liberia/	
34.	Libya$.tw or exp Libya/	
35.	Madagascar$.tw or exp Madagascar/	
36.	Malawi$.tw or exp Malawi/	
37.	Mali.tw or exp Mali/	
38.	Mauritania$.tw or exp Mauritania/	
39.	Mauritius$.tw or exp Mauritius/	
40.	Morocc$.tw or exp Morocco/	
41.	Mozambique$.tw or exp Mozambique/	
42.	Namibia$.tw or exp Namibia/	
43.	Niger.tw or exp Niger/	
44.	Nigeria$.tw or exp Nigeria/	
45.	Rwanda$.tw or exp Rwanda/	
46.	(Sao Tome and Principe).tw	
47.	Senegal$.tw or exp Senegal/	
48.	Seychell$.tw	
49.	Sierra Leone.tw or exp Sierra Leone/	
50.	Somalia$.tw or exp Somalia/	
51.	South Africa$.tw or exp South Africa.de	
52.	South Sudan.tw or exp South Sudan/	
53.	Sudan$.tw or exp Sudan/	
54.	Swaziland$.tw or exp Swaziland/	
55.	Tanzania$.tw or exp Tanzania/	
56.	Togo$.tw or exp Togo/	
57.	Tunisia$.tw or exp Tunisia/	
58.	Uganda$.tw or exp Uganda/	

Nr.	Searches (23th June 2020)	Results
59.	Zambia$.tw or exp Zambia/	
60.	Zimbabwe$.tw or exp Zimbabwe/	
61.	Somaliland$.tw or exp Somaliland/	
62.	Sahrawi Arab Democratic Republic.tw.	
63.	or/6-62	530 370
Study design		
64.	randomized controlled trial.pt.	
65.	controlled clinical trial.pt.	
66.	(randomized or randomised or randomly).ti,ab	
67.	placebo.ab.	
68.	trial.ab.	
69.	groups.ab.	
70.	or/64-69	2 757 989
71.	5 and 63 and 70	3036
72.	exp animals/ not humans.sh.	
73.	71 not 72	
74.	73 not (comment or editorial).pt	2964
75.	Limit 74 to yr= “2017-Current”	**538**

CENTRAL: Search on CVDs

Nr.	Searches (14th August 2017)	Results
1	Africa, explode all trees	
2	Algeria* or Angol* or Benin* or Botswan*	
3	(Burkina Faso) or Burund* or Cameroon* or (Cape Verde) or (Central African Republic)	
4	Chad* or Comoros* or Cote d'Ivoire or Congo*	
5	Djibout* or Egypt* or (Equatorial Guinea*) or Eritrea*	
6	Ethiop* or Gabon* or Gambia* or Ghana* or Guinea* or Guinea-Bissau	
7	Kenya* or Lesoth* or Liberia* or Libya* or Madagascar* or Malawi*	
8	Mali* or Mauritania* or Mauritius* or Morocc* or Mozambique* or Namibia* or Niger*	
9	Nigeria* or Rwanda* or (Sao Tome and Principe) or Senegal* or Seychell*	
10	Sierra Leone or Somalia* or (South Africa) or (South Sudan*) or Sudan* or Swasiland	
11	Tanzania* or Togo* or Tunisia* or Uganda* or Zambia* or Zimbabwe* or Somaliland or (Sahrawi Arab Democratic Republic)	
12	#1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10 or #11	39 610
13	MeSH descriptor Cardiovascular Diseases, this term only	
14	MeSH descriptor Heart Diseases explode all trees	
15	MeSH descriptor Vascular Diseases explode all trees	
16	MeSH descriptor Cerebrovascular Disorders, this term only	
17	MeSH descriptor Brain Ischemia explode all trees	
18	MeSH descriptor Carotid Artery Diseases explode all trees	
19	MeSH descriptor Dementia, Vascular explode all trees	
20	MeSH descriptor Intracranial Arterial Diseases explode all trees	
21	MeSH descriptor Intracranial Embolism and Thrombosis explode all trees	
22	MeSH descriptor Intracranial Hemorrhages explode all trees	
23	MeSH descriptor Stroke explode all trees	
24	MeSH descriptor Hyperlipidemias explode all trees (4197)	
25	(coronar* or heart or peripheral* or cerebrovascular* or myocardial) near 3 (disease or infarct*)	
26	myocardi* near 3 (infarct* or revascular* or ischaem* or ischem*)	
27	vascular* near 3 (peripheral* or disease* or complication*))	
28	hypertensi* or (high near 2 blood pressure)	
29	(heart near 2 failure) or stroke	
30	Endocarditis or myocarditis or Cardiomegaly or arrythmi*	
31	#13 or #14 or #15 or #16 or #17 or #18 or #19 or #20 or #21 or #22 or #23 or #24 or #25 or #26 or #27 or #28 or #29 or #30	101 472
32	#12 and #31	4139
32	Trials	**2008**

CENTRAL, Update on hypertension

Nr.	Searches (23th June 2020)	Results
1	Africa, explode all trees	
2	Algeria* or Angol* or Benin* or Botswan*	
3	(Burkina Faso) or Burund* or Cameroon* or (Cape Verde) or (Central African Republic)	
4	Chad* or Comoros* or Cote d'Ivoire or Congo*	
5	Djibout* or Egypt* or (Equatorial Guinea*) or Eritrea*	
6	Ethiop* or Gabon* or Gambia* or Ghana* or Guinea* or Guinea-Bissau	
7	Kenya* or Lesoth* or Liberia* or Libya* or Madagascar* or Malawi*	
8	Mali* or Mauritania* or Mauritius* or Morocc* or Mozambique* or Namibia* or Niger*	
9	Nigeria* or Rwanda* or (Sao Tome and Principe) or Senegal* or Seychell*	

Nr.	Searches (23th June 2020)	Results
10	Sierra Leone or Somalia* or (South Africa) or (South Sudan*) or Sudan* or Swasiland	
11	Tanzania* or Togo* or Tunisia* or Uganda* or Zambia* or Zimbabwe* or Somaliland or (Sahrawi Arab Democratic Republic)	
12	#1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10 or #11	60 623
13	MeSH descriptor: [Hypertension] explode all trees	
14	hypertensi* or (high near 2 blood pressure)	
15	#13 or #14	67 954
16	#12 and #15	2929
	Trials, 2017-Current	**333**

CINAHL, Search on 23.06.2020

(Africa$ or Africa$ or Algeria$ or Angol$ or Benin$ or Botswan$ or (Burkina Faso) or Burund$ or Cameroon$ or (Cape Verde) or (Central African Republic) or Chad$ or Comoros$ or Cote d'Ivoire or Congo$ Djibout$ or Egypt$ or (Equatorial Guinea$) or Eritrea$ or Ethiop$ or Gabon$ or Gambia$ or Ghana$ or Guinea$ or Guinea-Bissau or Kenya$ or Lesoth$ or Liberia$ or Libya$ or Madagascar$ or Malawi$ or Mali$ or Mauritania$ or Mauritius$ or Morocc$ or Mozambique$ or Namibia$ or Niger$ or Nigeria$ or Rwanda$ or (Sao Tome and Principe) or Senegal$ or Seychell$ or Sierra Leone or Somalia$ or (South Africa) or (South Sudan$) or Sudan$ or Swasiland or Tanzania$ or Togo$ or Tunisia$ or Uganda$ or Zambia$ or Zimbabwe$ or Somaliland or (Sahrawi Arab Democratic Republic)) in Abstract
AND
hypertension or high blood pressure or elevated blood pressure or htn or hypertensive in Abstract
AND
randomized or rct or randomised in Abstract
AND
In English
AND
Peer-reviewed
And
Humans
Total: 42 results

International Clinical Trials Registry Platform (http://apps.who.int/trialsearch/AdvSearch.aspx), Search on 22 October 2019

hypertension or (blood pressure control) or (high blood pressure) in the condition,

Recruitment status: all

Countries of recruitment:

- Africa or African in the title: 90 trials
- Algeria or Angola or Behin or Burkina Faso or Botswana or Burundi or Cameroon or Central Africa Republic or Chad or Congo or Cabo Verde or Cite D'Ivoire: 13 trials
- Democratic Republic of Congo or Djibouti or Egypt or Equatorial Guinea or Eritrea or Ethiopia or Gabon or Gambia or Ghana or Guinea or Guinea-Bissau or Kenya: 78 trials
- Lesotho or Liberia or Libya or Madagascar or Malawi or Mali or Mauritius or Morocco or Mozambique: 14 trials
- Namibia or Niger or Nigeria or Rwanda or Sao Tome andPrincipe or Senegal or Seychelles or Sierra Leone or Somalia or Sudan or South Sudan or Swaziland: 23 trials
- Togo or Tunezia or United Republic of Tanzania or Uganda or Zambia or Zimbabwe: 25 trials

Total: 18 results

Adeyemo 2013

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PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	4
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	4,5
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	2,6
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	6
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	6
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	6, supplementary file
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	6
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	6,7
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	7
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	8
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	8

PRISMA 2009 Checklist

Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	8

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	8
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	8
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	9
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	9
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	12, Table 3
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	10,11
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	None done, narrative synthesis
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	12, Figure 5
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	None done
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	13,14, 15
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	15, 16
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	17

PRISMA 2009 Checklist

FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	19

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