Circulation Research

HYPERTENSION COMPENDIUM

Hypertension in Low- and Middle-Income Countries

Aletta E. Schutte, Nikhil Srinivasapura Venkateshmurthy, Sailesh Mohan, Dorairaj Prabhakaran

ABSTRACT: In recent decades low- and middle-income countries (LMICs) have been witnessing a significant shift toward raised blood pressure; yet in LMICs, only 1 in 3 are aware of their hypertension status, and ≈8% have their blood pressure controlled. This rising burden widens the inequality gap, contributes to massive economic hardships of patients and carers, and increases costs to the health system, facing challenges such as low physician-to-patient ratios and lack of access to medicines. Established risk factors include unhealthy diet (high salt and low fruit and vegetable intake), physical inactivity, tobacco and alcohol use, and obesity. Emerging risk factors include pollution (air, water, noise, and light), urbanization, and a loss of green space. Risk factors that require further in-depth research are low birth weight and social and commercial determinants of health. Global actions include the HEARTS technical package and the push for universal health care. Promising research efforts highlight that successful interventions are feasible in LMICs. These include creation of health-promoting environments by introducing salt-reduction policies and sugar and alcohol tax; implementing cost-effective screening and simplified treatment protocols to mitigate treatment inertia; pooled procurement of low-cost single-pill combination therapy to improve adherence; increasing access to telehealth and mHealth (mobile health); and training health care staff, including community health workers, to strengthen team-based care. As the blood pressure trajectory continues creeping upward in LMICs, contextual research on effective, safe, and cost-effective interventions is urgent. New emergent risk factors require novel solutions. Lowering blood pressure in LMICs requires urgent global political and scientific priority and action.

Key Words: developing countries ■ diet ■ epidemiology ■ lifestyle ■ risk factors

The increasing burden of hypertension and its devastating consequences have come into focus only recently. We have come a long way from masterly inactivity as proposed by the physician of Franklin D. Roosevelt to the current aggressive management of hypertension as proposed by the American guidelines[1] based on the SPRINT (Systolic Blood Pressure Intervention Trial) results. Today, noncommunicable diseases (NCDs) such as cardiovascular disease (CVD), diabetes, cancers, and chronic respiratory disease are the leading cause of preventable disease, death, and disability, accounting for three-quarters of the 56.5 million deaths globally from all causes in 2019.[2] Nearly one-third (18.6 million) of these deaths in 2019 were due to CVD. The leading risk factor is raised blood pressure (BP) or hypertension, which accounted for 10.8 million deaths (19.2% of all deaths in 2019) and 9.3% of disability-adjusted life-years lost globally.[3,4]

There are many consequences of raised BP. A 20-mm Hg increase in systolic BP (SBP) is associated with a 35% greater risk for ischemic stroke (95% CI, 1.28–1.42), 29% greater risk for myocardial infarction (95% CI, 1.25–1.34), and a 10-mm Hg increase in diastolic BP with 45% increased risk for abdominal aortic aneurism (95% CI, 1.34–1.56).[5] A 20/10-mm Hg elevation from 120/80 mm Hg increases the adjusted relative risk of developing end-stage renal disease 2.6-fold.[6] Midlife and late-life hypertension is also associated with a 41% to 62% increased risk of incident dementia.[7]

Over the past 3 decades, raised BP has transitioned from a significant burden in high-income countries (HICs) to one that is now highly prominent in

Correspondence to: Aletta E. Schutte, PhD, School of Population Health, University of New South Wales Sydney, Kensington Campus, Samuels Bldg, NSW 2052, Australia. Email a.schutte@unsw.edu.au

The Data Supplement is available with this article at https://www.ahajournals.org/doi/suppl/10.1161/CIRCRESAHA.120.318729.

For Disclosures, see page 822.

Circulation Research is available at www.ahajournals.org/journal/res

Nonstandard Abbreviations and Acronyms

ACE	angiotensin-converting enzyme
aOR	adjusted odds ratio
BP	blood pressure
COVID-19	coronavirus disease 2019
CVD	Cardiovascular Disease
GBD	Global Burden of Disease
HIC	high-income country
ISH	International Society of Hypertension
LMIC	low- and middle-income country
NCD	noncommunicable disease
OR	odds ratio
PURE	Prospective Urban Rural Epidemiology
SBP	systolic blood pressure
SEV	summary exposure value
SPRINT	Systolic Blood Pressure Intervention Trial
TIPS-3	The International Polycap Study 3
TRIUMPH	Triple Pill Versus Usual Care Management for Patients With Mild-to-Moderate Hypertension
UHC	universal health coverage
WHO	World Health Organization

low- and middle-income countries (LMICs) including South and East Asia and Sub-Saharan Africa. This is evident from figures in 2015, where 23% of the 1.13 billion adults with raised BP lived in South Asia (199 million in India) and another 21% (235 million) in East Asia.[8] Uncontrolled hypertension is higher in LMICs compared with HICs.[9–12] It has not only several implications for the health of affected individuals and resource-constrained health systems in LMICs but also has substantial societal, developmental, and economic costs.

In this review, we report the epidemiology and burden of hypertension in LMICs according to the World Bank regions. Further, we examine the specific features and challenges in LMICs regarding the etiology, prevention, and management of hypertension. We also highlight the current research gaps and suggest key recommendations that can potentially help address the rising burden of uncontrolled hypertension in LMICs.

EPIDEMIOLOGY AND BURDEN OF DISEASE IN LMICS

Mortality and Disability

The prevalence of hypertension is increasing rapidly in many LMICs that are undergoing diverse health transitions. Using the GBD study (Global Burden of Disease) data, we examined the epidemiology and burden as per the World Bank classification of the world according to income levels. In 2019, the highest age-standardized death rates from CVD and SBP were reported from lower-middle-income and low-income countries (Table 1).

The deaths attributable to high SBP were the highest in the Middle East and North Africa and Sub-Saharan regions when compared with North America (Table I in the Data Supplement). In terms of disability-adjusted life-years lost, years lived with disability, and years of life lost, it was highest in upper middle-income countries (Table II in the Data Supplement). disability-adjusted life-years and years of life lost were the highest in Europe and Central Asian Regions while East Asia and Pacific Region had the highest loss in years lived with disability. When looking at changes in these 3 indices between 1990 and 2019, increases were observed in upper middle- and lower middle-income countries, whereas in HICs, it decreased. During this period, disability-adjusted life-years, years lived with disability, and years of life lost increased in all regions except in North America and European Regions (Figure 1).

Prevalence

A third of all adults are estimated to have hypertension, which translates to about 1.4 billion adults. Population-based reports on hypertension estimates are available for many LMICs, but an expansion of high-quality studies that accurately measure BP from LMICs are encouraged.[13] The GBD Study (which undertakes estimation of risk factors by sophisticated statistical modeling techniques including available large-scale national household surveys, population-level surveys provided by collaborators, programme-level data from government agencies, and systematic reviews of epidemiological studies) obtained a summary measure of exposure for each risk, called the summary exposure value (SEV).[14] The SEV is a metric that captures risk-weighted exposure for a population or risk-weighted prevalence of an exposure. The scale for SEV spans from 0% to 100%, with a SEV of 0% reflecting no risk exposure in a population and 100% indicating that an entire population is exposed to the maximum possible risk. In the absence of adequate national prevalence data on trends, this provides an indication of the likely burden of the risk factors or exposure to them in a population. Figure 2 shows the SEVs of the past 3 decades in the different World Bank regions and indicates an increasing trend in high SBP in several regions, especially in Sub-Saharan Africa, the Middle East and North Africa, East Asia, and the Pacific. Apart from the GBD data, a recent study that pooled data from 44 LMICs (1 100 507 participants) showed the prevalence of hypertension to be 17%.[15] The 2019 May Measurement Month campaign (1 508 130 screenees) reported that 34% had hypertension. Among those screened, 29.3% had hypertension in the South Asia region, while

Table 1. Age-Standardized Deaths (per 100 000 With 95% CIs) Due to CVD, High SBP, and High Sodium Intake According to World Bank Income Classification of Countries in 2019

	World Bank income classification of countries			
	High income	Upper middle income	Lower middle income	Low income
Deaths due to CVD	133 (118–142)	267 (24–283)	313 (287–337)	304 (270–340)
CVD deaths due to high SBP	64 (54–74)	143 (121–164)	172 (149–197)	167 (142–192)
Deaths due to high SBP	72 (61–83)	153 (131–175)	187 (162–213)	184 (157–211)
Deaths due to diet high in sodium	9 (1–24)	35 (11–69)	22 (3–58)	26 (3–71)

CVD indicates cardiovascular disease; and SBP, systolic blood pressure.

corresponding numbers in East Asia and Sub-Saharan Africa were 30.6% and 27.9%, respectively.[9]

ETIOLOGY AND PATHOPHYSIOLOGY–SPECIFIC FEATURES AND CHALLENGES IN LMICS

Diet and Physical Activity

A total of 27 dietary factors have been identified, which either increase the risk of developing hypertension or are protective.[16] Some prominent factors are sodium, potassium, fruits and vegetables, and alcohol.[16] The consumption of healthy and unhealthy diets var substantially between LMICs and HICs and also according to cultures and geographies.

There is an exceptionally strong relation between unhealthy diets and income, with low-income countries having the highest score for consumption of unhealthy diet compared with HICs (76 versus 46).[17] The affordability and availability of healthy foods such as fruits, vegetables, and nuts may explain some of these trends. A cost analysis of affordability for the EAT-Lancet healthy planetary diet shows that the proportion of mean daily household income per capita spent was 6% for HIC. By contrast, it was 28%, 52%, and 89% for upper middle, lower middle, and low-income countries.[18] These findings reflect the higher costs of consuming healthier diets and how low socioeconomic status likely limits the adoption of healthy dietary behaviors that are necessary for the prevention and control of hypertension.

The positive relationship between a high-salt diet and hypertension has been confirmed by multiple observational studies, trials, and meta-analyses.[19] As a result, several health organizations, including the World Health Organization (WHO), recommend restricting intake to <5 g/d. A meta-analysis reported that a reduction of ≈4.5 g of salt per day was associated with a decrease of 4.9 mm Hg of SBP and 2.7 mm Hg of diastolic BP among patients with hypertension as compared with 2.0 and 1.0 mm Hg, respectively, among people with no hypertension.[20] Food items like bread, meat and meat products, milk and dairy products, instant noodles, condiments, salted preserved foods, and bakery products contribute to high-salt diets in LMICs.[21] Low potassium intake, through inadequate consumption of fruits and vegetables, is also a major cause of high BP.[22,23]

Many hypertension treatment guidelines recommend regular physical activity to reduce BP. Yoga has also been found effective in reducing BP among patients with hypertension[24] and is recommended in the 2020 International Society of Hypertension (ISH) Hypertension Guidelines.[25] It is understood that practicing yoga and meditation may contribute to improved autonomic balance leading to a reduction in BP.[26]

Over the past decades, abundant epidemiological studies have confirmed that several elements of a healthy lifestyle and behaviors are related to BP lowering, as summarized in Table 2.

Tobacco and Alcohol

Tobacco kills >8 million people a year, with the stark reality that over 80% of all tobacco users live in LMICs.[35] With declining rates of tobacco consumption in HICs, the tobacco industry is shifting its focus to LMICs targeting the growing number of adolescents.[36] Tobacco and hypertension are independent risk factors for CVD. However, the link between tobacco and hypertension is unclear. Most of the evidence of tobacco and hypertension linkage is from smoking cigarettes. Tobacco use should be discouraged to reduce the absolute risk for vascular mortality among those with hypertension.

Alcohol is one of the most frequently abused substances worldwide. Though the prevalence of current alcohol drinkers is high in HICs (67.3%) compared with upper middle (47.4%), lower middle (30.1%), and low-income (26.8%) countries, the prevalence of heavy episodic drinking is high in low-income (45.4%) and upper-middle-income (40.7%) and similar in lower-middle-income (37.7%) countries, as compared with HICs (38.7%).[37] Recent evidence from the GBD study shows there is no safe level of alcohol drinking.[38]

Obesity

LMICs are facing a double burden of malnutrition, namely the coexistence of undernutrition and overweight

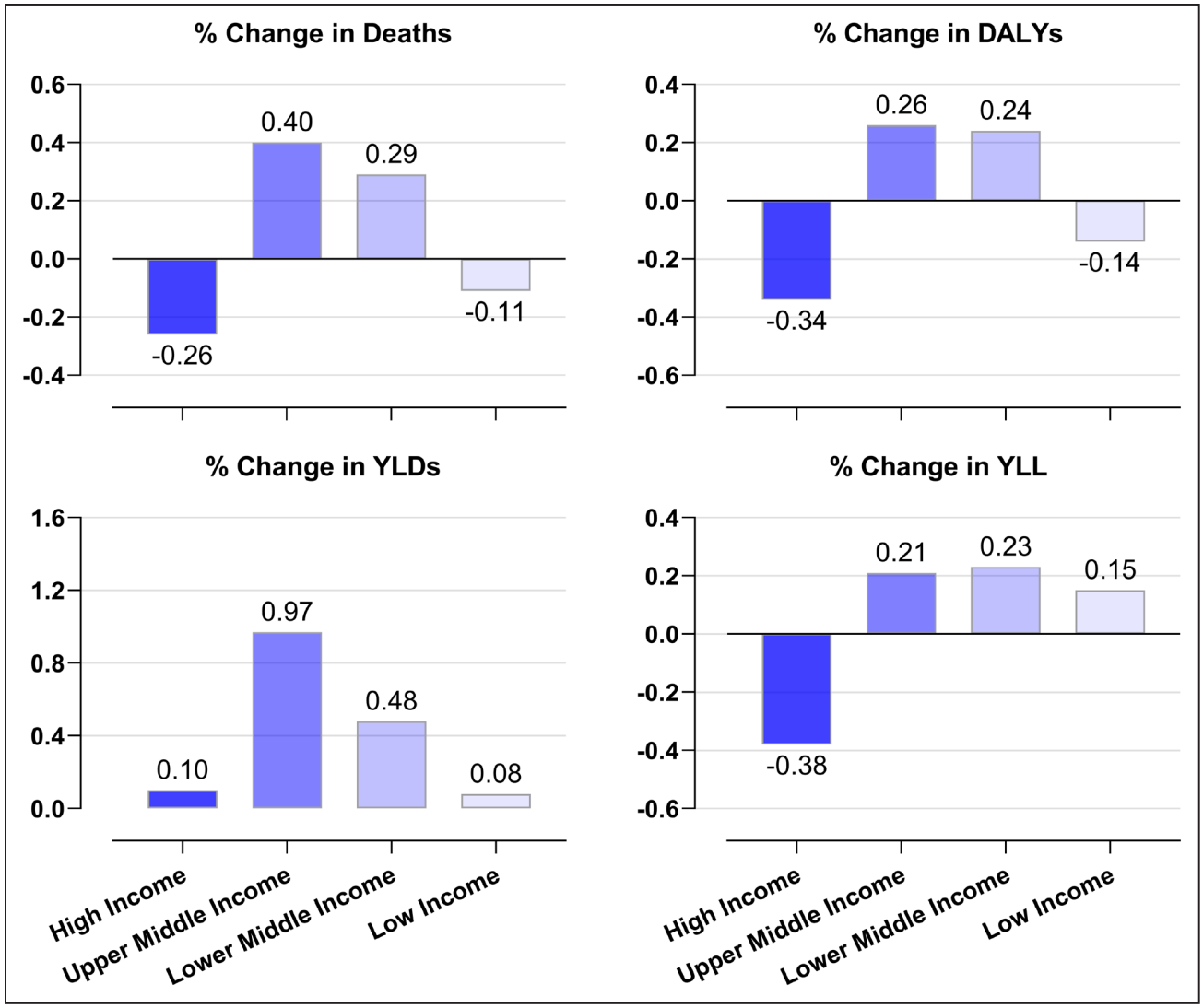

Figure 1. Percentage change in deaths, disability-adjusted life-years (DALYs), years lived with disability (YLDs), and years of life lost (YLLs) due to high systolic blood pressure according to the World Bank income classification of countries between 1990 and 2019.

or obesity.[39] Nearly half of the world's 671 million obese population lives in 10 countries, of which 6 are LMICs. India and China together contribute to 15% of the global obese population, despite a low prevalence of obesity.[40] Obesity, defined as body mass index ≥30 kg/m^2, is an important risk factor for CVD, exerting detrimental effects through several mechanisms.[41] Obesity may also lead to the development of chronic kidney disease, which in turn increases BP and hampers efforts to control BP among those with hypertension.[42]

Social and Commercial Determinants of Health

Social determinants include the *causes of the causes* of health inequality. These are the unequal conditions in which people are born, grow, live, work, and age. These unequal conditions depend on a person's socioeconomic status, sex, ethnicity, and disability.[43] Social determinants influence the distribution of risk factors for hypertension, such as unhealthy diets, physical inactivity, and tobacco and alcohol consumption. People in the low socioeconomic groups in LMICs are more likely to consume unhealthy diets and use tobacco and alcohol.[44] People in poor neighborhoods are also more likely to be exposed to air pollution[45]—an emerging risk factor for hypertension. Once diagnosed with hypertension, people with low socioeconomic status are less likely to afford out-of-pocket expenses for antihypertensive medication, leading to uncontrolled hypertension and early development of complications. The interplay between poverty and NCDs (which includes CVD, for which hypertension is an important risk factor)[46] is depicted in Figure 3.

More recently, it has also been established that unhealthy behaviors are often influenced by commercial determinants of health, namely "strategies and approaches used by the private sector or select industries

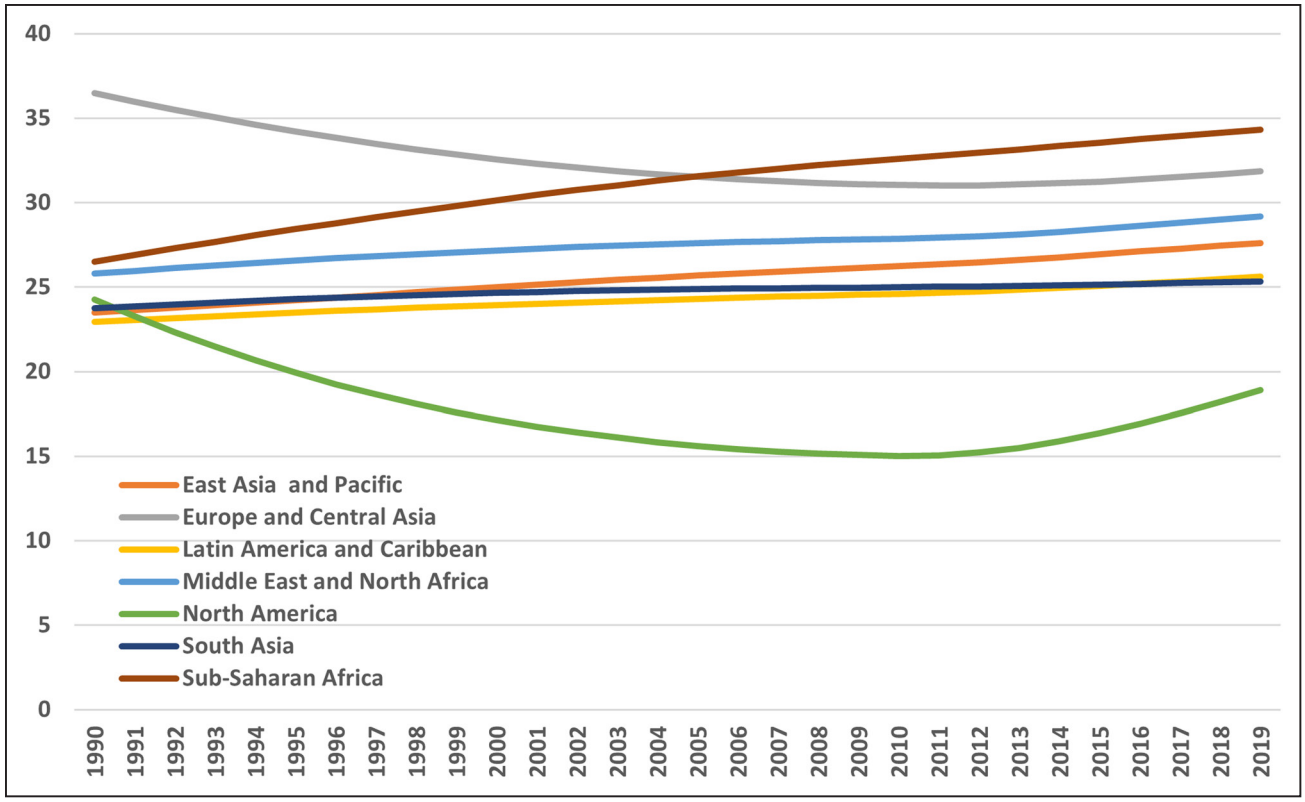

Figure 2. Trends in age-standardized summary exposure value of high systolic blood pressure, for the World Bank regions from 1990 to 2019.

to promote products and choices that are detrimental to health."[47] Large corporations selling unhealthy foods and tobacco often target consumers including children, public health professionals and organizations, researchers and research organizations, civil society, national governments, and even United Nations through their activities and earn profits at the expense of the health of individuals and societies. One example of such an activity is the sponsorship of sporting events.[48] Thus, a whole systems approach is needed to tackle the causes of the causes and a lifecourse approach to address such social inequalities and vested commercial determinants.[49]

Green Space, Pollution, and Urbanization

Environmental factors such as green space (eg, the amount of tree canopy), pollution, and urbanization are strongly associated with raised BP. Between 2001 and 2018, LMICs have had the most extensive urban expansion and the highest urban population growth compared with HIC.[50] Air pollution is 17× greater in cities of LMICs compared with that in North America and Europe.[51] The urban poor are disproportionately affected by air pollution as they live closer to industries and air-polluting activities.[52] The prevalence of hypertension among people exposed to >30% green space was 1.9 percentage points lower compared with those who were exposed to 0% to 4% green space. One percent increase in the amount of tree canopy was associated with lower odds of incident hypertension.[53] The effect of green space on hypertension can be explained by a multitude of factors that need to be considered in urban health planning in rapidly growing metropolitan areas in LMICs. Green space reduces exposure to environmental stressors such as air pollution, heat, and noise. It further enables physical activity and mental health and encourages social interaction and cohesion.[54]

Environmental pollution is becoming an increasingly important risk factor for hypertension, including water, noise,[55] light, and notably air pollution. Polluted air contains particulate matter of different sizes, of which $PM_{2.5}$ is particularly important. The particulate matter in the lungs leads to pulmonary oxidative stress and inflammation initiated by the release of cytokines, activated immune cells, and vasoactive molecules.[56] The soluble constituents in the inhaled polluted air can cross the alveolar membrane reaching the bloodstream and directly affecting the vascular endothelium resulting in vasoconstriction and arterial stiffness.[57] Particulate matter can also stimulate the autonomic nervous system resulting in sympathetic nervous system–mediated arterial vasoconstriction.[58] A recent study from India showed that for each interquartile range increase in monthly $PM_{2.5}$ exposure, SBP increased by 1.8 mm Hg and diastolic BP increased by 1.1 mm Hg.[59] Reducing the $PM_{2.5}$ level to recommended standards was estimated to potentially decrease the prevalence of hypertension by 15%.[59]

Table 2. Healthy Lifestyle and SBP

Modification	SBP reduction, mm Hg
Weight reduction	5–20 mm Hg per 10 kg of weight loss[27,28]
Adopting DASH diet	8–14[29,30]
Dietary salt/sodium reduction	2–8[29–31]
Physical activity	4–9[32,33]
Moderation in alcohol consumption	2–4[34]

DASH indicates Dietary Approaches to Stop Hypertension; and SBP, systolic blood pressure.

With the rapid migration of vast populations from rural to urban areas in most LMICs, it is now clear that the confluence of several exposures accompanying urbanization is conducive to the rapid development of hypertension. Urbanization leads to a nutrition transition (consumption of foods high in fat, salt, and sugar and low in fruits and vegetables), a decrease in physical activity, adoption of a sedentary lifestyle, greater access to tobacco, alcohol, and other unhealthy substances, and exposure to an environment characterized by pollution (air, water, light, and noise), stress, and a lower amount of green spaces. Understanding these pathways is essential to develop and implement interventions to prevent and curb hypertension development in this rapidly growing population.

Developmental Origins of Health and Exposures Across the Life Course

Epidemiological studies have examined the association between low birth weight and adult BP.[60–62] The global prevalence of low birth weight in 2015 was estimated to be 14.6% (95% CI, 12.4–17.1). But the prevalence in southern Asia was much higher at 26.4% (95% CI, 18.6–35.2). The prevalence in Sub-Saharan Africa was slightly lower than the global estimate at 14.0% (95% CI, 12.2–17.2). Southeast Asia and Oceania (excluding Australia and New Zealand) and northern Africa too had lower prevalence at 12.2%.[63]

Low birth weight affects kidney structure and function, is associated with an increase in large artery stiffness,[64] a reduction in the size of the aorta,[65] and an increase in aortic wall thickness, which may result in early vascular aging[66] (Figure 4). There is a cyclical relationship between hypertension and endothelial dysfunction—worsening of one may lead to worsening of the other.[68]

The mechanisms by which low birth weight affects BP are complex and involve nutrition, inflammation, glucocorticoids, and epigenetic changes.[69–73] It is, therefore, of paramount importance to improve nutritional quality during the first 1000 days of life, spanning from pregnancy to approximately age two (Figure 4), as it has far-reaching effects for future cardiovascular and metabolic health, cognition, and sociobehavioral development. These putative lifecourse risk factors, including low socioeconomic status, poor growth, shorter leg length, poor diet, and obesity, are strongly associated with chronic diseases in adult life and of increasing relevance in LMICs.[74]

PREVENTION AND MANAGEMENT: IMPLEMENTATION BARRIERS AND ACTIONS

Awareness, Treatment, and Control

Global hypertension disparities are substantial and continue to increase.[75] When comparing HICs with LMICs from 2000 to 2010, the proportions of awareness, treatment, and control improved by ≥10% in HICs. In LMICs, however, improvements were limited for awareness (32.3%–37.9%) and treatment (24.9%–29.0%) and even slightly declined for control (8.4%–7.7%).[75] A recent analysis of individual-level data from 1.1 million adults in nationally representative samples in 44 LMICs reports that among those with hypertension, 26% had never had their BP measured, 39% had been diagnosed with hypertension before the survey, 30% had been treated, and only 10% had achieved control of their hypertension.[15] The best hypertension care performance was found in Latin America and the Caribbean, whereas countries in Sub-Saharan Africa tended to show the poorest performance.

The first significant barrier to address in LMICs is its exceptionally poor awareness. The Lancet Commission on Hypertension proposed that "every adult should know their BP"—a critically important starting point.[67] In response to this call, the ISH launched a global BP measurement awareness campaign, namely May Measurement Month, screening >4.2 million adults from 2017 to 2019.[10] In 2019, 92 countries participated, and of the 1.5 million screenees, one-third had never had a BP measurement taken before.[9] It is difficult to comprehend that a BP measurement, which is arguably the cheapest, easiest, and the most essential first step and convenient method to assess cardiovascular risk, is still not widely implemented.

With hypertension control rates of ≈10% in LMICs,[15] and with significant population boom occurring among many LMICs, there is a need for radical improvement in detection and treatment strategies. However, the implementation of hypertension control strategies in low-resource settings depends largely on cost considerations.[76] A recent review of economic evaluations of hypertension treatment programmes across 15 LMICs found hypertension control to be a highly cost-effective intervention. However, there are apparent gaps in evidence on critical programme elements to improve cost-effectiveness. These include task-sharing strategies and standardized treatment protocols.[76]

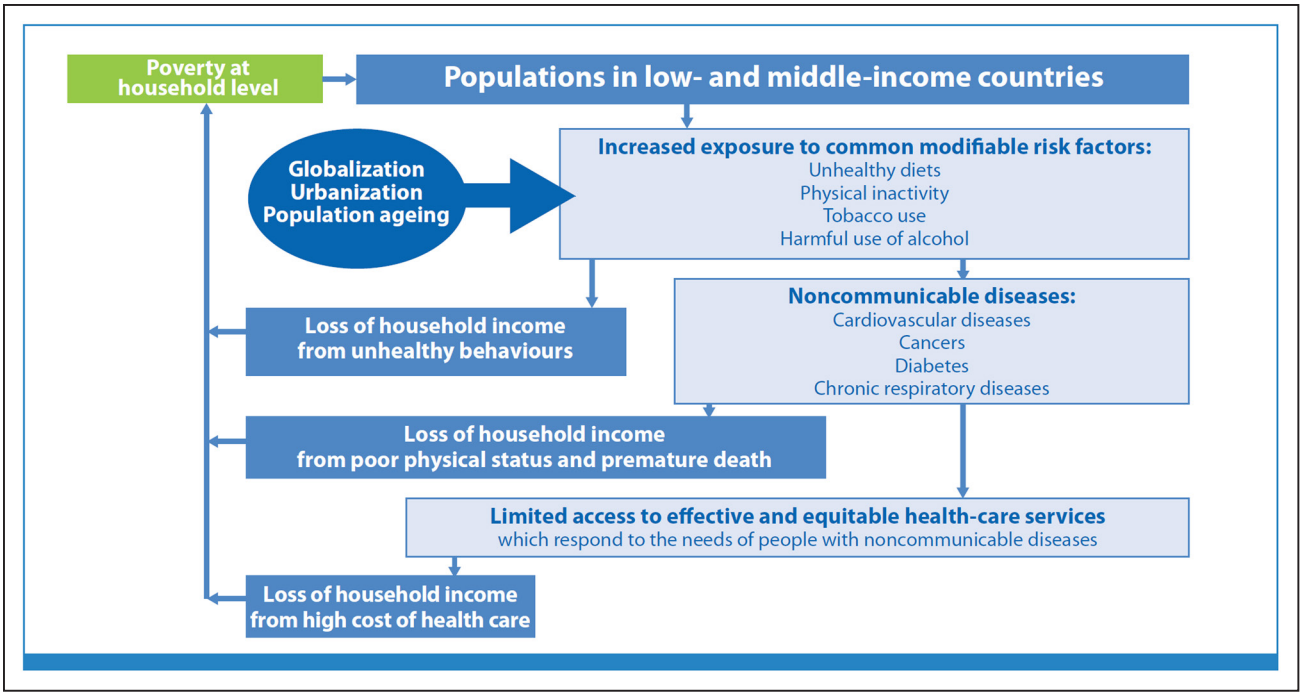

Figure 3. Relationship between poverty and noncommunicable diseases.
Reprinted from World Health Organization[46] with permission. Copyright © 2010, WHO.

Population-Based Approaches to Improve Cardiovascular Health

For improved control of hypertension, the individualized, targeted approach requires interventions to increase awareness, treatment, and control.[77,78] Individualized approaches are reliant on sufficient capacity by the health care system to ensure effective delivery of care—an aspect that remains challenging in LMICs as reflected by low physician-to-patient ratios and access to medicines. The emphasis is on curative care, rather than prevention.

Corresponding preventive population-based approaches involve interventions designed to achieve a small reduction in BP in the entire population. This mass approach, initially proposed by Geoffrey Rose,[79] has the potential to be far more effective by lowering the broader population risk in both hypertensives and normotensives.

The scope of population-based approaches that would be most effective in LMICs remains an important area of research. An overall understanding is that health-promoting environments should be created that encourage healthier living across the lifecourse, from preconception to the elderly[67] (Figure 4). This is highly relevant to LMICs where hypertension often occurs at younger ages (early vascular aging), and there is a growing burden of those with prehypertension, whose conversion to hypertension can be prevented or delayed through population-wide measures.

Such population-based approaches involve broad brush strokes and include the implementation of policies that support using sin taxes for, for example, tobacco, alcohol, and sugar-sweetened beverages, smoking restrictions, and ensuring safe built environments with sufficient green space that promotes mental health and physical activity. Ideally, sin tax revenue should be used to subsidize healthier food choices such as fruits and vegetables, which not only address the emerging obesity epidemic but would importantly increase potassium intake and other essential micronutrients.[67] A modeling study suggests that sugar tax would produce the biggest gains in health, followed by salt tax, saturated fat tax, and sugar-sweetened beverage tax.[80] Salt-reduction initiatives (such as industry engagement to reformulate products and the establishment of sodium content targets for foods) have been implemented widely, with 75 countries having a national salt-reduction strategy in 2015; yet, the authors conclude that wider initiation of strategies particularly in LMICs will be vital to achieving the WHO Member States target of a 30% global reduction in salt intake by 2025.[81] Other policy approaches should also gain higher priority on the agenda of health authorities in LMICs, such as best buys to impact future lifestyles including marketing (banning alcohol and fast food advertising).[82] Front-of-packet food labels were shown to encourage healthier choices made, and potentially a traffic light system may be implemented in regions with limited literacy levels.[83]

Hypertension Guidelines Targeting LMICs

In response to the startling reality that over three-quarters of heart disease and stroke-related deaths occur in

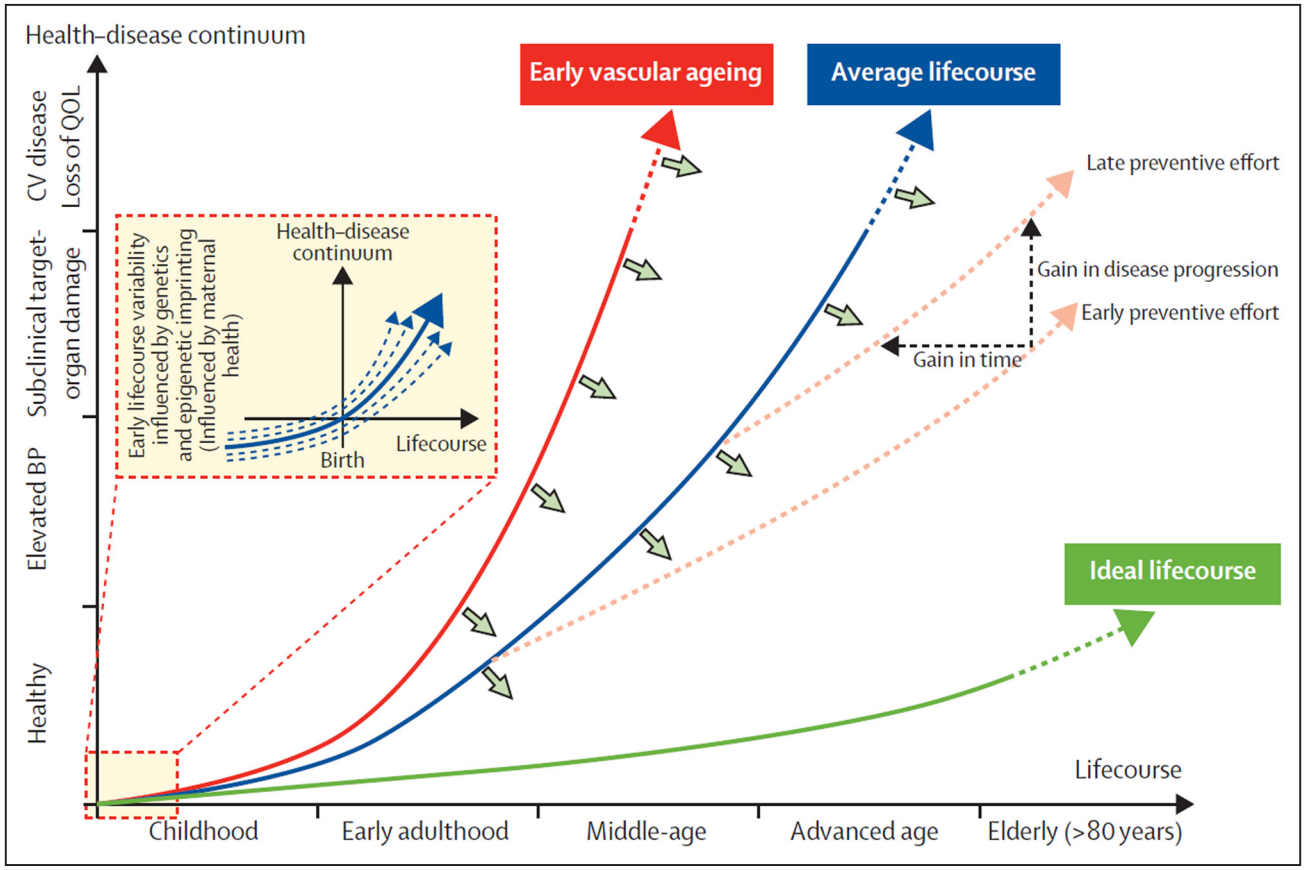

Figure 4. Early-life effects and preventive efforts across the life course to manage raised blood pressure (BP).
CV indicates cardiovascular; and QOL, quality of life. Reprinted from Olsen et al[67] with permission. Copyright © 2016, Elsevier, Lancet.

LMICs, the WHO and the US Centres for Disease Control and Prevention launched the Global Hearts Initiative. In partnership with several global organizations such as the American Heart Association, ISH, and Resolve to Save Lives, the HEARTS technical package[84] was developed with modules spanning

- Healthy-lifestyle counseling,
- Evidence-based treatment protocols,
- Access to essential medicines and technology,
- Risk-based CVD management,
- Team-based care, and
- Systems for monitoring.

This package is intended for use by policy makers and program managers within Ministries of Health and resource-limited settings. With availability in several languages, the implementation of the package should be promoted widely.

In recognition of the apparent shift of the highest BPs from high-income to low-income regions,[85] the ISH released the 2020 ISH Global Hypertension Practice Guidelines[25] and specifically tailored essential and optimal standards of care for the management of hypertension in low- and high-resource settings. While excellent evidence-based and thorough guidelines were released in the United States[1] and Europe[86] in previous years, these guidelines were designed for optimal care in HICs, and are thus not fit for a global purpose. The 2020 ISH Guidelines were produced in a practical format that is easy to use and to adapt according to local settings into national guidelines. It is relevant to low- but also high-resource settings for use by clinicians, nurses, and community health workers, as appropriate.

Aspects Relevant to LMICs Regarding Measurement and Diagnosis

Despite BP measurement being one of the most important tests in clinical medicine, inaccurate measurements can lead to diagnostic and management errors, and there remain major challenges in LMICs, particularly relating to the following:

Use of BP Devices That Are Not Validated for Accuracy

Since most BP devices available on the market are not validated for accuracy and generally cheaper than validated ones, health care officials in LMICs often purchase inappropriate devices.[87] Appropriate devices are listed on the STRIDE BP website (www.stridebp.org). In response to concerns about the lack of accurate, good-quality devices in LMICs, the WHO in 2020 published an updated report on technical specifications for automated

noninvasive BP-measuring devices with a cuff.[88] The WHO recognizes that automated measurements are gradually replacing manual BP measurement due to environmental concerns about mercury, poor calibration, and improper measurement with auscultatory devices, while acknowledging the superior, consistent accuracy of validated automated devices.[88]

Availability of BP Devices in Low-Resource Settings, Including Rural and Urban Health Care Environments

Key stakeholders expressed their concerns around the lack of accurate, good-quality BP devices, especially in LMICs, at a workshop on BP measurement during the Fourth WHO Global Forum on Medical Devices hosted by the Government of India in 2018.[89] The 2020 WHO technical report[88] on specifications of devices was developed in response to this concern, and although the report would assist implementers in procuring validated devices, the availability of devices in rural and urban settings cannot be guaranteed unless governments make active engagement. This is undoubtedly feasible when there is a political will, as was demonstrated by the HEARTS in the Americas program of the Pan American Health Organization, which held a meeting shortly following the release of the WHO Report to examine how national governments could best implement the recommendations. It is reassuring that several national government agencies were in the position to respond swiftly in introducing aligned device procurement policies. Cuba had already adopted many of the recommendations of the WHO report, including a certification course for BP measurement and the production, testing, and use of accuracy-validated electronic BP devices.

Optimizing the Performance of Health Care Practitioners in BP Measurement—Whether Clinicians, Nurses, or Community Health Workers

Accurate BP measurement is critical, even when using an automated validated device as recommended. A 5-mm Hg measurement error may lead to incorrect hypertension status classification in 84 million individuals worldwide.[90] A high-level recognition by government agencies is required on the importance and scope of proper hypertension care, which includes several practical aspects. Implementing team-based care, using a dedicated measurement workstation, and ensuring observer training (and retraining) is critical, especially since no-cost certification programmes are available for resource-constraint settings (eg, https://globalhypertensionathopkins.org/courses and www.stridebp.org/training).[90]

Most challenges in BP measurement faced by LMICs are relevant to the office or clinic BP measurement. But it should now be acknowledged that office BP measurement poses several challenges in the management of hypertension due to the variable nature of BP, which is why several hypertension guidelines propose that out-of-office measurements, especially 24-hour ambulatory BP, be used to diagnose hypertension.[1,25,86] In recognition of the challenges of financial resources and workforce capacity to implement ambulatory BP measurements in LMICs, the 2020 ISH Guidelines recommended that home and ambulatory BP measurements be implemented, where available and possible. The potential for wider implementation of home BP measurement in LMICs is excellent and has been proven feasible in Nigeria,[91] Argentina,[92] Mexico, and Honduras.[93] In Table 3, a summary on the usefulness of office and out-of-office measurement methods is provided, about resource-constraint settings.

Challenges in Modifying Lifestyle and Health Behaviors in LMICs

The appetite of health care providers and patients to actively engage and change unhealthy behaviors is low, often achieving poor results.[94] This is even more challenging in LMICs where rural and urban clinics are faced with high volumes of patients and limited numbers of health care staff to discuss these options carefully.

Challenges include: several complex societal factors are unique in LMICs that would prohibit people from following a healthy lifestyle and require acknowledgment and understanding by policymakers to successfully implement interventions. LMICs are often challenged by a double burden of malnutrition,[39] and these changing dynamics in nutrition have directly affected the poorest LMICs with increases in obesity mainly due to rapid changes in the food system. The dominant contributors include the availability and uptake of cheap ultra-processed food and beverages and activity-saving technologies resulting in major reductions in physical activity at work and in leisure times.[39] Several environmental factors may also discourage people from becoming more active, such as low air quality and pollution, high-density traffic, fear of crime and violence in outdoor areas, and limited green space, parks, sidewalks, and recreation facilities for activities.[95]

As with population-based interventions to improve lifestyle across the lifecourse, global population-based, multisectoral, multidisciplinary, and culturally relevant policies need to be implemented to create health-promoting environments.[67]

Pharmacotherapy in LMICs

The pharmacological treatment of hypertension is arguably the most evidence-based and cost-effective medical intervention ever, with clear benefits of reduced morbidity and mortality while saving costs as evident from many clinical trials.[96] Besides, BP medications are cheap, even in LMICs. A recent review on drug costs in LMICs reports a median monthly cost

Table 3. Usefulness of Office and Out-of-Office BP Measurement Methods in Low-Resource Settings

		Out-of-office BP	
	Office BP	24-h ambulatory BP	Home BP
Best for	Routine screening of untreated individuals. To follow-up treated patients*	Preferred method for diagnosis of hypertension if available*	Preferred method for long-term follow-up of patients using treatment
Screening	+++	–	+
Initial diagnosis	++*	+++	++
Medication dose adjustment	+	+++	++
Follow-up	++	+	+++
Affordability	+++	+	+++
Hypertension diagnosis, mm Hg	≥140/90	≥130/80	≥135/85

BP indicates blood pressure.

*Office or clinic BP could be used to diagnose hypertension, but if possible, it should not be made on a single office visit (usually 2–3 visits in 1–4 wk).[25] If possible and available, ambulatory BP should be used for diagnosis of hypertension – albeit usually unrealistic in low-resource settings.

of US $11 for ACE (angiotensin-converting enzyme) inhibitors, $17 for angiotensin-II receptor blockers, $6.56 for calcium-channel blockers, and $1.77 for diuretics.[76]

Yet, only about 10% of patients with hypertension in LMICs are controlled.[15] It is, therefore, imperative to identify and address the roadblocks as to why hypertension is not treated appropriately.

Availability and Overall Affordability

The PURE study (Prospective Urban Rural Epidemiology) recently assessed the availability and affordability of antihypertensive medicines in 158 274 individuals from 20 countries.[97] They found a lower availability of ≥2 drug classes in LMICs compared with HICs. Only 13% of communities in LIC (9 of 68 communities) had access to all 4 drug classes. Availability of antihypertensive medications has a profound effect on overall BP control, as it was shown that participants with known hypertension in communities with access to all 4 drug classes were more likely to use at least 1 medicine (odds ratio [OR], 2.23; $P<0.001$), combination therapy (OR, 1.53; $P=0.054$), and to have their BP controlled (OR, 2.06; $P<0.001$).[97] But apart from availability, affordability is also critical in resource-constrained settings. In PURE, it was reported that participants with hypertension from more affluent households were able to afford the 4 drug classes, were more likely to use at least 1 medicine, combination therapy, and to have their BP controlled, than those unable to afford the medicines.[97]

Monotherapy Versus SPC Therapy

Fixed-dose combination, also referred to as SPC therapies, is increasingly recommended for initial or early management of patients with hypertension.[25,86] The WHO also included dual combination therapy for hypertension in their 2019 Essential Medicines List[98] thereby encouraging individual countries to do the same. Most patients with hypertension generally require BP-lowering medication from multiple classes to achieve control. Accumulating evidence indicates that SPCs have significant benefits beyond monotherapy to contribute to attaining BP control, including (1) reducing treatment complexity, (2) accelerating the time taken to achieve control, (3) improving patient adherence, (4) fewer side effects, and (5) reducing therapeutic inertia.[86,99]

SPC therapy seems a feasible solution for LMICs in terms of effectiveness, safety, and cost-effectiveness. Effectiveness in lowering BP was demonstrated using a novel low-dose triple SPC in Sri Lanka. In the TRIUMPH trial (Triple Pill Versus Usual Care Management for Patients With Mild-to-Moderate Hypertension), low-dose triple SPCs achieved 70% BP control in a single treatment step, without increased withdrawals due to adverse effects, which was superior to usual care.[100] In terms of the cost of dual SPCs, they seem at present comparatively expensive in some LMICs, for example, US $0.10 to 0.33 per day in Nigeria and Kenya. However, in Uganda, SPCs including amlodipine, losartan, and hydrochlorothiazide were procured from the Novartis Access programme for US $0.03 per pill. With more coherent collaborative efforts, similar approaches can be implemented on a much wider scale in LMICs.

Wider implementation of polypills that include not only antihypertensive agents but also statins may also become a highly effective approach in LMICs. The recent TIPS-3 randomized trial (The International Polycap Study 3) found that a polypill (containing simvastatin, atenolol, hydrochlorothiazide, and ramipril) plus aspirin led to a lower incidence of cardiovascular events than placebo in participants without CVD.[101]

Clinical or Therapeutic Inertia

Treatment inertia "happens when a clinician does not initiate or intensify therapy in a patient who has not achieved therapeutic goals."[102] A recent real-world study of 100 982 hypertensive patients initiated on monotherapy showed that treatment intensification occurred in only 22% of patients after 6 months and

36% of patients after 3 years.[103] The impact appears even greater in LMICs, where studies in Nigeria, Ghana, and South Africa found that treatment was not increased in up to 90% of patients with uncontrolled BP.[104] Strategies to address inertia include the use of SPCs and simplified treatment protocols that can be followed by community health workers, nurses, and clinicians, which includes specific steps for treatment intensification.

Treatment Adherence

"Medicines do not work if you do not take them." This sentence summarizes the issue of medication adherence—an important determinant of treatment success. Nonadherence to medication for hypertension results in uncontrolled BP, leading to cardiovascular complications. Apart from poor health outcomes, nonadherence leads to increased health care costs, which the health systems of LMICs cannot afford.[105] Epidemiological studies use different scales to measure adherence. The Morisky Medication Adherence Scale and its modified version,[106] the Hill-Bone Compliance scale,[107] and the Medication adherence inventory and inventory of adherence to self-management[108] are some examples of adherence measurement scales.

A systematic review and meta-analysis published in 2017 looked at nonadherence to antihypertensive medication in LMICs.[109] The nonadherence ranged from 14.5% to 93.3%. The overall percentage of nonadherence, when measured using the Morisky Medication Adherence Scale (8-item), was 63% (95% CI, 39–88), whereas that using 80% and 90% cutoff scales was 25% (95% CI, 17–34). Older age (adjusted OR [aOR], 0.98 [95% CI, 0.96–0.99]), being female (aOR, 0.72 [95% CI, 0.53–1.00]), and having controlled BP (aOR, 0.58 [95% CI, 0.36–0.96]) lowers the odds of being nonadherent.[110] Data from low- and middle-income Sub-Saharan African countries show that percentage of low, medium, and high adherence was 30.8%, 33.6%, and 35.6%, respectively. Factors associated with a low adherence were the use of traditional medicines (aOR, 2.28 [95% CI, 1.79–2.90]) and low and middle individual wealth (aOR, 1.86 [95% CI, 1.35–2.56]) compared with high individual wealth. The main reasons reported for not taking the medicines were forgetfulness (34.3%), high cost of treatment (26.0%), side effects (16.8%), and feeling well (11.8%).[111] It has been shown that nonadherence is usually <10% with SPCs, rising to ≈20% with 2 pills, ≈40% with 3 pills, and high rates of partial or complete nonadherence in patients receiving ≥5 pills.[86] Multicomponent intervention targeted at patients (eg, reminders), physicians (eg, improved communication skills), drug treatment (eg, reducing pill burden), and health systems (eg, accessibility and affordability) may help to reduce nonadherence to treatment.[112]

COVID-19–RELATED CHALLENGES IN MANAGING HYPERTENSION IN LMICS

Notwithstanding the status that hypertension is the leading risk factor for death in the world,[113] it continues to compete with other major health threats in LMICs, such as HIV, tuberculosis, malaria, and malnutrition. More recently, the coronavirus disease 2019 (COVID-19) had an acute global impact on health systems, with LMICs being no exception. This inevitably continues to affect hypertension management.

Globally, the aggressive COVID-related lockdown and social isolation strategies had a profound effect on patients. Not only had it an impact on their mental health, but those with known CVD, including hypertension, generally avoided going to health care facilities. This was evident from a substantial drop in hospital admissions for stroke and myocardial infarction in HICs.[109] In Europe, Hypertension Excellence Centres reported shutting down for an average of 9 weeks, resulting in the number of patients treated per week decreasing by 90%.[114] In LMICs, patient barriers stretch beyond those in HICs, and with the pandemic having a more severe impact on unemployment, financial stresses resulting in not filling medication prescriptions that in turn may result in increased risk for complications and telehealth may limit access to less tech-savvy patients. On the health system level, barriers include diversification of finances to fund the COVID-19 response, disruption of medical supply chains, canceling of clinics during lockdowns, and social distancing limiting access to care.[115]

Importantly, patients with hypertension face a significantly greater risk for adverse COVID-19–related outcomes, independent of age, and require careful hypertension management.

Misinformation on the use of ACE inhibitors or angiotensin-II receptor blockers also resulted in confusion among millions of patients and clinicians.[109,114] Rapid responses by global hypertension societies ensured that messaging is reinforced, recommending that ACE inhibitor/angiotensin-II receptor blocker therapy should not be stopped or changed, which was later confirmed by observational studies and clinical trials.

With compromises in hypertension care during emergencies such as COVID-19, it becomes evident that new strategies for hypertension care are required, such as virtual clinics, telemedicine, as well as mHealth (mobile health) and eHealth (electronic technologies in health) strategies,[109,114] including home BP monitoring. While these solutions may hold value in HIC, its potential for sustainable improvements in hypertension care in LMICs may be much greater, mainly due to limited health care workforce capacity.

In the longer term, LMICs may face more severe consequences than HICs. The pandemic not only affected morbidity and mortality but is already resulting in massive

economic and physical hardships increasing health inequalities.[115] Social isolation is impossible in single-room households with >6 family members[109] or when sharing taxis in public transport. With stay-at-home strategies implemented, a no-work no-pay approach has a direct impact on household income. A sudden loss in income, or access to social support, socioeconomic vulnerabilities are significantly enhanced. With the acute challenges of COVID-19, hypertension management receives even less attention despite warnings that the hypertension crisis should not be separated from overall health care strategies.[115]

There is now unprecedented global demand for a COVID-19 vaccine. Claims are made to support vaccine allocation also to LMICs, and tough decisions are faced by policymakers who should ensure that vaccines are first given to those who need them most.

HEALTH SYSTEM CHALLENGES

Physician-to-Patient Ratio and Nurse-to-Patient Ratio

Achieving universal health coverage (UHC) is dependent on the availability, accessibility, and acceptability of high-quality health workforce. For the year 2018, India, Nigeria, and Mozambique, all LMICs, reported 0.9, 0.4, and 0.1 physicians per 1000 people, respectively. This is in contrast to Japan, an HIC, which reported 2.4 physicians per 1000 people in 2016.[116] Similarly, India, Nigeria, and Mozambique reported 1.7, 1.2, and 0.7 nurses and midwives per 1000 people in 2018, respectively, far lower than 12.2 for Japan in the same year.[117] The WHO estimates a shortfall of 18 million health workforce staff by 2030, mostly in the LMICs.[118] The shortage is due to many factors—underinvestment in education and training, mismatch in education and employment, the problem in posting of the workforce to rural and remote areas where the shortfall is pronounced, low remuneration, and migration of workforce from LMICs to HICs for better employment opportunities.[118] To overcome the shortfall, governments are required to address issues resulting in health labor market failures, maximize women's participation in the health sector, prioritize investment in education, organize health systems toward prevention and primary care and away from clinical specialties and hospitals, and secure health financing to invest in health workforce to ensure right skill mix and working condition.[119]

Unmet Need for Hypertension Care in LMICs

When reviewing the care cascade in LMICs by the proportions of patients with hypertension, namely those (1) unscreened and undiagnosed, (2) diagnosed but untreated, (3) treated but uncontrolled, and (4) treated and controlled, it is apparent that there is a significant unmet need in hypertension care. For instance, in Sub-Saharan Africa, these figures reflect 73% being unaware and untreated, 18% were treated, but only 7% were treated and controlled.[120]

For this reason, there is a global movement toward UHC aligned with the Sustainable Developmental Goal 3.8 target, which aims to achieve UHC. A recent analysis of the GBD data showed that global UHC effective coverage index improved from 45.8 (95% uncertainty index, 44.2–47.5) in 1990 to 60.3 (95% uncertainty index, 58.7–61.9) in 2019. When compared with HICs in 2018 (85.8), countries in Southeast Asia, East Asia and Oceania (64.2), South Asia (46.0), and Sub-Saharan Africa (43.9) had lower UHC coverage index.[121] Achieving UHC requires health system strengthening including increased numbers of well-trained health care staff and efficient procurement and medication access—aspects crucial to improve hypertension care. Achieving UHC can thus improve hypertension treatment and control rates as health system strengthening is central to achieving.[122]

High Out-of-Pocket Payments

Out-of-pocket payments are those payments made by individuals to health care providers at the time-of-service use. When these payments are large relative to a family's total income, it is termed as catastrophic out-of-pocket spending. In 2010, an estimated 808 million people worldwide incurred catastrophic health spending. The proportion of population incurring catastrophic health spending in Africa, Asia and Latin America, and the Caribbean was 11.4%, 12.8%, and 14.8%, respectively, compared with the global proportion of 11.7%.[123] Poor, less educated, rural, female-headed households, and households with members with chronic conditions are more likely to incur catastrophic health expenditure.[124,125] Households with a member diagnosed with hypertension experiencing catastrophic health expenditure and impoverished due to health expenditure were high in LMICs compared with households with no member diagnosed with hypertension or NCD.[126] Direct medical expenses toward consultation, laboratory tests, medication, hospitalization, and emergency care and indirect expenses toward transportation, food, and nonpharmacological treatment constituted a patient's annual out-of-pocket expenditure for hypertension care.[127] Strategies to reduce these payments are (1) abolish user fees and charges in public facilities, (2) exempt specific population subgroups from paying for health services, and (3) exempt specific health services from payment. These strategies need political support, decision-making, and proper preparation.[128]

Leveraging Technology for Hypertension Management (mHealth and eHealth)

The Global Observatory of eHealth defines mHealth or mobile Health as "medical and public health practice

supported by mobile devices such as smartphones, patient monitoring devices, personal digital assistants and other wireless devices."[129] Mobile phones are the primary means of internet access in LMICs. Of the total 3.5 billion people connected to mobile internet, 2.6 billion live in LMICs representing just over 40% of the total LMIC population.[130] mHealth is a powerful tool that can provide health education, promote behavior change, aid diagnosis through the use of a decision support system, and ensure record linkages. Many projects with the aim to improve detection and management of hypertension in select LMICs have used mHealth technology to identify, track, and follow-up patients with hypertension; improve medication adherence; and educate patients and community health workers.[131,132]

A systematic review published in 2020 reported that mHealth interventions reduced SBP by 2.99 mm Hg (weighted mean difference [WMD] [95% CI, 1.80–4.19]). But when the effect on SBP was restricted to studies conducted in developing countries, the reduction was not statistically significant (0.25 mm Hg, WMD [95% CI, −3.10 to 3.59]). The interventions included in the review were text messages, calls, mobile phone applications, and wearable or portable monitoring devices.[133] The evidence on clinical decision support systems from a cluster randomized controlled trial done in public health facilities in India shows that SBP reduced by 0.31 mm Hg (95% CI, −3.91 to 3.29) in the intervention arm compared with the enhanced usual care arm.[134] But when decision support system was compared with the chart-based system, the SBP reduced by 6.59 mm Hg (95% CI, −12.18 to −1.42).[135] A cluster randomized trial conducted in India and Tibet to test the effectiveness of a lifestyle modification plus appropriate medication intervention delivered by community health workers aided by an electronic decision support system led to a reduction of SBP by 2.7 mm Hg (P=0.04).[136] Adoption of mHealth to improve health system performance may lead to improving the quality of health care and closing the gap to attain UHC.

Team-Based Care (Task Sharing)

The WHO describes task sharing as "rational redistribution of tasks among health workforce team" wherein "specific tasks are moved, where appropriate, from highly qualified health workers (eg, physicians) to health workers (eg, community health workers) with fewer qualifications after adequate training."[137] The concept of task sharing arose due to the lack of personnel in the health systems of many countries in Africa affected by the HIV pandemic. It was a strategy to address the low capacity of existing health personnel and add a new cadre of workers to the health system.[138] In LMICs, task sharing has been shown to improve outcomes in various domains—maternal and child health, immunization, HIV/AIDS, malaria, and tuberculosis.[139–142] A systematic review reported that task sharing is cost-effective for a range of conditions in LMIC settings.[143] Even for NCDs, evidence exists on the effectiveness of task sharing.[144]

A study conducted in 4 LMICs (Bangladesh, Guatemala, Mexico, and South Africa) reported that community health workers could successfully screen people for NCD risk factors including high SBP after extensive training.[145] The mean level of agreement between risk scores assigned by the health workers and that by the health professionals was 96.8% (weighted κ, 0.948 [95% CI, 0.936–0.961]) with little between-country variation.

A systematic review and meta-analysis of 63 studies on task sharing with nonphysician health workers for BP management in LMICs found that SBP reduced by 4.85 mm Hg (95% CI, 3.57–6.12), whereas diastolic BP reduced by 2.92 mm Hg (95% CI, 2.09–3.75).[146] The reduction in BP differed by categories of nonphysician health workers—highest for pharmacists and lowest for community health workers (8.12 vs 3.67 mm Hg). The components of the intervention in the included studies were education about lifestyle modification, home visits, algorithm-based management of hypertension, and referral system. The enablers to task sharing are training of nonphysician health workers, provision of simple and clear algorithms, protocols and guidelines for screening, treatment and titration of drug dosage, and availability of drugs in health facilities. The barriers were staff retention, irregular drug supplies, and nonavailability of sphygmomanometers.[144] A carefully designed task-sharing program embedded within the health systems can address the factors mentioned above.

RESEARCH GAPS AND RECOMMENDATIONS

In this section, we provide some solutions to achieve BP control and recommendations for further research. Table 4 lists some barriers to achieve BP reduction at the patient, provider, and health system level together with the solutions.

Appropriate research in LMICs can help bridge several gaps in the current evidence for the management of hypertension for which contextual attention is needed. Some of these are summarized below:

1. Conduct clinical trials on improving BP control in LMICs in specific contexts, such as Sub-Saharan Africa, South Asia, and East Asia, focusing on effectiveness, cost-effectiveness, and safety of tailor-made local interventions. An example is the CREOLE trial,[147] which looked at 2-drug combination therapy for control of hypertension among Black African patients with hypertension. Another

Table 4. Barriers to BP Reduction at the Patient, Provider, and Health System Levels and Potential Solutions to These Barriers

Level	Barriers	Solutions
Patient	Inadequate access to hypertension care	Task sharing
		Virtual consultations with physicians via telemedicine (after the first visit, confirmation of diagnosis) for regular follow-up
	Poor awareness of hypertension	Leverage technology to disseminate information on hypertension
		Community-level activities to generate awareness
		Community-level events for hypertension screening (eg, May Measurement Month)
	Low treatment adherence due to asymptomatic nature of hypertension	Counseling by physicians/nurses at the health facility and by frontline health workers in the community to encourage patients to take medication regularly
		mHealth technology, in the form of apps, to remind patients to take medication regularly and monitor adherence
		Ensuring availability and affordability of quality medicines
	Socioeconomic issues	UHC
		Insurance schemes to cover costs associated with outpatient visits, medication, and laboratory tests
Provider	Lack of knowledge about the concept of absolute risk	Training through virtual learning courses such as "Implementation of the HEARTS Technical Package in Primary Health Care" by the Pan American Health Organization (https://www.campusvirtualsp.org/en/course/virtual-course-implementation-hearts-technical-package-primary-health-care) and "Fundamentals for Implementing a Hypertension Program in Resource-Constrained Settings" by Global Hypertension at Hopkins (https://globalhypertensionathopkins.org/courses)
	Time constraints in estimating absolute risk	mHealth technology
	Feeling of lack of autonomy and diffidence among lower level health care staff	Capacity building programs with a mix of face-to-face and distant learning for clinicians and health workers
Health system	Lack of trained health care staff in hypertension management	Training for clinicians. For example, the Certificate Course in Management of Hypertension in India aims to train clinicians to manage hypertension using the latest available evidence. The course is designed by national and international experts together with participation of the ISH and British and Irish Hypertension Society
	Drug procurement, availability, distribution, and frequent stockouts	Development of a list of core medicines based on recent evidence on the efficacy, safety, and cost
		Robust IT system to streamline drug procurement and distribution
	Poor surveillance and screening practices	Set up simplified surveillance system to monitor BP trends in the population and also among patients
		Community-level screening for hypertension through frontline health workers and opportunistic screening at the health facilities

app indicates application; BP, blood pressure; ISH, International Society of Hypertension; IT, information technology; mHealth, mobile health; and UHC, universal health coverage.

relevant example is the TRIUMPH study, conducted in Sri Lanka, which increased proportion of patients achieving their target BP goal versus usual care.[100]

2. Undertake context-specific studies to effectively implement proven evidence-based strategies (including mHealth) to bridge the know-do gap for rolling out promotive, preventive, and therapeutic interventions in LMIC settings, especially for rural, remote, poor, and disadvantaged populations. Recent studies from India indicate that task sharing and contextualized collaborative care models utilizing nonphysician health workers enabled with mHealth can improve hypertension and diabetes detection and control.[148,149]
3. Determine the effectiveness of different screening strategies (mass, targeted, or opportunistic) on advancing early detection and treatment initiation for hypertension.
4. Conduct research on effective implementation strategies for promoting healthy diets such as fruit and vegetable intake, reducing salt intake, regulating the sale of alcohol, and improving the environment by reducing air and other sources of pollution.
5. Undertake systematic reviews on determining the cost-effectiveness of interventions to reduce BP, contextualized to the unique health system settings of LMICs.
6. Build the evidence base on emerging risk factors for hypertension such as air and noise pollution,

light (as a proxy for urbanization), green space and the built environment, and neighborhood walkability. Data from cohort studies in combination with environmental data from secondary sources (eg, $PM_{2.5}$ levels, satellite imagery to assess change in green cover) would be required.

7. Conduct research on effectively involving community self-help groups to promote awareness regarding hypertension and to implement BP-reduction strategies. The feasibility of implementing family- and community-based interventions to reduce risk factors for hypertension, which usually tends to cluster at household level,[150,151] should also be explored.
8. Evaluate newer interventions like renal denervation, baroreflex activation therapy, and carotid body ablation and their appropriateness for treating hypertension in LMICs.

Potential funding sources available to conduct research on hypertension in LMICs include but are not limited to (1) the Global Alliance for Chronic Disease, "an alliance of research funders jointly funding research into chronic disease" including hypertension,[152] (2) the Fogarty International Centre of National Institutes of Health,[153] (3) the Wellcome Trust[154] and National Institute for Health Research,[155] and (4) the National Health and Medical Research Council of Australia.[156] Apart from global opportunities, country-specific opportunities are also available such as the Wellcome Trust–Department of Biotechnology India Alliance partnership[157] and the South African Medical Research Council.[158] Governmental and nongovernmental organizations can apply to LINKS[159] for 1-time grants for research to improve cardiovascular health, including hypertension control. The Global Environmental and Occupational Health funded by the Fogarty International Centre has currently 7 hubs based in various LMICs conducting research on environmental risk factors.[160] Some are investigating the relationship between air pollution, arsenic, and hypertension. The Kathmandu Declaration[161] recognizes various gaps that hinder prevention and control of hypertension and CVD in LMICs and provides recommendations to advance implementation research.

As a final recommendation, the WHO report titled "Scaling Up Action Against Noncommunicable Diseases: How Much Will It Cost?"[162] provides a helpful matrix for population-based NCD prevention measures, which can be adapted for hypertension control, including relevant steps to introduce sodium reduction for hypertension control (preparation of an evidence base and baseline assessments [year 1], draft legislation and consultation [eg, front of package labeling], inviting comments from experts and public [year 2], legislation and information campaign [year 3], and periodic national-level surveys to measure the impact [continuous]). There are clear examples of countries having implemented population-based interventions and have been successful in reducing BP and improving public health.[82]

ARTICLE INFORMATION

Affiliations

School of Population Health, University of New South Wales, Sydney, Australia (A.E.S.). George Institute for Global Health, Sydney, NSW, Australia (A.E.S.). Hypertension in Africa Research Team, MRC Unit for Hypertension and Cardiovascular Disease, North-West University, Potchefstroom, South Africa (A.E.S.). Centre for Chronic Conditions and Injuries, Public Health Foundation of India, Gurgaon (N.S.V., S.M., D.P.). Centre for Chronic Disease Control, New Delhi, India (N.S.V., S.M., D.P.). School of Exercise and Nutrition Sciences (N.S.V.) and Faculty of Health (S.M.), Deakin University, Burwood, VIC, Australia. Department of Epidemiology, London School of Hygiene and Tropical Medicine, United Kingdom (D.P.).

Disclosures

None.

REFERENCES

1. Whelton PK, Carey RM, Aronow WS, Casey DE Jr, Collins KJ, Dennison Himmelfarb C, DePalma SM, Gidding S, Jamerson KA, Jones DW, et al. 2017 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*. 2018;71:e13–e115. doi: 10.1161/HYP.0000000000000065
2. Institute for Health Metrics and Evaluation (IHME). Non-communicable Diseases - Level 1 Cause. IHME, University of Washington, 2019. Accessed December 16, 2020. http://www.healthdata.org/results/gbd_summaries/2019/non-communicable-diseases-level-1-cause
3. Institute for Health Metrics and Evaluation (IHME). Cardiovascular Diseases - Level 2 Cause. IHME, University of Washington, 2019. Accessed December 16, 2020. http://www.healthdata.org/results/gbd_summaries/2019/cardiovascular-diseases-level-2-cause
4. Institute for Health Metrics and Evaluation (IHME). High Systolic Blood Pressure - Level 2 Risk. IHME, University of Washington, 2019. Accessed December 16, 2020. http://www.healthdata.org/results/gbd_summaries/2019/high-systolic-blood-pressure-level-2-risk
5. Rapsomaniki E, Timmis A, George J, Pujades-Rodriguez M, Shah AD, Denaxas S, White IR, Caulfield MJ, Deanfield JE, Smeeth L, et al. Blood pressure and incidence of twelve cardiovascular diseases: lifetime risks, healthy life-years lost, and age-specific associations in 1·25 million people. *Lancet*. 2014;383:1899–1911. doi: 10.1016/S0140-6736(14)60685-1
6. Hsu CY, McCulloch CE, Darbinian J, Go AS, Iribarren C. Elevated blood pressure and risk of end-stage renal disease in subjects without baseline kidney disease. *Arch Intern Med*. 2005;165:923–928. doi: 10.1001/archinte.165.8.923
7. Walker KA, Sharrett AR, Wu A, Schneider ALC, Albert M, Lutsey PL, Bandeen-Roche K, Coresh J, Gross AL, Windham BG, et al. Association of midlife to late-life blood pressure patterns with incident dementia. *JAMA*. 2019;322:535–545. doi: 10.1001/jama.2019.10575
8. Zhou B, Bentham J, Di Cesare M; NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in blood pressure from 1975 to 2015: a pooled analysis of 1479 population-based measurement studies with 19.1 million participants. *Lancet*. 2017;389:37–55. doi: 10.1016/S0140-6736(16)31919-5
9. Beaney T, Schutte AE, Stergiou GS, Borghi C, Burger D, Charchar F, Cro S, Diaz A, Damasceno A, Espeche W, et al; MMM Investigators*. May Measurement Month 2019: the global blood pressure screening campaign of the International Society of Hypertension. *Hypertension*. 2020;76:333–341. doi: 10.1161/HYPERTENSIONAHA.120.14874
10. Beaney T, Schutte AE, Tomaszewski M, Ariti C, Burrell LM, Castillo RR, Charchar FJ, Damasceno A, Kruger R, Lackland DT, et al. May Measurement Month 2017: an analysis of blood pressure screening results worldwide. *Lancet Glob Health*. 2018;6:e736–e743.

11. Beaney T, Burrell LM, Castillo RR, Charchar FJ, Cro S, Damasceno A, Kruger R, Nilsson PM, Prabhakaran D, Ramirez AJ, et al; MMM Investigators. May Measurement Month 2018: a pragmatic global screening campaign to raise awareness of blood pressure by the International Society of Hypertension. *Eur Heart J*. 2019;40:2006–2017. doi: 10.1093/eurheartj/ehz300
12. Chow CK, Teo KK, Rangarajan S, Islam S, Gupta R, Avezum A, Bahonar A, Chifamba J, Dagenais G, Diaz R, et al; PURE (Prospective Urban Rural Epidemiology) Study Investigators. Prevalence, awareness, treatment, and control of hypertension in rural and urban communities in high-, middle-, and low-income countries. *JAMA*. 2013;310:959–968. doi: 10.1001/jama.2013.184182
13. Mills KT, Stefanescu A, He J. The global epidemiology of hypertension. *Nat Rev Nephrol*. 2020;16:223–237. doi: 10.1038/s41581-019-0244-2
14. Institute for Health Metrics and Evaluation (IHME). Summary Exposure Value. IHME, University of Washington; 2019. Accessed December 16, 2020. http://ghdx.healthdata.org/gbd-results-tool?params=gbd-api-2019-public/8e7c7297c78778aea18e543bb15bee61
15. Geldsetzer P, Manne-Goehler J, Marcus ME, Ebert C, Zhumadilov Z, Wesseh CS, Tsabedze L, Supiyev A, Sturua L, Bahendeka SK, et al. The state of hypertension care in 44 low-income and middle-income countries: a cross-sectional study of nationally representative individual-level data from 1·1 million adults. *Lancet*. 2019;394:652–662. doi: 10.1016/S0140-6736(19)30955-9
16. Zhao D, Qi Y, Zheng Z, Wang Y, Zhang XY, Li HJ, Liu HH, Zhang XT, Du J, Liu J. Dietary factors associated with hypertension. *Nat Rev Cardiol*. 2011;8:456–465. doi: 10.1038/nrcardio.2011.75
17. Imamura F, Micha R, Khatibzadeh S, Fahimi S, Shi P, Powles J, Mozaffarian D. Dietary quality among men and women in 187 countries in 1990 and 2010: a systematic assessment. *Lancet Glob Health*. 2015;3:e132–e142.
18. Hirvonen K, Bai Y, Headey D, Masters WA. Affordability of the EAT-Lancet reference diet: a global analysis. *Lancet Glob Health*. 2020;8:e59–e66. doi: 10.1016/S2214-109X(19)30447-4
19. O'Donnell M, Mente A, Alderman MH, Brady AJB, Diaz R, Gupta R, López-Jaramillo P, Luft FC, Lüscher TF, Mancia G, et al. Salt and cardiovascular disease: insufficient evidence to recommend low sodium intake. *Eur Heart J*. 2020;41:3363–3373. doi: 10.1093/eurheartj/ehaa586
20. He FJ, MacGregor GA. Effect of modest salt reduction on blood pressure: a meta-analysis of randomized trials. Implications for public health. *J Hum Hypertens*. 2002;16:761–770. doi: 10.1038/sj.jhh.1001459
21. Menyanu E, Russell J, Charlton K. Dietary sources of salt in low- and middle-income countries: a systematic literature review. *Int J Environ Res Public Health*. 2019;16:2082.
22. Crouch SH, Botha-Le Roux S, Delles C, Graham LA, Schutte AE. Inflammation and salt in young adults: the African-PREDICT study. *Eur J Nutr*. 2021;60:873–882. doi: 10.1007/s00394-020-02292-3
23. Swanepoel B, Schutte AE, Cockeran M, Steyn K, Wentzel-Viljoen E. Sodium and potassium intake in South Africa: an evaluation of 24-hour urine collections in a white, black, and Indian population. *J Am Soc Hypertens*. 2016;10:829–837. doi: 10.1016/j.jash.2016.08.007
24. Hagins M, States R, Selfe T, Innes K. Effectiveness of yoga for hypertension: systematic review and meta-analysis. *Evid Based Complement Alternat Med*. 2013;2013:649836. doi: 10.1155/2013/649836
25. Unger T, Borghi C, Charchar F, Khan NA, Poulter NR, Prabhakaran D, Ramirez A, Schlaich M, Stergiou GS, Tomaszewski M, et al. 2020 International Society of hypertension global hypertension practice guidelines. *Hypertension*. 2020;75:1334–1357. doi: 10.1161/HYPERTENSIONAHA.120.15026
26. Raghuraj P, Ramakrishnan AG, Nagendra HR, Telles S. Effect of two selected yogic breathing techniques of heart rate variability. *Indian J Physiol Pharmacol*. 1998;42:467–472.
27. The Trials of Hypertension Prevention Collaborative Research Group. Effects of weight loss and sodium reduction intervention on blood pressure and hypertension incidence in overweight people with high-normal blood pressure. The Trials of Hypertension Prevention, phase II.*Arch Intern Med*. 1997;157:657–667. doi: 10.1001/archinte.1997.00440270105009
28. He J, Whelton PK, Appel LJ, Charleston J, Klag MJ. Long-term effects of weight loss and dietary sodium reduction on incidence of hypertension. *Hypertension*. 2000;35:544–549. doi: 10.1161/01.hyp.35.2.544
29. Sacks FM, Svetkey LP, Vollmer WM, Appel LJ, Bray GA, Harsha D, Obarzanek E, Conlin PR, Miller ER III, Simons-Morton DG, et al; DASH-Sodium Collaborative Research Group. Effects on blood pressure of reduced dietary sodium and the Dietary Approaches to Stop Hypertension (DASH) diet. DASH-Sodium Collaborative Research Group. *N Engl J Med*. 2001;344:3–10. doi: 10.1056/NEJM200101043440101
30. Vollmer WM, Sacks FM, Ard J, Appel LJ, Bray GA, Simons-Morton DG, Conlin PR, Svetkey LP, Erlinger TP, Moore TJ, et al; DASH-Sodium Trial Collaborative Research Group. Effects of diet and sodium intake on blood pressure: subgroup analysis of the DASH-sodium trial. *Ann Intern Med*. 2001;135:1019–1028. doi: 10.7326/0003-4819-135-12-200112180-00005
31. Chobanian AV, Hill M. National Heart, Lung, and Blood Institute Workshop on sodium and blood pressure: a critical review of current scientific evidence. *Hypertension*. 2000;35:858–863. doi: 10.1161/01.hyp.35.4.858
32. Kelley GA, Kelley KS. Progressive resistance exercise and resting blood pressure: a meta-analysis of randomized controlled trials. *Hypertension*. 2000;35:838–843. doi: 10.1161/01.hyp.35.3.838
33. Whelton SP, Chin A, Xin X, He J. Effect of aerobic exercise on blood pressure: a meta-analysis of randomized, controlled trials. *Ann Intern Med*. 2002;136:493–503. doi: 10.7326/0003-4819-136-7-200204020-00006
34. Xin X, He J, Frontini MG, Ogden LG, Motsamai OI, Whelton PK. Effects of alcohol reduction on blood pressure: a meta-analysis of randomized controlled trials. *Hypertension*. 2001;38:1112–1117. doi: 10.1161/hy1101.093424
35. World Health Organization. Tobacco Key Facts. 2020. Accessed December 16, 2020. https://www.who.int/news-room/fact-sheets/detail/tobacco#:~:text=Key%20facts,exposed%20to%20second%2Dhand%20smoke
36. Gilmore AB, Fooks G, Drope J, Bialous SA, Jackson RR. Exposing and addressing tobacco industry conduct in low-income and middle-income countries. *Lancet*. 2015;385:1029–1043. doi: 10.1016/S0140-6736(15)60312-9
37. World Health Organization. Global Status Report on Alcohol and Health. 2018. Accessed December 16, 2020. https://www.who.int/publications/i/item/9789241565639
38. Griswold MG, Fullman N, Hawley C; GBD 2016 Alcohol Collaborators. Alcohol use and burden for 195 countries and territories, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet*. 2018;392:1015-1035. doi: 10.1016/S0140-6736(18)31310-2
39. Popkin BM, Corvalan C, Grummer-Strawn LM. Dynamics of the double burden of malnutrition and the changing nutrition reality. *Lancet*. 2020;395:65–74. doi: 10.1016/S0140-6736(19)32497-3
40. Ng M, Fleming T, Robinson M, Thomson B, Graetz N, Margono C, Mullany EC, Biryukov S, Abbafati C, Abera SF, et al. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet*. 2014;384:766–781. doi: 10.1016/S0140-6736(14)60460-8
41. Hall JE, do Carmo JM, da Silva AA, Wang Z, Hall ME. Obesity-induced hypertension: interaction of neurohumoral and renal mechanisms. *Circ Res*. 2015;116:991–1006. doi: 10.1161/CIRCRESAHA.116.305697
42. Hall ME, do Carmo JM, da Silva AA, Juncos LA, Wang Z, Hall JE. Obesity, hypertension, and chronic kidney disease. *Int J Nephrol Renovasc Dis*. 2014;7:75–88. doi: 10.2147/IJNRD.S39739
43. Marmot M, Friel S, Bell R, Houweling TA, Taylor S; Commission on Social Determinants of Health. Closing the gap in a generation: health equity through action on the social determinants of health. *Lancet*. 2008;372:1661–1669. doi: 10.1016/S0140-6736(08)61690-6
44. Allen L, Williams J, Townsend N, Mikkelsen B, Roberts N, Foster C, Wickramasinghe K. Socioeconomic status and non-communicable disease behavioural risk factors in low-income and lower-middle-income countries: a systematic review. *Lancet Glob Health*. 2017;5:e277–e289. doi: 10.1016/S2214-109X(17)30058-X
45. Hajat A, Hsia C, O'Neill MS. Socioeconomic disparities and air pollution exposure: a global review. *Curr Environ Health Rep*. 2015;2:440–450. doi: 10.1007/s40572-015-0069-5
46. World Health Organization. Global Status Report on NonCommunicable Diseases. 2010. Accessed on December 16, 2020. https://www.who.int/nmh/publications/ncd_report2010/
47. Kickbusch I, Allen L, Franz C. The commercial determinants of health. *Lancet Glob Health*. 2016;4:e895–e896. doi: 10.1016/S2214-109X(16)30217-0
48. Ireland R, Bunn C, Reith G, Philpott M, Capewell S, Boyland E, Chambers S. Commercial determinants of health: advertising of alcohol and unhealthy foods during sporting events. *Bull World Health Organ*. 2019;97:290–295. doi: 10.2471/BLT.18.220087
49. Marmot M, Bell R. Social determinants and non-communicable diseases: time for integrated action. *BMJ*. 2019;364:l251. doi: 10.1136/bmj.l251
50. Sun L, Chen J, Li Q, Huang D. Dramatic uneven urbanization of large cities throughout the world in recent decades. *Nat Commun*. 2020;11:5366. doi: 10.1038/s41467-020-19158-1
51. Anenberg SC, Achakulwisut P, Brauer M, Moran D, Apte JS, Henze DK. Particulate matter-attributable mortality and relationships with

carbon dioxide in 250 urban areas worldwide. *Sci Rep*. 2019;9:11552. doi: 10.1038/s41598-019-48057-9
52. Baumgartner J, Brauer M, Ezzati M. The role of cities in reducing the cardiovascular impacts of environmental pollution in low- and middle-income countries. *BMC Med*. 2020;18:39. doi: 10.1186/s12916-020-1499-y
53. Astell-Burt T, Feng X. Urban green space, tree canopy and prevention of cardiometabolic diseases: a multilevel longitudinal study of 46 786 Australians. *Int J Epidemiol*. 2020;49:926–933. doi: 10.1093/ije/dyz239
54. Markevych I, Schoierer J, Hartig T, Chudnovsky A, Hystad P, Dzhambov AM, de Vries S, Triguero-Mas M, Brauer M, Nieuwenhuijsen MJ, et al. Exploring pathways linking greenspace to health: theoretical and methodological guidance. *Environ Res*. 2017;158:301–317. doi: 10.1016/j.envres.2017.06.028
55. Münzel T, Sørensen M. Noise pollution and arterial hypertension. *Eur Cardiol*. 2017;12:26–29. doi: 10.15420/ecr.2016:31:2
56. Brook RD, Rajagopalan S, Pope CA 3rd, Brook JR, Bhatnagar A, Diez-Roux AV, Holguin F, Hong Y, Luepker RV, Mittleman MA, et al; American Heart Association Council on Epidemiology and Prevention, Council on the Kidney in Cardiovascular Disease, and Council on Nutrition, Physical Activity and Metabolism. Particulate matter air pollution and cardiovascular disease: an update to the scientific statement from the American Heart Association. *Circulation*. 2010;121:2331–2378. doi: 10.1161/CIR.0b013e3181dbece1
57. Furuyama A, Kanno S, Kobayashi T, Hirano S. Extrapulmonary translocation of intratracheally instilled fine and ultrafine particles via direct and alveolar macrophage-associated routes. *Arch Toxicol*. 2009;83:429–437. doi: 10.1007/s00204-008-0371-1
58. Bartoli CR, Wellenius GA, Diaz EA, Lawrence J, Coull BA, Akiyama I, Lee LM, Okabe K, Verrier RL, Godleski JJ. Mechanisms of inhaled fine particulate air pollution-induced arterial blood pressure changes. *Environ Health Perspect*. 2009;117:361–366. doi: 10.1289/ehp.11573
59. Prabhakaran D, Mandal S, Krishna B, Magsumbol M, Singh K, Tandon N, Venkat Narayan KM, Shivashankar R, Kondal D, Ali MK, et al; GeoHealth Hub Study investigators, COE-CARRS Study Investigators. Exposure to particulate matter is associated with elevated blood pressure and incident hypertension in Urban India. *Hypertension*. 2020;76:1289–1298. doi: 10.1161/HYPERTENSIONAHA.120.15373
60. Eriksson JG, Forsén TJ, Kajantie E, Osmond C, Barker DJ. Childhood growth and hypertension in later life. *Hypertension*. 2007;49:1415–1421. doi: 10.1161/HYPERTENSIONAHA.106.085597
61. Ben-Shlomo Y, McCarthy A, Hughes R, Tilling K, Davies D, Smith GD. Immediate postnatal growth is associated with blood pressure in young adulthood: the Barry Caerphilly Growth Study. *Hypertension*. 2008;52:638–644. doi: 10.1161/HYPERTENSIONAHA.108.114256
62. Siewert-Delle A, Ljungman S. The impact of birth weight and gestational age on blood pressure in adult life: a population-based study of 49-year-old men. *Am J Hypertens*. 1998;11:946–953. doi: 10.1016/s0895-7061(98)00090-9
63. Blencowe H, Krasevec J, de Onis M, Black RE, An X, Stevens GA, Borghi E, Hayashi C, Estevez D, Cegolon L, et al. National, regional, and worldwide estimates of low birthweight in 2015, with trends from 2000: a systematic analysis. *Lancet Glob Health*. 2019;7:e849–e860.
64. Tauzin L, Risso F, Buffat C, Serra G, Simeoni U. Vascular mechanisms in the developmental programming of cardio-vascular disease. *Pediatr Med Chir*. 2005;27:18–23.
65. Martyn CN, Barker DJ, Jespersen S, Greenwald S, Osmond C, Berry C. Growth in utero, adult blood pressure, and arterial compliance. *Br Heart J*. 1995;73:116–121. doi: 10.1136/hrt.73.2.116
66. Skilton MR, Evans N, Griffiths KA, Harmer JA, Celermajer DS. Aortic wall thickness in newborns with intrauterine growth restriction. *Lancet*. 2005;365:1484–1486. doi: 10.1016/S0140-6736(05)66419-7
67. Olsen MH, Angell SY, Asma S, Boutouyrie P, Burger D, Chirinos JA, Damasceno A, Delles C, Gimenez-Roqueplo AP, Hering D, et al. A call to action and a lifecourse strategy to address the global burden of raised blood pressure on current and future generations: the Lancet Commission on Hypertension. *Lancet*. 2016;388:2665–2712. doi: 10.1016/S0140-6736(16)31134-5
68. Mordi I, Mordi N, Delles C, Tzemos N. Endothelial dysfunction in human essential hypertension. *J Hypertens*. 2016;34:1464–1472. doi: 10.1097/HJH.0000000000000965
69. Barker DJ, Osmond C, Forsen TJ, Kajantie E, Eriksson JG. Maternal and social origins of hypertension. *Hypertension*. 2007;50:565–571. doi: 10.1161/HYPERTENSIONAHA.107.091512
70. Mohn A, Chiavaroli V, Cerruto M, Blasetti A, Giannini C, Bucciarelli T, Chiarelli F. Increased oxidative stress in prepubertal children born small for gestational age. *J Clin Endocrinol Metab*. 2007;92:1372–1378. doi: 10.1210/jc.2006-1344
71. Franco MC, Kawamoto EM, Gorjão R, Rastelli VM, Curi R, Scavone C, Sawaya AL, Fortes ZB, Sesso R. Biomarkers of oxidative stress and antioxidant status in children born small for gestational age: evidence of lipid peroxidation. *Pediatr Res*. 2007;62:204–208. doi: 10.1203/PDR.0b013e3180986d04
72. Drake AJ, Tang JI, Nyirenda MJ. Mechanisms underlying the role of glucocorticoids in the early life programming of adult disease. *Clin Sci (Lond)*. 2007;113:219–232. doi: 10.1042/CS20070107
73. Costantine MM, Ghulmiyyah LM, Tamayo E, Hankins GD, Saade GR, Longo M. Transgenerational effect of fetal programming on vascular phenotype and reactivity in endothelial nitric oxide synthase knockout mouse model. *Am J Obstet Gynecol*. 2008;199:250.e1-7.
74. Lynch J, Smith GD. A life course approach to chronic disease epidemiology. *Annu Rev Public Health*. 2005;26:1–35. doi: 10.1146/annurev.publhealth.26.021304.144505
75. Mills KT, Bundy JD, Kelly TN, Reed JE, Kearney PM, Reynolds K, Chen J, He J. Global disparities of hypertension prevalence and control: a systematic analysis of population-based studies from 90 Countries. *Circulation*. 2016;134:441–450. doi: 10.1161/CIRCULATIONAHA.115.018912
76. Kostova D, Spencer G, Moran AE, Cobb LK, Husain MJ, Datta BK, Matsushita K, Nugent R. The cost-effectiveness of hypertension management in low-income and middle-income countries: a review. *BMJ Glob Health*. 2020;5:e002213.
77. Carey RM, Muntner P, Bosworth HB, Whelton PK. Prevention and control of hypertension: JACC health promotion series. *J Am Coll Cardiol*. 2018;72:1278–1293. doi: 10.1016/j.jacc.2018.07.008
78. Campbell NRC, Schutte AE, Varghese CV, Ordunez P, Zhang X-H, Khan T, Sharman JE, Whelton PK, Parati G, Weber MA, et al. Sao Paulo call to action for the prevention and control of high blood pressure: 2020. *J Clin Hypertens*. 2019;21:1744–1752.
79. Rose G. Sick individuals and sick populations. *Int J Epidemiol*. 1985;14:32–38. doi: 10.1093/ije/14.1.32
80. Cobiac LJ, Tam K, Veerman L, Blakely T. Taxes and subsidies for improving diet and population health in Australia: a cost-effectiveness modelling study. *PLoS Med*. 2017;14:e1002232. doi: 10.1371/journal.pmed.1002232
81. Trieu K, Neal B, Hawkes C, Dunford E, Campbell N, Rodriguez-Fernandez R, Legetic B, McLaren L, Barberio A, Webster J. Salt reduction initiatives around the world - a systematic review of progress towards the global target. *PLoS One*. 2015;10:e0130247. doi: 10.1371/journal.pone.0130247
82. World Health Organization. High Blood Pressure - Country Experiences and Effective Interventions Utilized Across the European Region. 2013. Accessed February 22, 2021. https://apps.who.int/iris/bitstream/handle/10665/108619/e96816.pdf?sequence=1&isAllowed=y
83. Arrúa A, Machín L, Curutchet MR, Martínez J, Antúnez L, Alcaire F, Giménez A, Ares G. Warnings as a directive front-of-pack nutrition labelling scheme: comparison with the Guideline Daily Amount and traffic-light systems. *Public Health Nutr*. 2017;20:2308–2317. doi: 10.1017/S1368980017000866
84. World Health Organization. HEARTS Technical Package. 2018. Accessed December 16, 2020. https://www.who.int/cardiovascular_diseases/hearts/en/
85. NCD Risk Factor Collaboration. Worldwide trends in blood pressure from 1975 to 2015: a pooled analysis of 1479 population-based measurement studies with 19.1 million participants. *Lancet*. 2017;389:37–55. doi: 10.1016/S0140-6736(16)31919-5
86. Williams B, Mancia G, Spiering W, Agabiti Rosei E, Azizi M, Burnier M, Clement DL, Coca A, de Simone G, Dominiczak A, et al; Authors/Task Force Members. 2018 ESC/ESH Guidelines for the management of arterial hypertension: the task force for the management of arterial hypertension of the European Society of Cardiology and the European Society of Hypertension: the Task Force for the management of arterial hypertension of the European Society of Cardiology and the European Society of Hypertension. *J Hypertens*. 2018;36:1953–2041. doi: 10.1097/HJH.0000000000001940
87. Sharman JE, O'Brien E, Alpert B, Schutte AE, Delles C, Hecht Olsen M, Asmar R, Atkins N, Barbosa E, Calhoun D, et al; Lancet Commission on Hypertension Group. Lancet Commission on Hypertension group position statement on the global improvement of accuracy standards for devices that measure blood pressure. *J Hypertens*. 2020;38:21–29. doi: 10.1097/HJH.0000000000002246
88. World Health Organization. WHO Technical Specifications for Automated Non-Invasive Blood Pressure Measuring Devices With Cuff. 2020. Accessed December 16, 2020. https://www.who.int/medical_devices/publications/tech_specs_automated_non_invasive_blood_pressure_with_cuff/en/

89. World Health Organization. Fourth WHO Global Forum on Medical Devices Report. 2019. Accessed December 16, 2020. https://www.who.int/medical_devices/global_forum/4th_gfmd/en/
90. Padwal R, Campbell NRC, Schutte AE, Olsen MH, Delles C, Etyang A, Cruickshank JK, Stergiou G, Rakotz MK, Wozniak G, et al. Optimizing observer performance of clinic blood pressure measurement: a position statement from the Lancet Commission on Hypertension Group. *J Hypertens*. 2019;37:1737–1745. doi: 10.1097/HJH.0000000000002112
91. Odili AN, Abdullahi B, Nwankwo AM, Asayama K, Staessen JA. Characteristics of self-measured home blood pressure in a Nigerian urban community: the NIPREGH study. *Blood Press Monit*. 2015;20:260–265. doi: 10.1097/MBP.0000000000000136
92. He J, Irazola V, Mills KT, Poggio R, Beratarrechea A, Dolan J, Chen CS, Gibbons L, Krousel-Wood M, Bazzano LA, et al; HCPIA Investigators. Effect of a community health worker-led multicomponent intervention on blood pressure control in low-income patients in Argentina: a randomized clinical trial. *JAMA*. 2017;318:1016–1025. doi: 10.1001/jama.2017.11358
93. Piette JD, Datwani H, Gaudioso S, Foster SM, Westphal J, Perry W, Rodríguez-Saldaña J, Mendoza-Avelares MO, Marinec N. Hypertension management using mobile technology and home blood pressure monitoring: results of a randomized trial in two low/middle-income countries. *Telemed J E Health*. 2012;18:613–620. doi: 10.1089/tmj.2011.0271
94. Burger R, Christian CS, Gerdtham UG, Haal K, Hompashe DM, Smith A, Schutte AE. Use of simulated patients to assess hypertension case management at public healthcare facilities in South Africa. *J Hypertens*. 2020;38:362–367. doi: 10.1097/HJH.0000000000002258
95. World Health Organization. Physical Activity Fact Sheet. 2020. Accessed December 16, 2020. https://www.who.int/news-room/fact-sheets/detail/physical-activity
96. Turnbull F; Blood Pressure Lowering Treatment Trialists' Collaboration. Effects of different blood-pressure-lowering regimens on major cardiovascular events: results of prospectively-designed overviews of randomised trials. *Lancet*. 2003;362:1527–1535. doi: 10.1016/s0140-6736(03)14739-3
97. Attaei MW, Khatib R, McKee M, Lear S, Dagenais G, Igumbor EU, AlHabib KF, Kaur M, Kruger L, Teo K, et al; PURE Study Investigators. Availability and affordability of blood pressure-lowering medicines and the effect on blood pressure control in high-income, middle-income, and low-income countries: an analysis of the PURE study data. *Lancet Public Health*. 2017;2:e411–e419. doi: 10.1016/S2468-2667(17)30141-X
98. Benjamin IJ, Kreutz R, Olsen MH, Schutte AE, Lopez-Jaramillo P, Frieden TR, Sliwa K, Lackland DT, Brainin M. Fixed-dose combination antihypertensive medications. *Lancet*. 2019;394:637–638. doi: 10.1016/S0140-6736(19)31629-0
99. Wang N, Salam A, Webster R, de Silva A, Guggilla R, Stepien S, Mysore J, Billot L, Jan S, Maulik PK, et al; TRIUMPH Study Group. Association of low-dose triple combination therapy with therapeutic inertia and prescribing patterns in patients with hypertension: a secondary analysis of the TRIUMPH trial. *JAMA Cardiol*. 2020;5:1219–1226. doi: 10.1001/jamacardio.2020.2739
100. Webster R, Salam A, de Silva HA, Selak V, Stepien S, Rajapakse S, Amarasekara S, Amarasena N, Billot L, de Silva AP, et al; TRIUMPH Study Group. Fixed low-dose triple combination antihypertensive medication vs usual care for blood pressure control in patients with mild to moderate hypertension in Sri Lanka: a randomized clinical trial. *JAMA*. 2018;320:566–579. doi: 10.1001/jama.2018.10359
101. Yusuf S, Joseph P, Dans A, Gao P, Teo K, Xavier D, López-Jaramillo P, Yusoff K, Santoso A, Gamra H, et al; International Polycap Study 3 Investigators. Polypill with or without aspirin in persons without cardiovascular disease. *N Engl J Med*. 2021;384:216–228. doi: 10.1056/NEJMoa2028220
102. U.S. Department of Health and Human Services. The Surgeon General's Call to Action to Control Hypertension. 2020. Accessed November 30, 2020. https://www.hhs.gov/sites/default/files/call-to-action-to-control-hypertension.pdf
103. Rea F, Corrao G, Merlino L, Mancia G. Initial antihypertensive treatment strategies and therapeutic inertia. *Hypertension*. 2018;72:846–853. doi: 10.1161/HYPERTENSIONAHA.118.11308
104. van der Linden EL, Agyemang C, van den Born BH. Hypertension control in sub-Saharan Africa: clinical inertia is another elephant in the room. *J Clin Hypertens (Greenwich)*. 2020;22:959–961. doi: 10.1111/jch.13874
105. World Health Organization. Adherence to Long-Term Therapies: Evidence for Action. 2003. Accessed December 16, 2020. https://www.who.int/chp/knowledge/publications/adherence_full_report.pdf?ua=1
106. Morisky DE, Ang A, Krousel-Wood M, Ward HJ. Predictive validity of a medication adherence measure in an outpatient setting. *J Clin Hypertens (Greenwich)*. 2008;10:348–354. doi: 10.1111/j.1751-7176.2008.07572.x
107. Kim MT, Hill MN, Bone LR, Levine DM. Development and testing of the Hill-Bone compliance to high blood pressure therapy scale. *Prog Cardiovasc Nurs*. 2000;15:90–96. doi: 10.1111/j.1751-7117.2000.tb00211.x
108. Chen SL, Tsai JC, Lee WL. The impact of illness perception on adherence to therapeutic regimens of patients with hypertension in Taiwan. *J Clin Nurs*. 2009;18:2234–2244. doi: 10.1111/j.1365-2702.2008.02706.x
109. Modesti PA, Wang J, Damasceno A, Agyemang C, Van Bortel L, Persu A, Zhao D, Jarraya F, Marzotti I, Bamoshmoosh M, et al. Indirect implications of COVID-19 prevention strategies on non-communicable diseases: an opinion paper of the European Society of Hypertension working group on hypertension and cardiovascular risk assessment in subjects living in or emigrating from low resource settings. *BMC Med*. 2020;18:256. doi: 10.1186/s12916-020-01723-6
110. Nielsen JØ, Shrestha AD, Neupane D, Kallestrup P. Non-adherence to anti-hypertensive medication in low- and middle-income countries: a systematic review and meta-analysis of 92443 subjects. *J Hum Hypertens*. 2017;31:14–21. doi: 10.1038/jhh.2016.31
111. Macquart de Terline D, Kane A, Kramoh KE, et al. Factors associated with poor adherence to medication among hypertensive patients in twelve low and middle income Sub-Saharan countries. *PLoS One*. 2019;14:e0219266.
112. Burnier M, Egan BM. Adherence in hypertension. *Circ Res*. 2019;124:1124–1140. doi: 10.1161/CIRCRESAHA.118.313220
113. GBD 2019 Risk Factors Collaborators. Global burden of 87 risk factors in 204 countries and territories, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet*. 2020;396:1223-1249. doi: 10.1016/S0140-6736(20)30752-2
114. European Society of Hypertension Corona-virus Disease 19 Task Force* The corona-virus disease 2019 pandemic compromised routine care for hypertension: a survey conducted among excellence centers of the European Society of Hypertension. *J Hypertens*. 2021;39:190–195. doi: 10.1097/HJH.0000000000002703
115. Skeete J, Connell K, Ordunez P, DiPette DJ. Approaches to the management of hypertension in resource-limited settings: strategies to overcome the hypertension crisis in the Post-COVID Era. *Integr Blood Press Control*. 2020;13:125–133. doi: 10.2147/IBPC.S261031
116. The World Bank. *Physicians (per 1,000 people) - India, Japan, Nigeria, Mozambique*. The World Bank, 2020. Accessed December 14, 2020. https://data.worldbank.org/indicator/SH.MED.PHYS.ZS?end=2018&locations=IN-JP-NG-MZ&start=1960&view=chart&year=1999
117. The World Bank. *Nurses and midwives (per 1,000 people) - India, Japan, Nigeria, Mozambique*. The World Bank, 2020. Accessed December 14, 2020. https://data.worldbank.org/indicator/SH.MED.NUMW.P3?end=2018&locations=IN-JP-NG-MZ&start=1960&view=chart&year=1999
118. World Health Organization. *Health Workforce*. 2020. Accessed December 16, 2020. https://www.who.int/health-topics/health-workforce#tab=tab_2
119. World Health Organization. *Working for Health and Growth: Investing in the Health Workforce. Report of the High-Level Commission on Health Employment and Economic Growth*. 2016. Accessed December 16, 2020. https://apps.who.int/iris/bitstream/handle/10665/250047/9789241511308-eng.pdf?sequence=1
120. 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*. 2015;65:291–298. doi: 10.1161/HYPERTENSIONAHA.114.04394
121. Lozano R, Fullman N, Mumford JE; GBD 2019 Universal Health Coverage Collaborators. Measuring universal health coverage based on an index of effective coverage of health services in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet*. 2020;396:1250–1284. doi: 10.1016/S0140-6736(20)30750-9
122. Frieden TR, Varghese CV, Kishore SP, Campbell NRC, Moran AE, Padwal R, Jaffe MG. Scaling up effective treatment of hypertension-A pathfinder for universal health coverage. *J Clin Hypertens (Greenwich)*. 2019;21:1442–1449. doi: 10.1111/jch.13655
123. Wagstaff A, Flores G, Hsu J, Smitz MF, Chepynoga K, Buisman LR, van Wilgenburg K, Eozenou P. Progress on catastrophic health spending in 133 countries: a retrospective observational study. *Lancet Glob Health*. 2018;6:e169–e179. doi: 10.1016/S2214-109X(17)30429-1
124. Brinda EM, Andrés AR, Andrés RA, Enemark U. Correlates of out-of-pocket and catastrophic health expenditures in Tanzania: results from a national household survey. *BMC Int Health Hum Rights*. 2014;14:5. doi: 10.1186/1472-698X-14-5

125. Pandey A, Ploubidis GB, Clarke L, Dandona L. Trends in catastrophic health expenditure in India: 1993 to 2014. *Bull World Health Organ*. 2018;96:18–28. doi: 10.2471/BLT.17.191759
126. Murphy A, Palafox B, Walli-Attaei M, Powell-Jackson T, Rangarajan S, Alhabib KF, Avezum AJ, Calik KBT, Chifamba J, Choudhury T, et al. The household economic burden of non-communicable diseases in 18 countries. *BMJ Glob Health*. 2020;5:e002040. doi: 10.1136/bmjgh-2019-002040
127. Londoño Agudelo E, García Fariñas A, Pérez Ospina V, Taborda Pérez C, Villacrés Landeta T, Battaglioli T, Gómez Arias R, Van der Stuyft P. Out-of-pocket expenditure for hypertension care: a population-based study in low-income urban Medellin, Colombia. *Glob Health Action*. 2020;13:1806527. doi: 10.1080/16549716.2020.1806527
128. World Health Organization. Out-of-Pocket Payments, User Fees and Catastrophic Expenditure. 2020. Accessed December 16, 2020. https://www.who.int/health_financing/topics/financial-protection/out-of-pocket-payments/en/
129. World Health Organization. mHealth: New Horizons for Health Through Mobile Technologies: Second Global Survey on eHealth. 2011. Accessed December 16, 2020. https://apps.who.int/iris/bitstream/handle/10665/44607/9789241564250_eng.pdf?sequence=1&isAllowed=y
130. Bahia K, Suardi S. The State of Mobile Internet Connectivity. 2020. Accessed November 29, 2020. https://www.gsma.com/r/wp-content/uploads/2020/09/GSMA-State-of-Mobile-Internet-Connectivity-Report-2020.pdf
131. Vedanthan R, Bernabe-Ortiz A, Herasme OI, Joshi R, Lopez-Jaramillo P, Thrift AG, Webster J, Webster R, Yeates K, Gyamfi J, et al. Innovative approaches to hypertension control in low- and middle-income countries. *Cardiol Clin*. 2017;35:99–115. doi: 10.1016/j.ccl.2016.08.010
132. Weber MA, Lackland DT. The new wave of Asia: a major step forward in confronting global hypertension. *J Clin Hypertens (Greenwich)*. 2020;22:317–318. doi: 10.1111/jch.13801
133. Mao Y, Lin W, Wen J, Chen G. Impact and efficacy of mobile health intervention in the management of diabetes and hypertension: a systematic review and meta-analysis. *BMJ Open Diabetes Res Care*. 2020;8:e001225.
134. Prabhakaran D, Jha D, Ajay VS, Roy A, Perel P. Response by Prabhakaran et al to Letter Regarding Article, "Effectiveness of an mHealth-based electronic decision support system for integrated management of chronic conditions in primary care: the mWellcare Cluster-Randomized Controlled Trial". *Circulation*. 2019;139:e1039. doi: 10.1161/CIRCULATIONAHA.119.040782
135. Anchala R, Kaptoge S, Pant H, Di Angelantonio E, Franco OH, Prabhakaran D. Evaluation of effectiveness and cost-effectiveness of a clinical decision support system in managing hypertension in resource constrained primary health care settings: results from a cluster randomized trial. *J Am Heart Assoc*. 2015;4:e001213. doi: 10.1161/JAHA.114.001213
136. Tian M, Ajay VS, Dunzhu D, Hameed SS, Li X, Liu Z, Li C, Chen H, Cho K, Li R, et al. A cluster-randomized, controlled trial of a simplified multifaceted management program for individuals at high cardiovascular risk (SimCard Trial) in Rural Tibet, China, and Haryana, India. *Circulation*. 2015;132:815–824. doi: 10.1161/CIRCULATIONAHA.115.015373
137. World Health Organization. Task Shifting: Rational Redistribution of Tasks among Health Workforce Teams: Global Recommendations and Guidelines. 2008. Accessed December 16, 2020. https://apps.who.int/iris/bitstream/handle/10665/43821/9789241596312_eng.pdf?sequence=1&isAllowed=y
138. Samb B, Celletti F, Holloway J, Van Damme W, De Cock KM, Dybul M. Rapid expansion of the health workforce in response to the HIV epidemic. *N Engl J Med*. 2007;357:2510–2514. doi: 10.1056/NEJMsb071889
139. Callaghan M, Ford N, Schneider H. A systematic review of task- shifting for HIV treatment and care in Africa. *Hum Resour Health*. 2010;8:8. doi: 10.1186/1478-4491-8-8
140. Huicho L, Scherpbier RW, Nkowane AM, Victora CG; Multi-Country Evaluation of IMCI Study Group. How much does quality of child care vary between health workers with differing durations of training? An observational multicountry study. *Lancet*. 2008;372:910–916. doi: 10.1016/S0140-6736(08)61401-4
141. Christopher JB, Le May A, Lewin S, Ross DA. Thirty years after Alma-Ata: a systematic review of the impact of community health workers delivering curative interventions against malaria, pneumonia and diarrhoea on child mortality and morbidity in sub-Saharan Africa. *Hum Resour Health*. 2011;9:27. doi: 10.1186/1478-4491-9-27
142. Lewin S, Munabi-Babigumira S, Glenton C, Daniels K, Bosch-Capblanch X, van Wyk BE, Odgaard-Jensen J, Johansen M, Aja GN, Zwarenstein M, et al. Lay health workers in primary and community health care for maternal and child health and the management of infectious diseases. *Cochrane Database Syst Rev*. 2010:CD004015.
143. Seidman G, Atun R. Does task shifting yield cost savings and improve efficiency for health systems? A systematic review of evidence from low-income and middle-income countries. *Hum Resour Health*. 2017;15:29. doi: 10.1186/s12960-017-0200-9
144. Joshi R, Alim M, Kengne AP, Jan S, Maulik PK, Peiris D, Patel AA. Task shifting for non-communicable disease management in low and middle income countries–a systematic review. *PLoS One*. 2014;9:e103754. doi: 10.1371/journal.pone.0103754
145. Gaziano TA, Abrahams-Gessel S, Denman CA, Montano CM, Khanam M, Puoane T, Levitt NS. An assessment of community health workers' ability to screen for cardiovascular disease risk with a simple, non-invasive risk assessment instrument in Bangladesh, Guatemala, Mexico, and South Africa: an observational study. *Lancet Glob Health*. 2015;3:e556–e563. doi: 10.1016/S2214-109X(15)00143-6
146. Anand TN, Joseph LM, Geetha AV, Prabhakaran D, Jeemon P. Task sharing with non-physician health-care workers for management of blood pressure in low-income and middle-income countries: a systematic review and meta-analysis. *Lancet Glob Health*. 2019;7:e761–e771. doi: 10.1016/S2214-109X(19)30077-4
147. Ojji DB, Mayosi B, Francis V, Badri M, Cornelius V, Smythe W, Kramer N, Barasa F, Damasceno A, Dzudie A, et al; CREOLE Study Investigators. Comparison of dual therapies for lowering blood pressure in black Africans. *N Engl J Med*. 2019;380:2429–2439. doi: 10.1056/NEJMoa1901113
148. Ali MK, Chwastiak L, Poongothai S, Emmert-Fees KMF, Patel SA, Anjana RM, Sagar R, Shankar R, Sridhar GR, Kosuri M, et al; INDEPENDENT Study Group. Effect of a collaborative care model on depressive symptoms and glycated hemoglobin, blood pressure, and serum cholesterol among patients with depression and diabetes in India: the INDEPENDENT randomized clinical trial. *JAMA*. 2020;324:651–662. doi: 10.1001/jama.2020.11747
149. Ajay VS, Jindal D, Roy A, Venugopal V, Sharma R, Pawar A, Kinra S, Tandon N, Prabhakaran D. Development of a smartphone-enabled hypertension and diabetes mellitus management package to facilitate evidence-based care delivery in primary healthcare facilities in India: the mPower heart project. *J Am Heart Assoc*. 2016;5:e004343.
150. Patel SA, Dhillon PK, Kondal D, Jeemon P, Kahol K, Manimunda SP, Purty AJ, Deshpande A, Negi PC, Ladhani S, et al. Chronic disease concordance within Indian households: a cross-sectional study. *PLoS Med*. 2017;14:e1002395. doi: 10.1371/journal.pmed.1002395
151. Shen Y, Peng X, Wang M, Zheng X, Xu G, Lü L, Xu K, Burstrom B, Burstrom K, Wang J. Family member-based supervision of patients with hypertension: a cluster randomized trial in rural China. *J Hum Hypertens*. 2017;31:29–36. doi: 10.1038/jhh.2016.8
152. Global Alliance for Chronic Disease. 2021. Accessed February 22, 2021. https://www.gacd.org/
153. National Institutes of Health. Fogarty International Centre. 2021. Accessed February 22, 2021. https://www.fic.nih.gov/
154. Wellcome Trust. 2021. Accessed February 22, 2021. https://wellcome.org/
155. National Institute for Health Research. 2021. Accessed on February 22, 2021. https://www.nihr.ac.uk/
156. National Health and Medical Research Council. 2021. Accessed on February 22, 2021. https://www.nhmrc.gov.au
157. India Alliance DBT Wellcome. 2021. Accessed on February 22, 2021. https://www.indiaalliance.org/
158. South African Medical Research Council. 2021. Accessed on February 22, 2021. https://www.samrc.ac.za/
159. Links. 2021. Accessed on February 22, 2021. https://linkscommunity.org/
160. National Institutes of Health and Fogarty International Centre. Global Environmental and Occupational Health (GEOHealth). 2021. Accessed February 22, 2021. https://www.fic.nih.gov/Programs/Pages/environmental-occupational.aspx
161. Aifah A, Iwelunmor J, Akwanalo C, Allison J, Amberbir A, Asante KP, Baumann A, Brown A, Butler M, Dalton M, et al. The Kathmandu declaration on global CVD/Hypertension research and implementation science: a framework to advance implementation research for cardiovascular and other noncommunicable diseases in low- and middle-income Countries. *Glob Heart*. 2019;14:103–107. doi: 10.1016/j.gheart.2019.05.006
162. World Health Organization. Scaling Up Action Against Noncommunicable Diseases: How Much will it Cost? 2011. Accessed February 22, 2021. https://apps.who.int/iris/bitstream/handle/10665/44706/9789241502313_eng.pdf;jsessionid=5E6994E058684E512D3874D45CA75256?sequence=1