Current Hypertension Reports (2019) 21:75
https://doi.org/10.1007/s11906-019-0983-2

TELEMEDICINE AND TECHNOLOGY (HB BOSWORTH, SECTION EDITOR)

Opportunities to Leverage Telehealth Approaches Along the Hypertension Control Cascade in Sub-Saharan Africa

Charles Muiruri[1,2,3] · Preeti Manavalan[2] · Shelley A. Jazowski[1,4] · Brandon A. Knettel[2] · Helene Vilme[1] · Leah L. Zullig[1,5]

Abstract

Purpose of Review To review the current literature on use of telehealth at different stages of the hypertension control cascade in sub-Saharan Africa (SSA) and to discuss opportunities to harness technology infrastructure in SSA to improve population-level blood pressure control.

Recent Findings Despite the high burden of hypertension in SAA, strategies to improve awareness, diagnosis, and management are inadequate. In high-income countries, telehealth has increased patient access to high-quality care at reduced costs. Notwithstanding the limited evidence on the use of telehealth at the different stages of the hypertension control cascade in SSA, the few published interventions in this review reported reduction of blood pressure and increase in the proportion of individuals with controlled blood pressure.

Summary Telehealth use across the hypertension control cascade in SSA is promising. These under-resourced settings provide opportunity to better understand the demand for these interventions in order to achieve meaningful clinical outcomes.

Keywords Hypertension · Hypertension control cascade · Sub-Saharan Africa · Telehealth

Introduction

There has been a dramatic increase in the prevalence of noncommunicable diseases—especially hypertension—in sub-Saharan Africa (SSA) in the past two decades [1–3]. Reasons for this shift include increased life expectancy, urbanization, and lifestyle changes (e.g., dietary habits, physical activity, and smoking/tobacco use) [4–8]. Approximately 46% of African adults (≥ 25 years of age) have hypertension, a prevalence rate that now surpasses high-income countries (35%) and other nations (40%) throughout the world [1, 2, 9, 10]. Hypertension is the primary risk factor for myocardial infarction, chronic kidney disease, stroke, heart failure, and cardiovascular-related deaths [11].

Despite this burgeoning epidemic, efforts focused on the prevention and control of hypertension in SSA have been limited [12]. For example, in a recent meta-analysis, 27% of hypertensive adults in SSA were aware of their diagnosis, only 18% of those with a diagnosis were receiving treatment, and only 7% of those receiving treatment had achieved blood pressure control [13]. In response to these alarming rates, the Pan-African Society of Cardiology (PASCAR) released their "roadmap to achieving 25% hypertension control in Africa by 2025" [10]. In this ten-point action plan, PASCAR identified structural interventions to achieve this goal, including the allocation of adequate funding and resources to improve detection, diagnosis, treatment, and control of hypertension—the four components of the hypertension control cascade [10].

This article is part of the Topical Collection on *Telemedicine and Technology*

✉ Charles Muiruri
charles.muiruri@duke.edu

[1] Department of Population Health Sciences, Duke University School of Medicine, 215 Morris St., Suite 210, Durham, NC 27701, USA

[2] Duke Global Health Institute, Duke University, Durham, NC, USA

[3] Kilimanjaro Christian Medical University College, Moshi, Tanzania

[4] Department of Health Policy and Management, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

[5] Center of Innovation to Accelerate Discovery and Practice Transformation (ADAPT), Durham Veterans Affairs Health Care System, Durham, NC, USA

Published online: 26 August 2019

Hypertension Control Cascade

The hypertension control cascade is composed of sequential steps that describe how hypertensives access healthcare services and treatment and acknowledges lapses that may occur at each stage, leading patients to "fall off" the cascade and, ultimately, prevent blood pressure control (Fig. 1) [14]. These steps include [1] hypertension screening [2], hypertension diagnosis [3], appropriate and effective hypertension management, and [4] achievement of blood pressure control [14].

The first stage of the cascade focuses on increasing patients' awareness of the risks of hypertension to encourage health-seeking behaviors and screening [15]. Additionally, routine and standardized screening is a critical step in making timely diagnosis of hypertension [16]. Individuals who are diagnosed with hypertension should promptly receive appropriate treatment (e.g., pharmacologic agents and/or lifestyle modifications) to manage their condition [17]. Clinical guidelines recommend treatment initiation when blood pressure is ≥ 130/80 mmHg among adults [17–19]. Finally, if treatment is successful and maintained over time, then patients should achieve blood pressure control (i.e., blood pressure < 130/80 mmHg).

To advance people along the hypertension control cascade (HCC) to ultimately achieve blood pressure control, interventions in SSA have focused on community engagement, provider education, building capacity within healthcare systems (including task shifting), and promoting patient behavior modifications such as salt reduction or substitution, smoking cessation, and promoting physical activity [20]. However, in SSA, barriers to achieving and maintaining blood pressure control continue to exist, including lack of established policies or political willingness to implement policies to address the burden of hypertension; dearth of healthcare resources (e.g., screening programs, antihypertensive medications, and healthcare providers); lack of evidence-based guidelines; limitations in healthcare provider education; noncompliance with existing guidelines and best practices; and high out-of-pocket expenditures associated with necessary healthcare services [21]. Therefore, there is a critical need for innovative, cost-effective approaches to achieve meaningful gains towards hypertension control.

Telehealth Strategies in SSA

Telehealth approaches, "the use of telecommunications and virtual technology to deliver healthcare outside of traditional healthcare facilities," may represent a promising opportunity to overcome barriers to access, cost, and quality of care for hypertension in SSA [22, 23]. Telehealth is a broad term that encompasses telemedicine, telecommunication, and mHealth that is provided via computers, mobile phones, or other handheld devices that have internet access [24]. Telehealth has been used in high-income settings to increase patient access to high-quality care at a reduced cost [25]. Interventions that incorporate telehealth strategies have been shown to be effective in raising awareness, improving screening and diagnosis, and sustaining blood pressure control in high-income countries [24]. For example, use of web-based platforms and electronic messaging has been widely used for raising hypertension awareness and eliciting behavior change [26], while short message service (SMS), or text messages, and telemonitoring (the use of information technology to monitor patients' blood pressure at a distance) have been associated with improved blood pressure control [27–29].

In contrast to high-income countries, where the use of computers with broadband internet access may be a viable mode of delivering telehealth interventions, few people in SSA own computers or tablets. A more accessible telehealth modality in SSA is mobile phones. According to 2012 World Bank estimates, less than 10% of households in SSA had computers, while approximately 70% of adults had mobile phone subscriptions in South Africa. Smartphone adoption is rapidly increasing in SSA as well, with a median of 37% smartphone ownership in 2015 [3]. Furthermore, data plans are often inexpensive, wireless internet access is rapidly expanding, and SMS messaging and video call applications are widespread regardless of socioeconomic status, thus creating multiple opportunities for easy-to-access, free, or low-cost communication [30]. The availability of mobile technology to a majority of the population provides a great opportunity to address the burden of hypertension and associated cardiovascular morbidity and mortality. Telehealth interventions have the potential to improve outcomes along the HCC and support the goals of

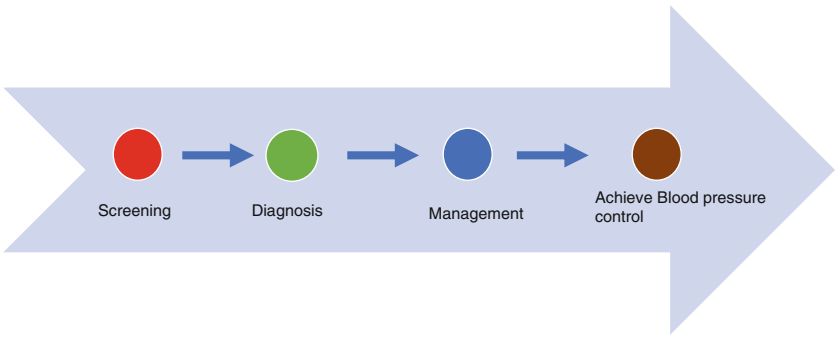

Fig. 1 The hypertension control cascade

PASCAR to dramatically increase the number of patients in SSA who have achieved effective, long-term hypertension control.

Literature Review

We conducted a narrative literature review to (1) examine the current landscape and success of telehealth interventions in SSA occurring at each step of the HCC and (2) identify opportunities to expand current or develop new telehealth strategies to achieve blood pressure control in SSA. To evaluate the current landscape of telehealth interventions in hypertension, we searched PubMed including MEDLINE to identify articles published in English until May 1, 2019, using a combination of keywords and phrases: "hypertension," "high blood pressure," "sub Saharan Africa," "Africa," "mHealth," and "telehealth." Our search yielded 28 articles, of which 20 were excluded for the reasons specified in Fig. 2. Most of the excluded articles were systematic reviews; however, we examined each review to determine if any pertinent articles were missed. Other excluded articles specified outcomes that were not related to stages of the HCC.

Overall, 8 studies from 5 countries in SSA were included; 2 studies used telehealth strategies to address hypertension awareness and screening, 2 studies addressed hypertension diagnosis, and 4 studies used telehealth interventions to assess hypertension management and control (Table 1).

Four studies used telehealth approaches aimed at providers, 3 studies assessed strategies focused on patients, and 1 study focused on both patients and providers. Four studies utilized SMS text messaging and phone calls and 4 studies used mHealth and smart phone application tools as the method of telehealth delivery. Studies assessed a variety of patient populations: 1 study focused on pregnant women attending an antenatal clinic; 1 study evaluated deaf adults; 1 study targeted hypertensive adults with a prior history of stroke; 3 studies assessed hypertensive adults; and 2 studies included adults from the general population.

Hypertension Awareness to Increase Screening

We identified two studies that focused on awareness with the aim of increasing hypertension screening rates. In Cape Town, South Africa, researchers tested an intervention whereby patients received 90 SMS text messages with hypertension facts and lifestyle education over a period of 17 weeks. While this content did not improve hypertension knowledge, it was associated with motivating positive self-reported behavior change, including smoking cessation, reduced alcohol consumption, weight loss, decreased salt intake, eating a healthier diet, and increased exercise [31].

A second study sought to assess the acceptability and effectiveness of SMS messages at improving hypertension knowledge among deaf adults in Cape Town. SMS messages included medical information on hypertension, such as

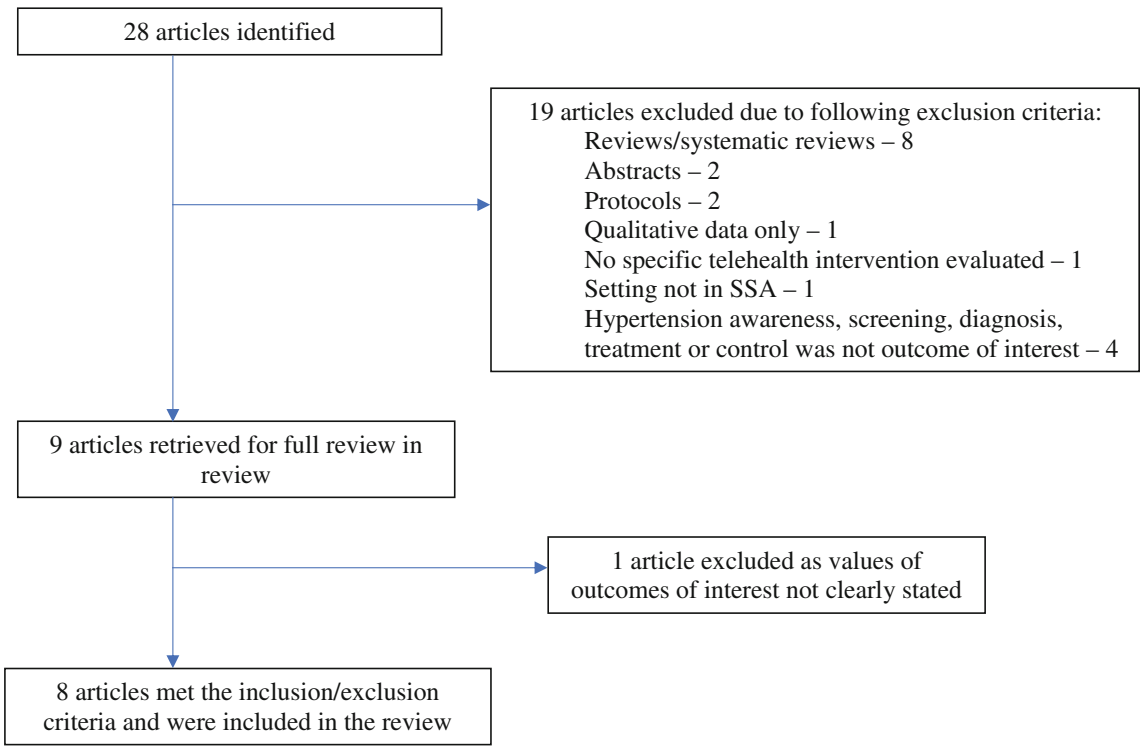

Fig. 2 Reasons for exclusion of studies. Diagram of the number of studies identified by literature search and reasons for exclusion to arrive at 8 studies that were included in the review

Table 1 Published articles addressing telehealth interventions along the hypertension control cascade

Stage(s) of hypertension control cascade	Setting	Author	Year	Mode of telehealth delivery	Study design	Sample size	Outcomes
Awareness to increase screening	Cape Town, SA	Hacking et al. [31]	2016	SMS text messages with hypertension knowledge sent to patients	RCT	76 adults in intervention; 70 adults in control	No improvement in hypertension knowledge score between intervention and control (17.5 v. 17.7, $p = 0.69$) Increased positive self-reported behavioral change for intervention participants
Awareness to increase screening	Cape Town, SA	Haricharan et al. [32]	2017	SMS text messages with hypertension knowledge sent to patients	C-S with pre- and post-test analysis	41 deaf adults	Increased knowledge of hypertension in overall test score between baseline and follow-up ($p = 0.0033$)
Diagnosis	Western Kenya	Haskew et al. [33]	2015	Cloud-based EMR tool for hypertension documentation and screening used by providers	Prospective cohort with pre- and post-test analysis	946 pregnant women	Significant difference in the amount of missing documentation for screening of hypertension pre- and post-implementation (25.1%, 95%, CI 20.5–29.7, $p < 0.001$) No increase in hypertension screening. Only 5 (0.5%) patients screened for hypertension during the study period
Diagnosis	Rural Kenya	Mannik et al. [34]	2018	Two-way mHealth SMS-based hypertension screening tool used by CHWs	C-S	2865 adults	Screened 2865 adults for hypertension and found a point prevalence of hypertension of 23%
Management and control	Lagos, Nigeria	Nelissen et al. [35]	2018	mHealth application used by cardiologists and pharmacists	Prospective cohort	165 hypertensive adults	Reduction in mean BP with an average change in SBP − 9.9 mmHg (SD 18.0) and in DBP − 5.9 mmHg (SD 11.4) among baseline and endline No difference observed in average change in SBP among newly diagnosed (− 9.6 mmHg, SD 14.3) and previously diagnosed (− 10.0 mmHg, SD 18.8, $p = 0.907$), those not on antihypertensive medication (− 12.8 mmHg, SD 17.8) and those using antihypertensive medications at baseline

Table 1 (continued)

Stage(s) of hypertension control cascade	Setting	Author	Year	Mode of telehealth delivery	Study design	Sample size	Outcomes
							(− 8.5 mmHg, SD 18, $p = 0.083$) Increased BP control from 24% at baseline to 56% at endline, $p < 0.001$
Management and control	Kumasi, Ghana	Sarfo et al. [36]	2018	Smart phone application driven by nurses and used by patients	RCT	30 hypertensive, stroke adults in intervention; 30 hypertensive, stroke adults in control	Trend towards BP control in the intervention arm compared with the control arm (46.7% v. 40.0%, $p = 0.79$) Increase in SBP control in the intervention arm compared with the control arm (73.3% v. 43.3%, $p = 0.035$) No difference in medication adherence between arms (0.95 ± 0.16 v. 0.98 ± 0.24, $p = 0.56$)
Management and control	Cape Town, SA	Bobrow et al. [37]	2016	Information-only SMS text messaging and interactive text messaging sent to patients	Multi-arm RCT	457 hypertensive adults in information-only text messaging intervention; 458 hypertensive adults in interactive text messaging intervention; 457 hypertensive adults in control	Reduction in mean SBP from baseline to 12 months for the information-only message group compared with usual care − 2.2 mmHg (95% CI − 4.4–− 0.04, $p = 0.046$) Reduction in mean SBP from baseline to 12 months for the interactive message group compared with usual care − 1.6 mmHg (95% CI − 3.7—0.6, $p = 0.16$) Blood pressure control for information-only messages and interactive message compared with usual care with adjusted odds ratio of 1.4 (95% CI 1.0–1.9, $p = 0.04$) and 1.4 (95% CI 1.0–1.9, $p = 0.04$), respectively Increased medication adherence with 62.8% of information-only message participants, 59.7% of interactive message participants, and 49.4% of

Table 1 (continued)

Stage(s) of hypertension control cascade	Setting	Author	Year	Mode of telehealth delivery	Study design	Sample size	Outcomes
							usual care ($p < 0.001$) meeting a goal of 80% medication coverage over a 12-month period
Management and control	Yaounde, Cameroon	Kingue et al. [38]	2013	Telephone calls and text messages from nurses to cardiologists and nephrologists	RCT	165 hypertensive adults in intervention; 103 hypertensive adults in control	Increased BP control among intervention participants with stage 3 hypertension compared with the usual care group (50% v. 39.1%, $p = 0.04$) No change in BP control among intervention participants with stage 1 and stage 2 hypertension compared with the usual care group (65.2% v. 70%, $p = 0.20$) Reduced mean BP among intervention participants compared with the usual care group between baseline and final visits, (33.3% v. 27.5% $p = 0.04$)

RCT randomized control trial, *C-S* cross-sectional study, *CHW* community health worker, *BP* blood pressure, *SBP* systolic blood pressure, *DBP* diastolic blood pressure, *EMR* electronic medical record

symptoms and possible consequences of hypertension, as well as information on how high blood pressure could be prevented or managed through healthy lifestyle changes. Haricharan and colleagues found that this approach increased awareness and improved overall knowledge of hypertension [32].

Hypertension Diagnosis

We found two studies that focused on diagnosis of hypertension using telehealth approaches. In Western Kenya, a cloud-based electronic medical record (EMR) tool was implemented for providers in antenatal care clinics and was found to improve documentation of hypertension care for pregnant women. Despite increased completeness in documentation, there was no increase in the number of women screened for hypertension; only five patients were screened during the entire study period [33]. Additionally, community health workers in rural Kenya utilized an mHealth screening tool that estimated cardiovascular disease profiles in a sample of adults living in the community and found that the point prevalence of hypertension was 23% [34].

Hypertension Management and Control

We identified four studies that used telehealth to improve hypertension management and control. In a study in Lagos, Nigeria, hypertensive adults were linked to healthcare providers through an mHealth application that allowed cardiologists to review blood pressure data, patient concerns, and prescriptions, as well as communicate directly with pharmacists. Between baseline and endline (median duration of 3.3 months), use of the application led to a significant reduction in mean systolic blood pressure of 9.9 mmHg (SD 18) and an increase in the proportion of patients achieving blood pressure control [35]. In Ghana, the use of a nurse-driven smart phone application, composed of a Bluetooth blood pressure monitor and tool for a patient's self-monitoring of blood pressure measurements and medication use, demonstrated a trend towards increased blood pressure control among hypertensive, stroke participants; however, no difference in antihypertensive medication adherence was observed between the intervention and control groups [36]. In a study in South Africa, information-only text messaging (e.g., hypertension education, medication and appointment scheduling reminders) or interactive text messaging (e.g., ability to modify clinic appointments) that addressed a range of common issues with antihypertensive medication adherence and persistence were associated with both a modest reduction in blood pressure and an improvement in medication adherence [37]. Similarly, healthcare providers in rural Cameroon who received telephone calls and text messages with patient-specific blood pressure and treatment data from a large referral hospital contributed to improvements in their patients' blood pressure control [38].

Discussion

We identified a small number of studies ($n = 8$) addressing telehealth-delivered interventions in SSA. Among the articles that we reviewed, evidence largely suggests that telehealth innovations addressing hypertension outcomes are promising, but future research is required to confirm the potential of these interventions. Specifically, studies that focused on the management and control stages of the HCC produced positive results, whereas studies that assessed the first two stages had mixed results. SMS messages that included educational content had the potential to not only improve a patient's knowledge of hypertension but also influence health behaviors, including discussions with providers about hypertension screenings. However, areas of future inquiry should include the evaluation of whether a message type impacts study outcomes (e.g., facts about hypertension v. motivation for lifestyle modification v. patient-centered messaging), assessing outcomes when SMS are delivered at different times of the day or days of the week, and strengthening of study designs with the inclusion of a comparator group, among other approaches.

Provider reminders and mobile screening tools were found to have the potential to improve screening and diagnosis of hypertension. Introducing automated algorithms to assist community health workers and nonphysician healthcare providers with timely screening and appropriate diagnosis was found to increase access to care. Expanding the use of automated guidelines may support implementation of innovative approaches, such as task shifting, to address the shortage of physicians and other healthcare workers in SSA [39].

Given the dearth of evidence on the use of telehealth in the different stages of the HCC, we offer our reflections on the opportunities to expand telehealth in order to improve hypertension control in SSA. First, we examine lessons learned from telehealth interventions in SSA that have largely focused on communicable diseases (i.e., HIV and malaria) and maternal and child health [40]. In recent systematic reviews, mHealth interventions targeting pregnant women were found to increase antenatal care attendance, skilled attendance at birth, and vaccination rates [41]. In HIV, telehealth studies have increased risk awareness and retention in care [42, 43]. Telehealth innovations targeting communicable diseases and maternal and child health have been found to be highly acceptable and feasible and have significantly improved medication adherence, engagement in care, and use of health services [40]. Therefore, it is important to leverage the established precedence in these disease areas to increase the use of telehealth along the HCC. Since there is a growing number of older adults living with HIV [44], embedding

interventions at different stages of the HCC in ongoing HIV-focused telehealth interventions may not only improve the overall health of people living with HIV but also support the 5th point of PASCAR's action plan "integrate hypertension detection, treatment and control within existing health services such as vertical programs (e.g. HIV, TB)." Researchers could also adapt key components of communicable disease telehealth interventions whose goals are to raise awareness and encourage screening into the first stages of the HCC [45]. Telehealth interventions that have been successful in improving adherence to antiretroviral therapy and achievement of viral suppression could also be adapted to support the later stages of HCC [46].

Another area to explore in the use of telehealth for hypertension control is to reflect on the already-existing infrastructure that supports other sectors of governments in SSA. For example, as of February 2014, at least 49 countries in Africa required or were in the process of requiring the registration of personally identifiable data in order to activate a prepaid subscriber identification module (SIM) card for national security purposes [47]. Although the mandatory registration of SIM cards has been met with controversies over privacy, access to population-based mobile phone ownership has allowed governments to send alerts to citizens when there are threats to security (e.g., terrorism). With the capability to reach broad audiences, member countries of PASCAR could utilize this platform to disseminate health education and support goals associated with the different stages of the HCC. For instance, to prevent hypertension through behavior modification, member countries could use the national mobile phone registry to send messages related to the adoption of healthier lifestyles (e.g., promote physical activity, healthy eating). However, given the privacy concerns, study designs using these platforms would need to undergo careful evaluation for legality, ethical considerations, feasibility, and acceptability prior to implementation.

Conclusions

The recent development of technology in SSA provides great potential to incorporate telehealth strategies into the different stages of the HCC. In the context of SSA, telehealth interventions are potentially scalable due to the accessibility and lower costs associated with mobile phone ownership. Given the paucity of published work on telehealth interventions in hypertension, some of the key questions for researchers and policymakers in SSA include the following:

- In adaptation of telehealth approaches used in communicable diseases interventions, what are the active components of the intervention that should be adapted?
- On the current infrastructure where governments have access to individual data through SIM registration, to what extent can the different telehealth approaches be successfully delivered to the intended sub-populations? Which stages of the HCC would be more likely to produce significant results?
- How can telehealth approaches be integrated into the existing healthcare systems in SSA?
- Are telehealth interventions for hypertension control cost-effective in SSA?

Funding Information CM effort was supported by a diversity supplement from the National Heart, Lung, and Blood Institute of the National Institutes of Health (NHLBI) U01HL142099-01S1. PM received support from the NIH Ruth L. Kirschstein National Research Service Award (NRSA) 5T32AI007392 and US National Institutes of Health Fogarty International Center grant D43W009337. LZ was supported by a VA Health Service Research and Development (HSR&D) Career Development Award (CDA 13-025). We also acknowledge support received from the Duke University Center for AIDS Research grant 5P30AI064518.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

Disclaimer The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

References

Papers of particular interest, published recently, have been highlighted as:
- • Of importance
- •• Of major importance

1. Ibrahim MM, Damasceno A. Hypertension in developing countries. Lancet (London, England). 2012;380(9841):611–9.
2. Mills KT, Bundy JD, Kelly TN, Reed JE, Kearney PM, Reynolds K, et al. Global disparities of hypertension prevalence and control: a systematic analysis of population-based studies from 90 countries. Circulation. 2016;134(6):441–50.
3. Pauletto P, Caroli M, Pessina AC, Dal PC. Hypertension prevalence and age-related changes of blood-pressure in semi-nomadic and urban Oromos of Ethiopia. Eur J Epidemiol. 1994;10(2):159–64.
4. Kabudula CW, Houle B, Collinson MA, Kahn K, Gómez-Olivé FX, Clark SJ, et al. Progression of the epidemiological transition in a rural South African setting: findings from population surveillance in Agincourt, 1993–2013. BMC Public Health. 2017;17(1):424.
5. Hendriks ME, Wit FW, Roos MT, Brewster LM, Akande TM, de Beer IH, et al. Hypertension in sub-Saharan Africa: cross-sectional

surveys in four rural and urban communities. PLoS One. 2012;7(3): e32638.
6. Njelekela M, Negishi H, Nara Y, Tomohiro M, Kuga S, Noguchi T, et al. Cardiovascular risk factors in Tanzania: a revisit. Acta Trop. 2001;79(3):231–9.
7. Nyirenda MJ. Non-communicable diseases in sub-Saharan Africa: understanding the drivers of the epidemic to inform intervention strategies. Int Health. 2016;8(3):157–8.
8. Twagirumukiza M, De Bacquer D, Kips JG, de Backer G, Stichele RV, Van Bortel LM. Current and projected prevalence of arterial hypertension in sub-Saharan Africa by sex, age and habitat: an estimate from population studies. J Hypertens. 2011;29(7):1243–52.
9. WHO. Global status report on noncommunicable diseases 2014 2014 [Available from: https://www.who.int/nmh/publications/ncd-status-report-2014/en/. Accessed 13 May 2019.
10. Dzudie A, Rayner B, Ojji D, Schutte AE, Twagirumukiza M, Damasceno A. PASCAR task force on hypertension. Roadmap to achieve 25% hypertension control in Africa by 2025. Cardiovasc J Afr. 2018;28(4):262–72.
11. Lim SS, Vos T, Flaxman AD, Danaei G, Shibuya K, Adair-Rohani H, et al. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet (London, England). 2012;380(9859): 2224–60.
12. Kayima JWR, Wanyenze RK, Katamba A, Leontsini E, Nuwaha F. Hypertension awareness, treatment and control in Africa: a systematic review. BMC Cardiovasc Disord. 2013;13(54). https://doi.org/10.1186/1471-2261-13-54.
13. Ataklte F, Erqou S, Kaptoge S, Taye B, Echouffo-Tcheugui JB, Kengne AP. Burden of undiagnosed hypertension in sub-saharan Africa: a systematic review and meta-analysis. Hypertension (Dallas, Tex : 1979). 2015;65(2):291–8.
14. Wozniak GKT, Gillespie C, Sifuentes L, Hasan O, Ritchey M, Kmetik K, et al. Hypertension control cascade: a framework to improve hypertension awareness, treatment, and control. J Clin Hypertens (Greenwich). 2015;18(3):232–9.
15. Booth JN 3rd, Li J, Zhang L, Chen L, Muntner P, Egan B. Trends in prehypertension and hypertension risk factors in US adults: 1999–2012. Hypertension (Dallas, Tex : 1979). 2017;70(2):275–84.
16. Pickering TGHJ, Appel LJ, Falkner BE, Graves J, Hill MN, et al. Recommendations for blood pressure measurement in humans and experimental animals: part 1: blood pressure measurement in humans: a statement for professionals from the Subcommittee of Professional and Public Education of the American Heart Association Council on High Blood Pressure Research. Circulation. 2005;111:697–716.
17. Armstrong C. JNC8 guidelines for the management of hypertension in adults. Am Fam Physician. 2014;90(7):503–4.
18. Whelton PK, Carey RM, Aronow WS, Casey DE Jr, Collins KJ, Dennison Himmelfarb C, et al. ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. Hypertension. 2017. https://doi.org/10.1161/HYP.0000000000000065.
19. Chopra HK, Ram CVS. Recent guidelines for hypertension. Circ Res. 2019;124(7):984–6.
20. Vedanthan R, Bernabe-Ortiz A, Herasme OI, Joshi R, Lopez-Jaramillo P, Thrift AG, et al. Innovative approaches to hypertension control in low- and middle-income countries. Cardiol Clin. 2017;35(1):99–115.
21. Piette JD, List J, Rana GK, Townsend W, Striplin D, Heisler M. Mobile health devices as tools for worldwide cardiovascular risk reduction and disease management. Circulation. 2015;132(21): 2012–27.
22. WHO. mHealth: new horizons for health through 414 mobile technologies. 2011 [Available from: http://www.who.int/goe/publications/goe_mhealth_web.pdf. Accessed 14 May 2019.
23. WHO. Telehealth 2019 [Available from: https://www.who.int/sustainable-development/health-sector/strategies/telehealth/en/.
24. June McKoy KF, Margetts M, Heckinger E, Specker J, Roth L, Izenberg M, et al. Are telehealth technologies for hypertension care and self-management effective or simply risky and costly? Popul Health Manag. 2015;18(3).
25. Kvedar J, Coye MJ, Everett W. Connected health: a review of technologies and strategies to improve patient care with telemedicine and telehealth. Health Aff (Millwood). 2014;33(2):194–9.
26. Thiboutot J, Sciamanna CN, Falkner B, Kephart DK, Stuckey HL, Adelman AM, et al. Effects of a web-based patient activation intervention to overcome clinical inertia on blood pressure control: cluster randomized controlled trial. J Med Internet Res. 2013;15(9): e158.
27. CA RJD, Anderson ML, Catz SL, Fishman PA, Carlson J, Johnson R, et al. Home blood pressure monitoring, secure electronic messaging and medication intensification for improving hypertension control: a mediation analysis. Appl Clin Inform. 2014;12(5(1)): 232–48.
28. Zullig LL, Melnyk SD, Stechuchak KM, McCant F, Danus S, Oddone E, et al. The Cardiovascular Intervention Improvement Telemedicine Study (CITIES): rationale for a tailored behavioral and educational pharmacist-administered intervention for achieving cardiovascular disease risk reduction. Telemed J E Health. 2014;20(2):135–43.
29. Sivakumaran D, Earle KA. Telemonitoring: use in the management of hypertension. Vasc Health Risk Manag. 2014;10:217–24.
30. Okoro EO, Sholagberu HO, Kolo PM. Mobile phone ownership among Nigerians with diabetes. Afr Health Sci. 2010;10(2):183–6.
31. Hacking D, Haricharan HJ, Brittain K, Lau YK, Cassidy T, Heap M. Hypertension health promotion via text messaging at a community health center in South Africa: a mixed methods study. JMIR mHealth uHealth. 2016;4(1):e22.
32. Haricharan HJ, Heap M, Hacking D, Lau YK. Health promotion via SMS improves hypertension knowledge for deaf South Africans. BMC Public Health. 2017;17(1):663.
33. Haskew J, Ro G, Saito K, Turner K, Odhiambo G, Wamae A, et al. Implementation of a cloud-based electronic medical record for maternal and child health in rural Kenya. Int J Med Inform. 2015;84(5):349–54.
34. Mannik J, Figol A, Churchill V, Aw J, Francis S, Karino E, et al. Community-based screening for cardiovascular risk using a novel mHealth tool in rural Kenya. J Innov Health Inform. 2018;25(3): 176–82.
35. Nelissen HE, Cremers AL, Okwor TJ, Kool S, van Leth F, Brewster L, et al. Pharmacy-based hypertension care employing mHealth in Lagos, Nigeria - a mixed methods feasibility study. BMC Health Serv Res. 2018;18(1):934.
36. Sarfo FS, Treiber F, Gebregziabher M, Adamu S, Nichols M, Singh A, et al. Phone-based intervention for blood pressure control among Ghanaian stroke survivors: a pilot randomized controlled trial. Int J Stroke. 2018. https://doi.org/10.1177/1747493018816423.
37. Bobrow K, Farmer AJ, Springer D, Shanyinde M, Yu LM, Brennan T, et al. Mobile phone text messages to support treatment adherence in adults with high blood pressure (SMS-text adherence support [StAR]): a single-blind, Randomized Trial. Circulation. 2016;133(6):592–600.
38. Kingue S, Angandji P, Menanga AP, Ashuntantang G, Sobngwi E, Dossou-Yovo RA, et al. Efficiency of an intervention package for arterial hypertension comprising telemanagement in a Cameroonian

rural setting: the TELEMED-CAM study. Pan Afr Med J. 2013;15:153.
39. Yohannes Kinfu MRDP, Mercer H, Evans DB. The health worker shortage in Africa: are enough physicians and nurses being trained? WHO Bulletin; 2009. [Available from: https://www.who.int/workforcealliance/knowledge/resources/hrh_africa_training/en/. Accessed 20 Jun 2019.
40. Bloomfield GS, Vedanthan R, Vasudevan L, Kithei A, Were M, Velazquez EJ. Mobile health for non-communicable diseases in sub-Saharan Africa: a systematic review of the literature and strategic framework for research. Glob Health. 2014;10:49.
41. Sondaal SF, Browne JL, Amoakoh-Coleman M, Borgstein A, Miltenburg AS, Verwijs M, et al. Assessing the effect of mHealth interventions in improving maternal and neonatal care in low- and middle-income countries: a systematic review. PLoS One. 2016;11(5):e0154664.
42. Kiwanuka N, Mpendo J, Asiimwe S, Ssempiira J, Nalutaaya A, Nambuusi B, et al. A randomized trial to assess retention rates using mobile phone reminders versus physical contact tracing in a potential HIV vaccine efficacy population of fishing communities around Lake Victoria, Uganda. BMC Infect Dis. 2018;18(1):591.
43. Winskell K, Sabben G, Akelo V, Ondeng'e K, Obong'o C, Stephenson R, et al. A smartphone game-based intervention (Tumaini) to prevent HIV among young Africans: pilot randomized controlled trial. JMIR mHealth uHealth. 2018;6(8):e10482.
44. Negin JC, R. G. HIV infection in older adults in sub-Saharan Africa: extrapolating prevalence from existing data. Bull World Health Organ. 2010;88:847–53.
45. Noar SM, Willoughby JF. eHealth interventions for HIV prevention. AIDS Care. 2012;24(8):945–52.
46. Jongbloed KPS, van der Kop M, Spittal PM, Lester RT. Recent evidence for emerging digital technologies to support global HIV engagement in care. Curr HIV/AIDS Rep. 2015;12(4):451–61.
47. Donovan KP, Martin AK. The rise of African SIM registration: the emerging dynamics of regulatory change. First Monday. 2014;19:1–2. https://doi.org/10.2139/ssrn.2172283. https://ssrn.com/abstract=2172283. Accessed 20 Jun 2019.