Editorial

Hypertension in the Time of the COVID-19 Pandemic: New Issues and Enduring Controversies

Suzanne Oparil, MD
Vascular Biology and Hypertension Program, Division of Cardiovascular Disease, Department of Medicine, University of Alabama at Birmingham, Birmingham, Alabama

In his recent review, "Future of Hypertension: The Need for Transformation," Victor Dzau, president of the National Academy of Medicine, emphasized the need for sweeping transformation in the ways we diagnose and treat hypertension so as to reduce the global burden of the disease (1). The review emphasizes the role of emerging technologies in changing the way healthcare is delivered, with an overall trend shifting away from hospitals and clinics toward care delivered on a daily basis in the home. This will require improved technologies for out-of-office BP monitoring, along with enhanced digital technologies for the transfer and analysis of BP information so as to identify and deliver optimal treatment regimens that are evidence based (Figure 1). The five key areas in which progress is needed to advance hypertension treatment and control are depicted in this figure.

The personal isolation and distancing strategies mandated in the COVID-19 pandemic accelerate the need for telemedicine approaches for monitoring home BPs and delivering the values to the healthcare provider in a manner that can be readily applied to managing antihypertensive medical regimens. A variety of devices for noninvasive continuous BP monitoring are currently available (2,3), and more are on the way (4). These devices have their greatest potential to revolutionize the care of the hypertensive patient when coupled with artificial intelligence, the science and engineering of making intelligent machines (computer programs), in the healthcare system (5). Artificial intelligence, coupled with accurate monitoring devices, can improve access to care and provide more detailed and accurate BP monitoring, thus enhancing clinical decision making. Furthermore, increased patient engagement in these processes may enhance adherence to prescribed medical and lifestyle regimens, thus slowing the progression of hypertension and preventing its cardiovascular disease (CVD) complications. In addition to the need for improved diagnosis and treatment of hypertension in the out-of-office setting, there is continuing need for fundamental research on the pathogenesis of hypertension and its cardiovascular and renal complications, with the ultimate goal of developing novel targeted therapies that are well tolerated and effective in not only lowering BP but also preventing target organ damage.

The National Heart, Lung and Blood Institute (NHLBI) recently weighed in on the issue of translating basic research to improve control of hypertension (6). The NHLBI Working Group on Hypertension reviewed recent discoveries that may be ready for testing in clinical trials and highlighted the most promising areas in which to improve translation. It also identified gaps in knowledge that appear to impede translation, and key challenges and barriers to moving basic science discoveries into the clinic. Finally, the Working Group identified several research opportunities that promise to enhance the translation of hypertension research to clinical care (Table 1). Overall, the Working Group concluded that multilevel multicomponent strategies, along with patient-level strategies, are needed to improve BP control in hypertensive patients. Nonadherence to prescribed medical regimens and clinical inertia were found to be major barriers to BP control. The panel concluded that enhancements in the field of implementation science are needed to ensure that successful programs of BP control reach the large and growing population of hypertensive patients in a timely manner.

Currently, several controversies in hypertension management deserve particular attention.

Renin-Angiotensin-Aldosterone System Inhibitor Use During the COVID-19 Pandemic

Angiotensin-converting enzyme 2 (ACE2), the monocarboxypeptidase that inactivates angiotensin II and thereby counters the activation of the classical renin-angiotensin-aldosterone system (RAAS), has been identified as the functional receptor for the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Figure 2) (7). The SARS-CoV-2 virus is responsible for the COVID-19 pandemic (8). The virus has spike proteins that bind to ACE2 on the surface of lung alveolar epithelial cells. The virus is then endocytosed, causing downregulation of surface ACE2 and accumulation of angiotensin II in the lung, with attendant increases in oxidative injury. The coronavirus replicates in the lung, further damaging lung tissue.

Early reports of clinical characteristics of patients with COVID-19 in China found a high prevalence of hypertension, CVD, and diabetes in those with more severe forms of the disease (9,10). These comorbidities are commonly treated with ACE inhibitors or angiotensin receptor blockers (ARBs). ACE inhibitors and ARBs have been shown to upregulate ACE2 in some animal models (11,12) and in some patients with hypertension or diabetes (13). These observations have raised concerns that the ACE inhibitors or ARBs may increase expression of ACE2, the known receptor for coronavirus, and thus increase the risk of infection with COVID-19 or worsen the severity of COVID-19 in those who are already infected (14). These issues have led to extensive discussion in the literature and in medical societies around the world about three critical questions that are of great importance to patients and healthcare providers in the setting of the COVID-19 pandemic (15,16): 1) Is there a link between hypertension and increased risk of COVID-19 infection in humans? 2) Are patients on ACE inhibitors/ARBs at an increased risk of infection or severity of disease? 3) Does starting, stopping, or continuing these drugs lead to better or worse outcomes in COVID-19?

Whereas hypertension has been reported as the most prevalent coexisting condition in patients with severe COVID-19 in China,

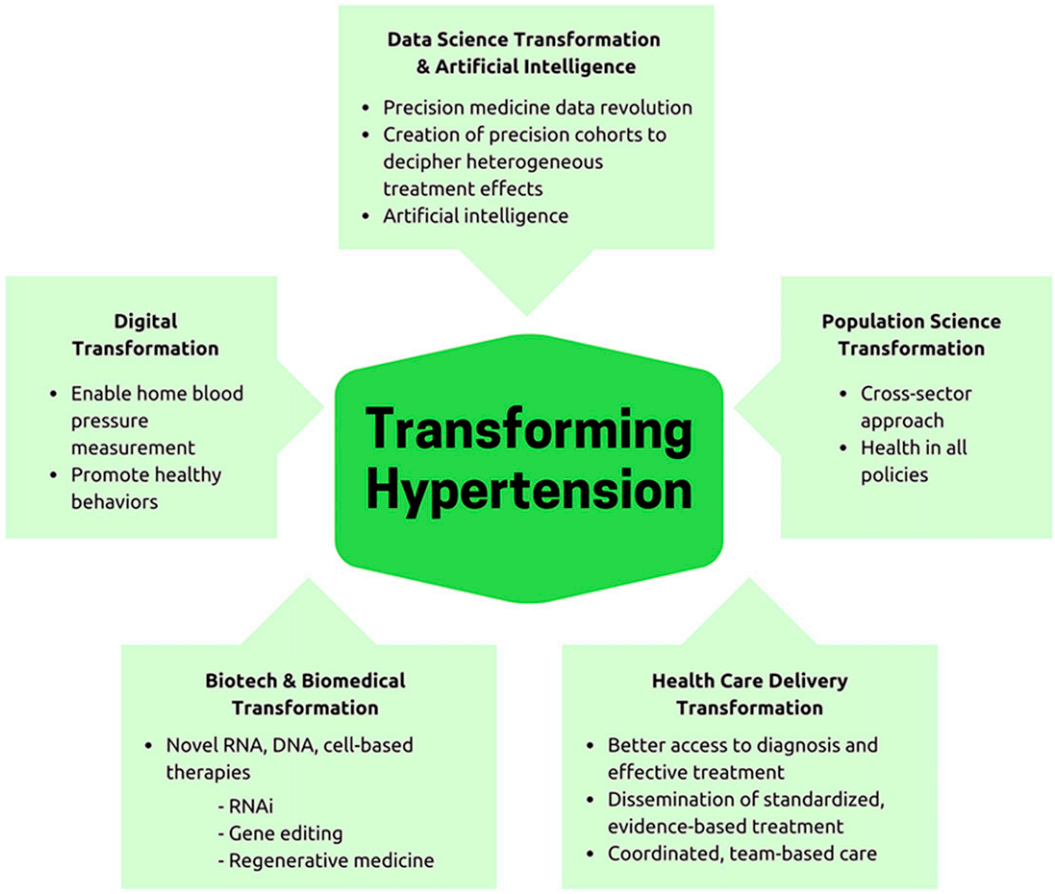


Figure 1. Hypertension: need for transformation. To control or eliminate hypertension, there is a need for system-wide transformation in research and clinical care and in the convergence of disciplines. This figure highlights the five key areas where progress is needed to advance hypertension control and treatment. Achieving maximum benefit will require convergence of these areas. Used with permission from Figure 1 of reference 1 (Dzau VJ, Balatbat CA: Future of hypertension. *Hypertension* 74: 450–457, 2019).

this relationship is confounded by the strong association with advancing age, which is currently the strongest predictor of COVID-19–related death (17). Furthermore, data on ACE inhibitor/ARB use in hypertensive Chinese patients before and during the course of COVID-19 are sparse. Further study is needed to determine whether hypertensive persons are at increased risk of COVID-19 infection/severity of disease.

Data on the effects of ACE inhibitors and ARBs on ACE2 levels or activity in animal models are inconsistent, with some studies showing increases in ACE2 mRNA or protein levels and others showing no effect (11,12,18,19). Furthermore, data on the effects of ACE inhibitors and ARBs on ACE2 expression and ACE2-directed angiotensin II metabolism in humans are sparse and inconsistent, and data on the effects of RAAS inhibitors on lung-specific expression of ACE2 are nonexistent (8). Contrary to the hypothesis that RAAS blockers predispose to lung injury in the setting of COVID-19 infection, there is evidence that ACE inhibitors and ARBs can lessen the extent of coronavirus-mediated acute lung injury by maintaining ACE2 levels and thus reducing generation of angiotensin II in lung (20). Similarly, administration of recombinant ACE2 protein has been shown to protect against lung injury induced by respiratory syncytial virus injection in animal models (21) and to reduce angiotensin II levels in a phase 2 trial in humans with acute respiratory distress syndrome (22). Consistent with these preliminary observations, clinical trials of recombinant ACE2 protein and of the ARB losartan are under way in patients with COVID-19 to restore balance to the RAAS and prevent organ injury (8).

In contrast to the uncertainty about the potential benefit of initiating RAAS blocker use in patients with COVID-19, there is a clear potential for harm in withdrawing these agents in high-risk COVID-19 patients with established myocardial injury, hypertension, or heart failure (8). Abrupt withdrawal of RAAS blockers from clinically stable patients with COVID-19 and these comorbidities may result in clinical instability and adverse health outcomes. Accordingly, major medical societies recommend continuing ACE inhibitors and ARBs in hypertensive patients with COVID-19 because of lack of evidence of benefit and strong evidence of harm from discontinuation (Table 2). Some specifically conclude that routine use of ACE inhibitors or ARBs to treat hypertension should not be influenced by concerns about COVID-19 in the absence of compelling data that ACE inhibitors/ARBs either improve or worsen susceptibility to COVID-19 infection or affect the outcomes in those infected (23). These recommendations apply to patients who are in stable condition and are at risk for, being evaluated for, or infected with COVID-19 (8).

Table 1. Research opportunities to enhance translation of hypertension research

Encourage innovative translational research that requires collaboration among basic and clinical scientists and includes patient-oriented research.
Facilitate training that encourages collaboration and cross-training in basic science and clinical application.
Develop new drugs and treatments (such as potassium-rich diets) to target diverse hypertensive patient populations, such as patients with resistant hypertension.
Capitalize on resources currently or previously supported by NHLBI, such as databases, clinical populations, and clinical trial data, that will facilitate discovery.
Develop new technologies for better phenotyping of humans and animals through in vivo imaging, single-cell analysis (central repository and analysis), analysis of large data sets, validation of surrogate endpoints and biomarkers, robust long-term follow-up, and assessment of tissue- and organ-based sympathetic activity.
Support studies on hypertension and aging, including arterial aging, cognition, medication adherence, and complications of antihypertensive therapy.
Support studies related to the role of sex differences in the complications of hypertension and hypertension in pregnancy and preeclampsia.
Develop and use animal models that are best suited to the scientific question posed irrespective of cost.
Develop approaches to optimally detect and reverse antihypertensive medication nonadherence.
Strengthen the evidence base for genetic screening tools for both risk of hypertension and optimal treatment options, with collection of genetic data in clinical trials and population-based studies across the lifespan.
Support clinical trials for early intervention in high BP, particularly in stage 1 hypertension and in younger populations, with long-term tracking of outcomes.
Develop strategies to engage healthcare practitioners in strong patient relationship bonds and trust to promote lifestyle modification in high-risk populations.
Support studies that focus on multilevel, collaborative system-based approaches, including patients, providers, and health systems (at a minimum of 2 levels).
Encourage researchers to incorporate implementation science methodologies that can look broadly to bridge healthcare and community settings.
Support clinical trials designed to use quasi-experimental or mixed methodologies and those that specifically address the questions, such as "who does it work for?" and "when does it work?"
Convene representatives and leaders from NHLBI, healthcare systems, payers, industry, insurers, and other government agencies to address implementation science in hypertension.
Support training for the next generation of health disparities and implementation science researchers, including laypersons and community health workers.

Used with permission from Table 2 of reference 6 (Sigmund CD, Carey RM, Appel LJ, et al.: Report of the National Heart, Lung, and Blood Institute Working Group on Hypertension: barriers to translation. *Hypertension* 75: 902–917, 2020).

NHLBI, National Heart, Lung, and Blood Institute.

Further research that will address key unanswered questions about the role of the RAAS in the pathogenesis and possible treatment of COVID-19 and other coronavirus-based diseases is urgently needed.

Timing of Antihypertensive Medication Dosing

Awareness of diurnal rhythms in BP, and particularly the importance of nocturnal BP in determining risk of CVD, has led to discussions about the appropriate timing of antihypertensive medication dosing. Ambulatory BP monitoring studies have shown that nighttime BP levels are more predictive of CVD outcomes than 24-hour or daytime levels and that dipping status also may be an independent predictor of outcomes (24). A series of studies, including the Prognostic Value of Ambulatory Blood Pressure Monitoring in the Prediction of Cardiovascular Events and Effects of Chronotherapy in Relation to Risk (MAPEC) study (25) and the Heart Outcomes Prevention Evaluation (HOPE) study (26), culminating in the recently published Hygia Chronotherapy Trial (27), have reported beneficial effects of bedtime hypertension treatment on CVD risk. The MAPEC study enrolled 2156 patients with uncontrolled BP on three antihypertensive agents taken in the morning and randomized them to either continue their current regimen or take one of the medications in the evening and two in the morning. MAPEC reported that administration of at least one antihypertensive agent at bedtime, compared with morning-only dosing, was associated with better BP control overall and with reduction in nondipping BP patterns and CVD events. The HOPE trial showed that, compared with placebo

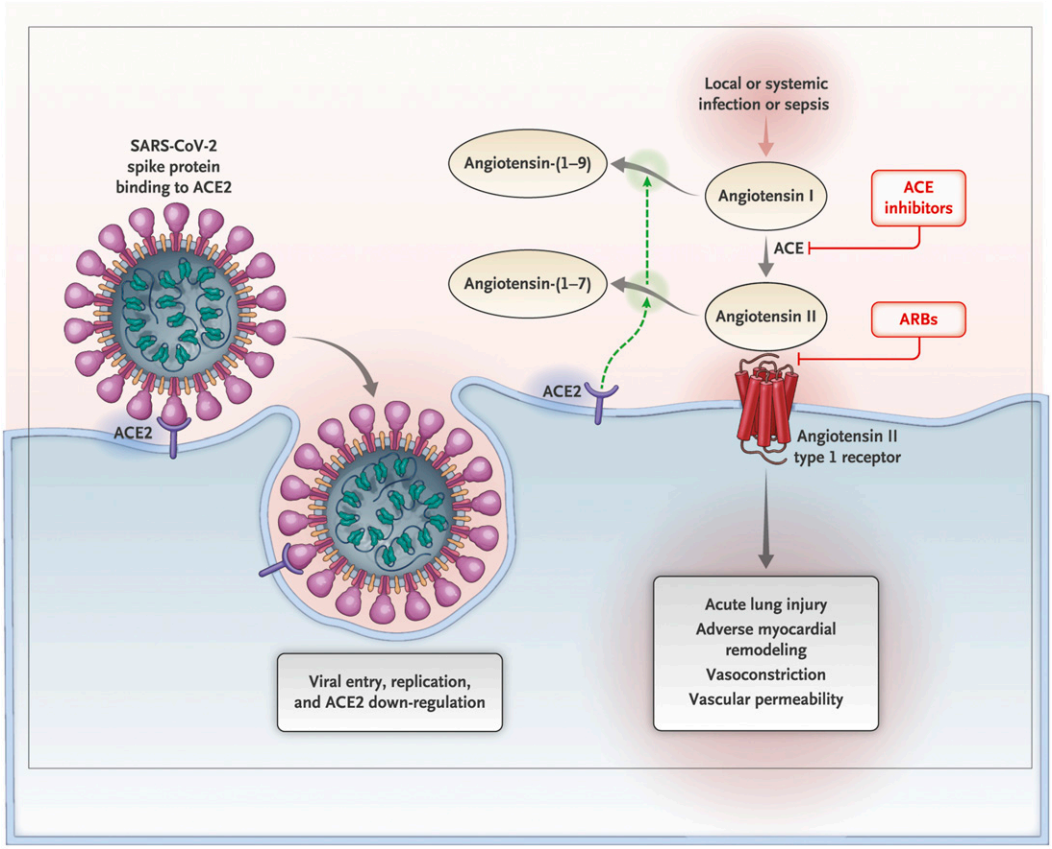


Figure 2. Interaction between SARS-CoV-2 and the renin-angiotensin-aldosterone system. Shown is the initial entry of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) into cells, primarily type II pneumocytes, after binding to its functional receptor, angiotensin-converting enzyme 2 (ACE2). After endocytosis of the viral complex, surface ACE2 is further downregulated, resulting in unopposed angiotensin II accumulation. Local activation of the renin-angiotensin-aldosterone system may mediate lung injury responses to viral insults. ACE, angiotensin-converting enzyme; ARB, angiotensin receptor blocker. Reprinted with permission from reference 8 (Vaduganathan M, Vardeny O, Michel T, McMurray J, Pfeffer MA, Solomon SD: Renin-angiotensin-aldosterone system inhibitors in patients with Covid-19. *N Engl J Med* 382: 1653-1659, 2020). Copyright © (2020) Massachusetts Medical Society. Reprinted with permission from Massachusetts Medical Society.

control, nighttime dosing with ramipril resulted in large reductions in CVD outcomes without major effects on daytime office BP.

The Hygia Chronotherapy Trial enrolled 19,084 hypertensive patients who underwent 48-hour ambulatory BP monitoring at baseline and at yearly intervals throughout the study (median follow-up time 6.3 years). At the end of the study, nighttime ambulatory BP was significantly lower (114.7/64.5 mmHg) in the bedtime-dosing group than in the morning-dosing group (118.0/66.1 mmHg), and daytime ambulatory BP was nearly identical in the two groups. The mean number of antihypertensive drugs taken at the end of the study was significantly lower (1.71) in the bedtime group compared with the morning group (1.80, $P<0.001$). Dramatic reductions were reported in all-cause mortality and cardiovascular mortality and in CVD-outcome events, including myocardial infarction, heart failure, stroke, and coronary revascularization, with adjusted hazard ratios for total events = 0.58 and for all-cause mortality = 0.55.

The report of the Hygia study (27) and the accompanying editorial (28) have been widely discussed among hypertension researchers and clinicians, in the lay press, and among patients. Major concerns have been expressed related to study design (uncertainty whether it was really a randomized controlled trial that conformed to common standards ([CONSORT]), statistical issues, and questions about adequacy of monitoring and the independence of adjudicators of study outcomes (29–31). Most importantly, critics have questioned how such dramatic reductions in mortality and CVD events could have been related to the very modest between-group differences in BP that were reported.

Earlier studies have shown that excessive nighttime lowering of BP, including overdipping or extreme dipping, is associated with increased risk of ischemic injury in patients with coronary artery disease (32) or silent cerebral infarcts (33), particularly in the elderly (34). These findings suggest that bedtime dosing of antihypertensive medications could harm those patients by further reducing their nighttime BPs. The recommendation for bedtime dosing of BP-lowering medications has also been questioned based on evidence that adherence to prescribed antihypertensive medications, documented by using the Medication Event Monitoring System (MEMS), is significantly lower when medications are taken at bedtime versus morning (35)

Numerous well-designed randomized controlled trials of hypertension treatment, with hundreds of thousands of participants, have dosed the medication in the morning rather than at bedtime.

Table 2. Professional societies' recommendations for use of ACE inhibitors/ARBs in COVID-19 patients

Society	Summary of Recommendations	Last Statement Update
European Society of Hypertension	Recommend continuing ACEs/ARBs due to lack of evidence to support differential use in COVID-19 patients. In those with severe symptoms of sepsis, antihypertensive decisions should be made on a case-by-case basis taking into account current guidelines	March 12, 2020
European Society of Cardiology Council on Hypertension	Strongly encourage continuing ACEs/ARBs due to lack of evidence to support discontinuing	March 13, 2020
Hypertension Canada	Recommend continuing ACEs/ARBs due to lack of evidence that patients with hypertension or those treated with ACEs/ARBs are at higher risk of adverse outcomes from COVID-19 infection	March 13, 2020
Canadian Cardiovascular Society	Strongly encourage continuing ACEs/ARBs and Angiotensin Receptor Neprilysin Inhibitors due to a lack of clinical evidence to support withdrawal of these agents	March 15, 2020
The Renal Association, United Kingdom	Strongly encourage continuing ACEs/ARBs due to unconvincing evidence that these medications increase risk	March 15, 2020
International Society of Hypertension	Strongly recommend that the routine use of ACEs/ARBs to treat hypertension should not be influenced by concerns about COVID-19 in the absence of compelling data that ACEs/ARBs either improve or worsen susceptibility to COVID-19 infection nor do they affect the outcomes of those infected	March 16, 2020
American College of Physicians	Encourage continuing ACEs/ARBs because there is no evidence linking them to COVID-19 disease severity, and discontinuation of antihypertensive therapy without medica indication could in some circumstances result in harm	March 16, 2020
Spanish Society of Hypertension	Recommend that ACEs/ARBs should not be empirically stopped in patients who are already taking them; in seriously ill patients, changes should be made on a case-by-case basis	March 16, 2020
American Heart Association, Heart Failure Society of America, American College of Cardiology	Recommend continuing ACEs/ARBs for all patients already prescribed them	March 17, 2020
European Renal Association – European Dialysis and Transplant Association	Recommend continuing ACEs/ARBs in COVID-19 infection patients due to a lack of evidence to support differential use and the discontinuation of ACEis/ARBs in COVID-19 patients	March 17, 2020
American Society of Pediatric Nephrology	Strongly recommend continuing ACEs/ARBs until new evidence to the contrary becomes available	March 17, 2020
High Blood Pressure Research Council of Australia	Recommend continuing routine use of ACEs/ARBs; patients should not cease BP-lowering medications unless advised to do so by their physician	March 18, 2020
Australian Diabetes Society	Recommend that usual antihypertensive therapy is continued given that speculation about risk of ACE inhibitors and ARBs is purely theoretical	March 29, 2020

Used with permission from reference 15 (Sparks MA, Hiremath S, et al.: The coronavirus conundrum: ACE2 and hypertension. NephJC http://www.nephjc.com/news/covidace2). Accessed April 13, 2020.

ACE, angiotensin-converting enzyme; ARB angiotensin receptor blockers,

There is to date no reliable evidence that BP-lowering medications should be routinely dosed at bedtime unless there is a specific evidence-supported indication. The recent Hellenic-Anglo Research into Morning or Night Antihypertensive Drug Delivery (HARMONY) trial was a prospective randomized crossover trial that tested whether there are differential effects of morning versus evening antihypertensive medication dosing on mean 24-hour ABP levels (36). The HARMONY trial demonstrated that the timing of

antihypertensive drug dosing (6–11 AM versus 6–11 PM] did not affect mean 24-hour ABP or clinic BP levels in patients with reasonably controlled hypertension on stable therapy with ≥1 antihypertensive medication at baseline. The ongoing Treatment in the Morning versus Evening (TIME) study is comparing the effects of evening versus morning dosing of antihypertensive medication on major CVD outcomes in 21,113 hypertensive patients recruited from population-based settings throughout the United Kingdom and expected to be followed up for 4 years (37). Pending results of the TIME trial (and similar trials when available), it is reasonable to base the timing of antihypertensive medication dosing on patient preference while using as simple a regimen as possible, including long-acting agents (36).

Diuretic Choices

The majority of the >103 million adults in the United States who have a diagnosis of hypertension are candidates for medical antihypertensive therapy. Current guidelines recommend multiple first-line drug classes, including thiazide or thiazide-like diuretics, ACE inhibitors, ARBs, and calcium channel blockers (38). Which of these classes should be preferentially initiated in newly diagnosed hypertensive patients who are free of comorbidities for whom there are compelling treatment indications is uncertain in the absence of strong evidence from randomized clinical trials with head-to-head comparisons. The recently published Large-Scale Evidence Generation and Evaluation Across a Network of Databases for Hypertension (LEGEND-HTN) study used real-world data from nearly 5 million patients with newly diagnosed hypertension in an attempt to answer this question (39). Their main finding was that CVD outcomes, including myocardial infarction, stroke, and hospitalization for heart failure, were reduced in patients treated with thiazide or thiazide-type diuretics compared with other drug classes. The nondihydropyridine calcium channel blockers were inferior to other classes.

Within the thiazide or thiazide-type diuretic class, hydrochlorothiazide is by far the most commonly used agent to treat hypertension. This may relate to the wide availability of multiple doses of hydrochlorothiazide and its desirable safety profile. In contrast, most randomized controlled trials comparing different classes of antihypertensive drugs, including SHEP, ALLHAT and SPRINT, have chosen chlorthalidone as the diuretic because of its demonstrated efficacy for reducing CVD events. In addition, head-to-head comparison studies have shown that chlorthalidone is superior to hydrochlorothiazide in reducing both office BP and 24-hour ambulatory BP (40,41). A recent retrospective observational cohort study, a component of the LEGEND-HTN study cited above, compared hydrochlorothiazide and chlorthalidone with respect to CVD outcomes and safety concerns (42). The study found no differences in CVD outcomes (acute myocardial infarction, hospitalization for heart failure, stroke, and a composite CVD outcome). However, chlorthalidone use was associated with significantly higher risk of several adverse effects, including hypokalemia, hyponatremia, acute renal failure, exacerbation of chronic kidney disease, and type 2 diabetes. The authors concluded that these findings did not support current recommendations to prefer chlorthalidone versus hydrochlorothiazide for hypertension treatment. These conclusions have been questioned because of the brief follow-up times used (0.25 years and 0.7 years in separate analyses), time periods too brief to adequately capture CVD benefits of treatment if they were present (43). in the landmark SHEP, ALLHAT, and SPRINT CVD outcome trials, all of which used chlorthalidone as the diuretic, CVD outcome curves started to diverge only after 6 to 12 months. The extremely abbreviated follow-up period in the study of Hripcsak *et al.* (42) biases toward zero any inherent between-group differences in preventing CV events. Furthermore, an observational study of a cohort of 12,866 men 35 to 37 years of age, analyzed by Dorsch *et al.* (44) with a median follow-up time of 6 years, found that chlorthalidone was superior to hydrochlorothiazide in reducing CVD events. Very similar findings were reported in a network meta-analysis of randomized trials by Roush *et al.* (45).

Clearly, the abbreviated follow-up in the study by Hripcsak *et al.* (42) puts into question the validity of these retrospective observational data for clinical use. This is particularly important in view of the outstanding safety and efficacy record of chlorthalidone (43,46) and the lack thereof with hydrochlorothiazide (47). Importantly, there are no randomized placebo-controlled trials demonstrating the efficacy of hydrochlorothiazide for reducing CVD events (45,47), and the only head-to-head trial comparing the effects of chlorthalidone with hydrochlorothiazide on CVD outcomes is still in progress in the Veterans Affairs system (48).

For all of these reasons, I strongly prefer chlorthalidone to hydrochlorothiazide for treatment of my hypertensive patients. I limit use of hydrochlorothiazide to situations when single-pill combination therapy that includes a diuretic is desirable for patient convenience, because far more combinations are available with hydrochlorothiazide than with chlorthalidone.

References

1. Dzau VJ, Balatbat CA: Future of hypertension. *Hypertension* 74: 450–457, 2019 PubMed
2. Bard DM, Joseph JI, van Helmond N: Cuff-less methods for blood pressure telemonitoring. *Front Cardiovasc Med* 6: 40, 2019 PubMed
3. Mukherjee R, Ghosh S, Gupta B, Chakravarty T: A universal noninvasive continuous blood pressure measurement system for remote healthcare monitoring. *Telemed J E Health* 24: 803–810, 2018 PubMed
4. Stein A: A real blood-pressure smartwatch is coming from Omron this year. Available at: https://www.cnet.com/news/omron-heartguide-blood-pressure-smartwatch-ces/. Published Jan 7, 2018. Accessed March 15, 2020
5. Topol EJ: High-performance medicine: the convergence of human and artificial intelligence. *Nat Med* 25: 44–56, 2019 PubMed
6. Sigmund CD, Carey RM, Appel LJ, Arnett DK, Bosworth HB, Cushman WC, et al.: Report of the National Heart, Lung, and Blood Institute working group on hypertension: barriers to translation. *Hypertension* 75: 902–917, 2020 PubMed
7. Hoffmann M, Kleine-Weber H, Schroeder S, Krüger N, Herrler T, Erichsen S, et al.: SARS-CoV-2 cell entry depends on ACE2 and TMPRSS2 and is blocked by a clinically proven protease inhibitor. *Cell* 181: 271–280.e8, 2020 PubMed
8. Vaduganathan M, Vardeny O, Michel T, McMurray J, Pfeffer MA, Solomon SD: Renin-angiotensin-aldosterone system inhibitors in patients with Covid-19. *N Engl J Med* 382: 1653–1659, 2020 PubMed
9. Wu Z, McGoogan JM: Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: summary of a report of 72 314 cases from the Chinese Center for Disease Control and Prevention [published online ahead of print Feb 24, 2020]. *JAMA* doi: 10.1001/jama.2020.2648.PubMed
10. Bavishi C, Maddox TM, Messerli FH: Coronavirus disease 2019 (COVID-19) infection and renin angiotensin system blockers [published online ahead of print Apr 3, 2020]. *JAMA Cardiol* doi:10.1001/jamacardio.2020.1282. PubMed
11. Ferrario CM, Jessup J, Chappell MC, Averill DB, Brosnihan KB, Tallant EA, et al.: Effect of angiotensin-converting enzyme inhibition and

angiotensin II receptor blockers on cardiac angiotensin-converting enzyme 2. *Circulation* 111: 2605–2610, 2005 PubMed
12. Klimas J, Olvedy M, Ochodnicka-Mackovicova K, Kruzliak P, Cacanyiova S, Kristek F, et al.: Perinatally administered losartan augments renal ACE2 expression but not cardiac or renal Mas receptor in spontaneously hypertensive rats. *J Cell Mol Med* 19: 1965–1974, 2015 PubMed
13. Soro-Paavonen A, Gordin D, Forsblom C, Rosengard-Barlund M, Waden J, Thorn L, et al.; FinnDiane Study Group: Circulating ACE2 activity is increased in patients with type 1 diabetes and vascular complications. *J Hypertens* 30: 375–383, 2012 PubMed
14. Fang L, Karakiulakis G, Roth M: Are patients with hypertension and diabetes mellitus at increased risk for COVID-19 infection? *Lancet Respir Med* 8: e21, 2020 PubMed
15. Sparks MA, Hiremath S, et al.: The coronavirus conundrum: ACE2 and hypertension. NephJC http://www.nephjc.com/news/covidace2. Accessed March 31, 2020
16. Sparks MA, South A, Welling P, et al.: Sound science before quick judgement regarding RAS blockade in COVID-19 [published online ahead of print Mar 27, 2020]. *Clin J Am Soc Nephrol* doi: 10.2215/CJN.03530320
17. Zhou F, Yu T, Du R, Fan G, Liu Y, Liul Z, et al.: Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. *Lancet* 395: 1054–1062, 2020 PubMed
18. Burrell LM, Risvanis J, Kubota E, Dean RG, MacDonald PS, Lu S, et al.: Myocardial infarction increases ACE2 expression in rat and humans. *Eur Heart J* 26: 369–375, discussion 322–324, 2005 PubMed
19. Burchill LJ, Velkoska E, Dean RG, Griggs K, Patel SK, Burrell LM: Combination renin-angiotensin system blockade and angiotensin-converting enzyme 2 in experimental myocardial infarction: implications for future therapeutic directions. *Clin Sci (Lond)* 123: 649–658, 2012 PubMed
20. Kuba K, Imai Y, Rao S, Gao H, Guo F, Guan B, et al.: A crucial role of angiotensin converting enzyme 2 (ACE2) in SARS coronavirus-induced lung injury. *Nat Med* 11: 875–879, 2005 PubMed
21. Gu H, Xie Z, Li T, Zhang S, Lai C, Zhu P, et al.: Angiotensin-converting enzyme 2 inhibits lung injury induced by respiratory syncytial virus. *Sci Rep* 6: 19840, 2016 PubMed
22. Khan A, Benthin C, Zeno B, Albertson TE, Boyd J, Christie JD, et al.: A pilot clinical trial of recombinant human angiotensin-converting enzyme 2 in acute respiratory distress syndrome. *Crit Care* 21: 234, 2017 PubMed
23. Kreutz R, Algharably EAE, Azizi M, Dobrowolski P, Guzik T, Januszewicz A, et al.: Hypertension, the renin-angiotensin system, and the risk of lower respiratory tract infections and lung injury: implications for COVID-19 [published online ahead of print Apr 15, 2020]. Cardiovasc Res doi: 10.1093/cvr/cvaa097.
24. Salles GF, Reboldi G, Fagard RH, Cardoso CR, Pierdomenico SD, Verdecchia P, et al.; ABC-H Investigators: Prognostic effect of the nocturnal blood pressure fall in hypertensive patients: the ambulatory blood pressure collaboration in patients with hypertension (ABC-H) meta-analysis. *Hypertension* 67: 693–700, 2016 PubMed
25. Hermida RC: Ambulatory blood pressure monitoring in the prediction of cardiovascular events and effects of chronotherapy: rationale and design of the MAPEC study. *Chronobiol Int* 24: 749–775, 2007 PubMed
26. Yusuf S, Sleight P, Pogue J, Bosch J, Davies R, Dagenais G; Heart Outcomes Prevention Evaluation Study Investigators: Effects of an angiotensin-converting-enzyme inhibitor, ramipril, on cardiovascular events in high-risk patients. *N Engl J Med* 342: 145–153, 2000 PubMed
27. Hermida RC, Crespo JJ, Domínguez-Sardiña M, Otero A, Moyá A, Ríos MT, et al.; Hygia Project Investigators: Bedtime hypertension treatment improves cardiovascular risk reduction: the Hygia chronotherapy trial [published online ahead of print Oct 22, 2019]. *Eur Heart J* doi: 10.1093./eurheartj/ehz754. 2019 PubMed
28. Mathur P, Kadavath S, Marsh JD, Mehta JL: Chronotherapy for hypertension: improvement in patient outcomes with bedtime administration of antihypertensive drugs [published online ahead of print Nov 14, 2019]. *Eur Heart J* doi: 10.1093/eurheartj/ehz836.PubMed
29. Kreutz R, Kjeldsen SE, Burnier M, Narkiewicz K, Oparil S, Mancia G: Blood pressure medication should not routinely be used at bedtime We must disregard the data from the HYGIA project. *Blood Press* 27: 1–2, 2020
30. Carlberg B, Brunstrom M: Invited comment: is bedtime the best time of the day? International Society of Hypertension. Available at: https://ish-world.com/data/uploads/2003-9.pdf. Accessed April 19, 2020
31. Bruno RM, Taddei S: Asleep blood pressure: a target for cardiovascular event reduction? *Eur Heart J* 39: 4172–4174, 2018 PubMed
32. Pierdomenico SD, Bucci A, Costantini F, Lapenna D, Cuccurullo F, Mezzetti A: Circadian blood pressure changes and myocardial ischemia in hypertensive patients with coronary artery disease. *J Am Coll Cardiol* 31: 1627–1634, 199 PubMed
33. Kario K, Pickering TG, Matsuo T, Hoshide S, Schwartz JE, Kazuyuki S: Stroke prognosis and abnormal nocturnal blood pressure falls in older hypertensives. *Hypertension* 38: 852–857, 2001 PubMed
34. Pierdomenico SD, Pierdomenico AM, Coccina F, Lapenna D, Porreca E: Circadian blood pressure changes and cardiovascular risk in elderly-treated hypertensive patients. *Hypertens Res* 39: 805–811, 2016 PubMed
35. Vrijens B, Vincze G, Kristanto P, Urquhart J, Burnier M: Adherence to prescribed antihypertensive drug treatments: longitudinal study of electronically compiled dosing histories. *BMJ* 336: 1114–1117, 2008 PubMed
36. Poulter NR, Savopoulos C, Anjum A, Apostolopoulou M, Chapman N, Cross M, et al.: Randomized crossover trial of the impact of morning or evening dosing of antihypertensive agents on 24-hour ambulatory blood pressure. *Hypertension* 72: 870–873, 2018 PubMed
37. Rorie DA, Flynn RWV, Mackenzie IS, MacDonald TM, Rogers A: The treatment in morning versus evening (TIME) study: analysis of recruitment, follow-up and retention rates post-recruitment. *Trials* 18: 557, 2017 PubMed
38. Whelton PK, Carey RM, Aronow WS, Casey DE Jr, Collins KJ, Dennison Himmelfarb C, 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* 71: e13–e115, 2018 PubMed
39. Suchard MA, Schuemie MJ, Krumholz HM, You SC, Chen R, Pratt N, et al.: Comprehensive comparative effectiveness and safety of first-line antihypertensive drug classes: a systematic, multinational, large-scale analysis. *Lancet* 394: 1816–1826, 2019 PubMed
40. Ernst ME, Carter BL, Goerdt CJ, Steffensmeier JJ, Phillips BB, Zimmerman MB, et al.: Comparative antihypertensive effects of hydrochlorothiazide and chlorthalidone on ambulatory and office blood pressure. *Hypertension* 47: 352–358, 2006 PubMed
41. Dhalla IA, Gomes T, Yao Z, Nagge J, Persaud N, Hellings C, et al.: Chlorthalidone versus hydrochlorothiazide for the treatment of hypertension in older adults: a population-based cohort study. *Ann Intern Med* 158: 447–455, 2013 PubMed
42. Hripcsak G, Suchard MA, Shea S, Chen R, You SC, Pratt N, et al.: Comparison of cardiovascular and safety outcomes of chlorthalidone vs hydrochlorothiazide to treat hypertension. *JAMA Intern Med* 180: 542–551, 2020 10.1001/jamainternmed.2019.7454 [Online ahead of print.]PubMed
43. Messerli FH, Roush GC, Oparil S: Comparative efficacy and safety of chlorthalidone (CTD) and hydrochlorothiazide (HCTZ). *JAMA Intern Med*: 2020
44. Dorsch MP, Gillespie BW, Erickson SR, Bleske BE, Weder AB: Chlorthalidone reduces cardiovascular events compared with hydrochlorothiazide: a retrospective cohort analysis. *Hypertension* 57: 689–694, 2011 PubMed
45. Roush GC, Holford TR, Guddati AK: Chlorthalidone compared with hydrochlorothiazide in reducing cardiovascular events: systematic review and network meta-analysis. *Hypertension* 59: 450–1110, 2012 PubMed
46. Oparil S, Cushman WC, Lederle FA: Chlorthalidone versus hydrochlorothiazide in hypertension treatment: do we have the evidence to decide? *Am J Kidney Dis* 63: 387–389, 2014 PubMed
47. Messerli FH, Bangalore S: Half a century of hydrochlorothiazide: facts, fads, fiction, and follies. *Am J Med* 124: 896–899, 2011 PubMed
48. Lederle FA, Cushman WC, Ferguson RE, Brophy MT, Fiore Md LD: Chlorthalidone versus hydrochlorothiazide: a new kind of Veterans Affairs cooperative study. *Ann Intern Med* 165: 663–664, 2016 PubMed

The Surgeon General's Call to Action to

Control Hypertension

U.S. Department of Health and Human Services

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
U.S. Public Health Service
Office of the Surgeon General

Suggested Citation

U.S. Department of Health and Human Services. *The Surgeon General's Call to Action to Control Hypertension*. Washington, DC: U.S. Department of Health and Human Services, Office of the Surgeon General; 2020.

This publication is available at **www.surgeongeneral.gov**.

The Surgeon General's Call to Action to

Control Hypertension

Message from the Secretary, U.S. Department of Health and Human Services

As a nation, our ability to improve hypertension control requires focus. We must focus on better using the interventions that we already know work, and we must focus on conducting science that supports the creation of new, innovative interventions. As Secretary, I have a unique perspective across multiple sectors that influence hypertension control, including the roles that social services, health insurers, patient care, research, public health, and the pharmaceutical industry can play.

While we normally look to the health care sector to combat chronic diseases, the high burden of hypertension requires us to expand our partnerships across settings to maximize our collective influence.

I am excited about *The Surgeon General's Call to Action to Control Hypertension,* because it includes specific hypertension control goals for our nation and provides proven strategies and relevant resources that multiple sectors can use immediately.

The data speak for themselves—nearly one in two adults have hypertension, and only about one in four people with hypertension have it under control. This places millions of Americans at heightened risk for heart disease and stroke, the first and fifth leading causes of death in the United States.

We must address this threat to our health. The time to act is now.

Alex M. Azar II
Secretary
U.S. Department of Health and Human Services

Foreword from the Surgeon General, U.S. Department of Health and Human Services

As a physician, I've seen firsthand the devastating effects of hypertension. Left uncontrolled, it leads to heart attacks, stroke, kidney disease, and cognitive decline in later life, and it can impact mother and baby during and after pregnancy. In addition, as evidenced from the global COVID-19 outbreak earlier in the year, we've seen the broad impact of preventable health conditions on worse outcomes.

Hypertension is unfortunately common, but there are interventions and programs that have been successful in improving control. Our country has many hypertension control champions—doctors, practices, communities, and health systems that have excelled at achieving high rates of hypertension control among their patients. We need to learn from their many years of "blood, sweat, and tears" and apply their principles in new settings.

While hypertension is more prominent among older adults, it is not simply a condition of the elderly. All ages are impacted, and early identification and long-term control can preserve cardiovascular health now and into the future. We know that lifestyle changes, such as being physically active and adopting a healthy diet, can promote hypertension control, yet many communities have significant barriers that prevent people from making these changes. We also know that many people with hypertension require medications to achieve control. Access to high-quality health care, prescription of appropriate medications, and clinical and community support are needed to prevent and treat hypertension, publicize local resources, and establish a plan for care supportive of long-term control.

The Surgeon General's Call to Action to Control Hypertension summarizes recent data on hypertension control, identifies select goals and strategies, and provides recommendations for areas of focus when resources are limited. While the recent trends don't look good—we've hit a plateau in hypertension control—I believe that with focus and collaboration, we can improve our trajectory.

Join me in taking control of hypertension across our nation. Together, we've got this!

Jerome M. Adams, MD, MPH
Vice Admiral, U.S. Public Health Service
Surgeon General
U.S. Department of Health and Human Services

Contents

Introduction

Hypertension, or high blood pressure, affects nearly one in two U.S. adults and is a major preventable risk factor for heart disease and stroke.[1] Despite the common nature of this condition and a large amount of national attention,[2,3] only about 24% (26 million) have their blood pressure controlled to ≤130/80 mmHg.[1] Regardless of the threshold used to measure control, national rates have stagnated and disparities persist.[3,4] *The Surgeon General's Call to Action to Control Hypertension* seeks to avert the negative health effects of hypertension across the U.S. by identifying interventions that can be implemented, adapted, and expanded across diverse settings.

The *Call to Action* is divided into three sections. **Section 1** summarizes the current state of hypertension control, including the economic costs and disparities between different population groups. It notes that progress in hypertension control has been demonstrated in communities and health care systems across the country.[5,6,7] In many areas, we know what works, but we need to replicate and expand these efforts and continue to explore new interventions to achieve control across all population groups.

Section 2 presents three overall goals to support improvements in hypertension control:

> **Goal 1.** Make hypertension control a national priority.
>
> **Goal 2.** Ensure that the places where people live, learn, work, and play support hypertension control.
>
> **Goal 3.** Optimize patient care for hypertension control.

These goals take into account the need for national attention on hypertension control because of its broad adverse effects on health. They also recognize that community and clinical interventions designed to improve control must address the social determinants of health. Each goal is supported by strategies intended to accelerate actions to achieve success. The strategies were selected according to available scientific literature, identified promising practices, and expert opinion.

Section 3 identifies the sectors that can influence hypertension control. Diverse activities across many sectors are needed. Recognizing the importance of these sectors, *Call to Action Guides* were developed to provide sector-specific recommendations and resources. A significant amount of existing resources were identified during the development of this publication. Efforts were made to highlight these resources and not duplicate efforts.

To improve hypertension control across the U.S. for all populations, we need broadscale, culturally sensitive, and diverse interventions that address the social determinants of health. Although progress in hypertension control has stalled at the national level, our efforts must not. Many strategic partners have devoted significant energy to advancing hypertension control across our nation. This *Call to Action* seeks to further support and amplify those efforts. The challenge is significant, but the tools are plentiful. ***Together, we've got this!***

Section 1. Evidence and the Need for Action

Hypertension in the United States

Hypertension is a major preventable risk factor for heart disease and stroke, which are the first and fifth leading causes of death in the U.S., respectively.[1] Clinicians diagnose patients with hypertension, make decisions about treatment recommendations, and determine control status by comparing patients' systolic and diastolic blood pressure readings to defined thresholds (e.g., ≥130/80 mmHg). If left uncontrolled, hypertension can also increase a person's risk of developing other health conditions, including heart failure, kidney disease, pregnancy complications, and cognitive decline in later life.[8] The negative health effects of hypertension may be avoided with the use of evidence-based interventions, and multiple sectors can play an active role in implementing, adapting, and expanding these interventions across the U.S.

Although many of the interventions described in this publication can help prevent hypertension, the focus of this *Call to Action* is on improving control among the millions of U.S. adults who already have hypertension. Applying the criteria from the most recent national hypertension guideline,[8] nearly half of U.S. adults (108 million) have hypertension and are recommended to make lifestyle changes and, if appropriate, take antihypertension medication to lower their blood pressure **(Figure 1)**. Among the

Figure 1. Prevalence, Control Status, and Treatment of Hypertension Among U.S. Adults, National Health and Nutrition Examination Survey, 2013–2016

[a] Based on the American College of Cardiology and American Heart Association's 2017 Hypertension Clinical Practice guideline for adults aged 18 years or older who have blood pressure ≥130/80 mmHg or who are currently using prescription medication to lower their blood pressure.

[b] Among those recommended to take prescription medication and make lifestyle changes.

Source: Centers for Disease Control and Prevention (CDC). Hypertension Cascade: Hypertension Prevalence, Treatment and Control Estimates Among US Adults Aged 18 Years and Older Applying the Criteria From the American College of Cardiology and American Heart Association's 2017 Hypertension Guideline—NHANES 2013–2016. Atlanta, GA: US Department of Health and Human Services; 2019.

87 million U.S. adults with hypertension who are estimated to have received recommendations to make lifestyle changes and take medication, hypertension control rates are alarmingly inadequate. About 71% (61 million) have uncontrolled hypertension (≥130/80 mmHg).

To achieve control below the 130/80-mmHg threshold, many adults (31 million) who are already taking medication may need to have their prescription adjusted.[1] Another 30 million adults whose blood pressure is at levels where medication use is recommended but who are untreated may need to be assessed for starting medication and making lifestyle changes. These estimates are derived from clinical guidelines and applied to a population health perspective. Individual treatment plans and target thresholds may vary due to age, co-morbidities, or other factors, and maintaining a consistent medical home can allow for specific tailoring of recommendations. The most recent national guidelines also include additional categories of blood pressure thresholds (Normal: <120 and <80 mmHg; Elevated: 120–129 and <80 mmHg; Hypertension Stage 1: 130–139 or 80–89 mmHg; Hypertension Stage 2: ≥140 or ≥90 mmHg), with lower blood pressure generally associated with improved outcomes.[8]

Improving management of hypertension has been traditionally described in terms of improving *awareness* (the percentage of people who have hypertension and know they have it), *treatment* (the percentage who have hypertension and are receiving recommended care), and *control* (the percentage who have hypertension and whose blood pressure has been lowered below specified thresholds). Assessing progress in each of these indicator areas can help identify potential gaps in care, and it offers opportunities for action.

Low awareness of hypertension in a population may indicate a lack of access to and engagement with the health care system, which may require interventions that draw on community and clinical resources to increase blood pressure screening and take action if high values are found. Low treatment rates in a population may indicate a lack of access to care, low rates of health literacy, cost barriers, or a lack of action by individuals (e.g., nonadherence to recommended treatment) or clinicians (e.g., clinical inertia) to address hypertension. Interventions that have proven to be effective in reducing treatment gaps in both community and clinical settings are those that provide individuals, families, clinicians, and community-based care coordinators and programs with the knowledge, tools, and resources needed to ensure that individuals receive guideline-recommended care. Hypertension control is key to reducing the risk of future cardiovascular events in a population. It is potentially the most important indicator to use to evaluate the overall effectiveness of interventions designed to manage blood pressure in a health care practice, health care system, or community.

Awareness, treatment, and control of hypertension are important across the lifespan. Although most of the goals and strategies identified in this *Call to Action* focus on improving hypertension control among adults because of the high rates in this population, hypertension—or the path toward developing hypertension—can begin in childhood or adolescence.[9] Early identification of hypertension and related risk factors among young people can allow for early intervention to prevent progression of this condition and support successful transition from pediatric to adult care.[10,11] Although many of the clinical and community approaches in this *Call to Action* are relevant across the lifespan, unique aspects of blood pressure management for young people would likely require additional strategies and resources beyond those presented in this publication.

In this *Call to Action*, the term "sectors" refers to groups that may use the information in this publication for action, including government entities, organizations, and industries that have a stake in the health of the communities they serve. For each sector we highlight, we recommend specific strategies they can use to take advantage of their unique resources and opportunities for intervention to collectively support achievement of local and national hypertension control goals.

Control Is Possible

High levels of hypertension control can be achieved in clinical settings and communities.[5,6,12,13] Many health care providers—from large integrated health care systems to community health centers serving different populations to individual health care providers—have demonstrated significant improvements in hypertension control in their patient populations and been recognized nationally for their efforts.[6,12,13] They have done so by making hypertension control a priority, implementing evidence-based strategies, and being dedicated to monitoring improvement over time.[6,7,14,15,16,17,18,19,20] These strategies include the following:

- Enhancing electronic health record systems to improve clinical workflows and provide decision support tools.
- Implementing treatment protocols.
- Expanding the use of integrated care teams.
- Providing clinician feedback on performance.
- Prioritizing medication intensification and adherence.
- Promoting shared management through self-measured blood pressure monitoring.

Some communities have also taken steps to develop policies and programs that implement many of the strategies included in this *Call to Action* and worked with partners in other sectors to amplify their efforts to make population-level improvements in hypertension control.[5]

Barriers to Control

Despite the successes that many health systems and communities have had in achieving high rates of hypertension control, significant barriers still exist. These barriers include individuals having inadequate health insurance coverage, high deductibles and copayments, or limited access to health care services, which can limit their receipt of hypertension-related care.[21,22,23] Individuals may have low levels of health literacy and complex medical management needs that may prevent them from accessing or using medications and technology (e.g., self-measured blood pressure monitors) to help them lower their blood pressure.[24,25] Further, although advice from a clinician is a critical first step that empowers many individuals to attempt lifestyle changes to manage their blood pressure,[26] it can be insufficient when not adequately supported by policy, systemic, and environmental interventions that make it easier for people to make healthy choices.[27,28,29] For example, people may have limited access to safe areas to be physically active or to transportation to receive health care services, or they may have physical or mental disabilities or time limitations because of caregiver and work responsibilities.[30,31,32,33,34,35] Mental health challenges can complicate hypertension management, and engagement of a mental health clinician may be needed to meet collaborative goals.[36,37] In addition, these barriers may occur in tandem and can be either compounded or mitigated by people's past or existing experiences, beliefs, biases, and cultures.[30,38,39,40] Understanding these factors and the role they may play in limiting or supporting hypertension control is important for improving adherence to prescribed therapy and recommended lifestyle changes.

Promoting Health Equity

> ***"Achieving health equity requires valuing everyone equally with focused and ongoing societal efforts to address avoidable inequalities, historical and contemporary injustices, and the elimination of health and health care disparities."***
>
> —*National Stakeholder Strategy for Achieving Health Equity*. National Partnership for Action to End Health Disparities.

Health equity has been defined as being achieved when every person has the opportunity to "attain their full health potential and that no one should be disadvantaged from achieving this potential because of their social position or other socially determined circumstance."[41,42] Health inequities may be demonstrated in differences in length and quality of life, rates and severity of disease, rates of death, and access to prevention and treatment.[43] Health disparities have been defined by many groups and generally refer to differences that may adversely affect groups of people who have "systematically experienced greater obstacles to health based on their racial or ethnic group; religion; socioeconomic status; gender; age; mental health; cognitive, sensory, or physical disability; sexual orientation or gender identity; geographic location; or other characteristics historically linked to discrimination or exclusion."[44,45]

In the U.S., certain groups of people have disproportionately high rates of hypertension and its related health consequences. Prevalence is higher among older adults and is also notably higher among certain racial and ethnic groups, especially non-Hispanic blacks.[46] Although several modifiable and nonmodifiable factors are regularly recognized as contributing to hypertension, a "third arm of risk," identified as the social determinants of health, should be prioritized.[47] Social determinants of health, such as inequalities in the distribution of social, economic, and environmental conditions needed for health, have been associated with hypertension risk among non-Hispanic blacks and other minority groups.[47,48] Psychosocial and socioeconomic stressors—such as low socioeconomic status, depression, job stress, financial stress, segregated neighborhoods, and neighborhood poverty level—also contribute to the risk of hypertension.[49,50,51,52,53] In addition, past research has shown an association between racial discrimination and hypertension.[54,55] Health inequities and disparities extend beyond prevalence and are present across all aspects of hypertension, from awareness to disease severity to treatment and control.[3,56]

To identify and address these health inequities and disparities and to promote health equity in communities and across various sectors, we need to better understand why these differences exist, identify success stories and areas where inequities or disparities have been reduced, identify and address barriers, and use community resources to initiate change. Surveillance or electronic health record data can be used to identify populations and communities with the highest rates so interventions can focus on those most in need. Human, technical, and financial resources can be allocated equitably to communities to address factors that contribute to disparities. Key partners, resources, and gaps in support can be identified in communities to address areas of need. Tailored policy, system, and environmental approaches, which are considered broad-scale, sustainable, and potentially scalable, are also needed to promote continued change within communities and to establish communities as places of opportunity for health and prosperity for all.[57]

The need for broadscale actions has never been more relevant. In 2020, disparities in the burden of disease—especially among minority populations—have been recognized during the COVID-19 pandemic. A growing body of evidence has shown that people with underlying health conditions, including cardiovascular disease, are at increased risk of worse outcomes related to COVID-19 infection.[58] Infectious disease outbreaks can be amplified when they occur in populations with high rates of chronic disease, because they may affect the clinical course of the infectious disease or limit the ongoing management of the underlying chronic disease.[59] Therefore, population health efforts that promote cardiovascular health, especially those that address social determinants of health, are needed now more than ever.

Why Now?

Intervention is needed now because progress on reducing cardiovascular disease deaths, including among younger adults, has stalled.[60] In addition, the U.S. population is aging,[61] and there is more recognition of the negative health effects of uncontrolled hypertension.[62] Fortunately, changes in health care systems, such as protocol-driven and team-based care, have been shown to improve hypertension control across many different populations groups.[6,7,14,15] A growing number of success stories from across the country suggest that focused efforts can inspire rapid, far-reaching progress.[5,6,7] Therefore, we have many of the tools and resources we need to accelerate progress in hypertension control. Now we need to apply them more widely. This *Call to Action* provides targeted strategies that different sectors can take to collectively improve hypertension control across the U.S. The time to act is now. ***Together, we've got this!***

Section 2. Goals and Strategies: The Call to Action

Goal 1. Make Hypertension Control a National Priority

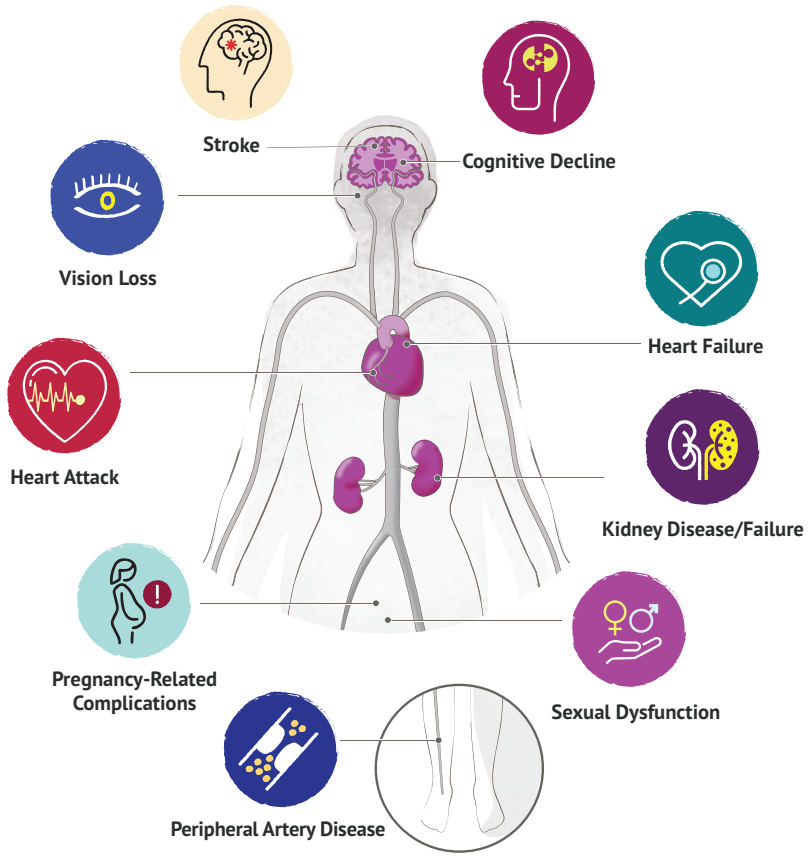
As a nation, we need to better coordinate our approach to hypertension across sectors. Risk factors for hypertension and barriers to control are complex. So too are the diverse populations that hypertension affects and the many different settings and sectors that can play a role in identifying, treating, and controlling hypertension. Our solutions must be multifaceted, multisector, and adaptable. Major improvements in hypertension control will take thoughtful efforts that take advantage of the unique assets of many sectors, including public health, clinical medicine, business and industry, insurance payers, community organizations, and government agencies. Making hypertension control a national priority allows members of multiple sectors to work together to achieve the best cardiovascular health for our nation.

Strategy A. Increase awareness of the health risks of uncontrolled hypertension.

The prevalence of hypertension has remained generally stable over the past 20 years, and limited gains have been made in improving hypertension control during the past decade.[4,63,64] Estimates indicate that more than one in three U.S. adults with hypertension are not aware that they have the condition, with variations in awareness among subgroups and geography.[62,65,66] Hypertension has been called a "silent killer" because it generally has no noticeable signs or symptoms.[67,68,69] Without awareness and action, uncontrolled hypertension can damage many body systems and organs, including the heart, brain, kidneys, and eyes, and it can lead to a wide range of complications **(Figure 2)**. Awareness of the association between hypertension and negative health outcomes is generally higher for cardiovascular events such as heart attack, heart failure, and stroke than for conditions such as kidney disease, blindness, or cognitive decline.[70]

Despite the lack of awareness, hypertension and its effects are common. Annually, about 500,000 U.S. deaths have hypertension as a primary or contributing cause.[71] Although risk increases with age, adults who have hypertension before age 40 years are at even higher risk of having a cardiovascular event later in life.[72]

Figure 2. Health Problems Caused by Hypertension



Sources:

Whelton PK, Carey RM, Aronow WS, 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: Executive Summary: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *Hypertension*. 2018;71(6):1269-1324.

Virani SS, Alonso A, Benjamin EJ, et al. Heart Disease and Stroke Statistics-2020 Update: A Report From the American Heart Association. *Circulation*. 2020;141(9):e139-e596.

Wang, X., Huang, W. & Zhang, Y. Relation between hypertension and erectile dysfunction: a meta-analysis of cross-section studies. *Int J Impot Res*. 2018;30(3):141-146.

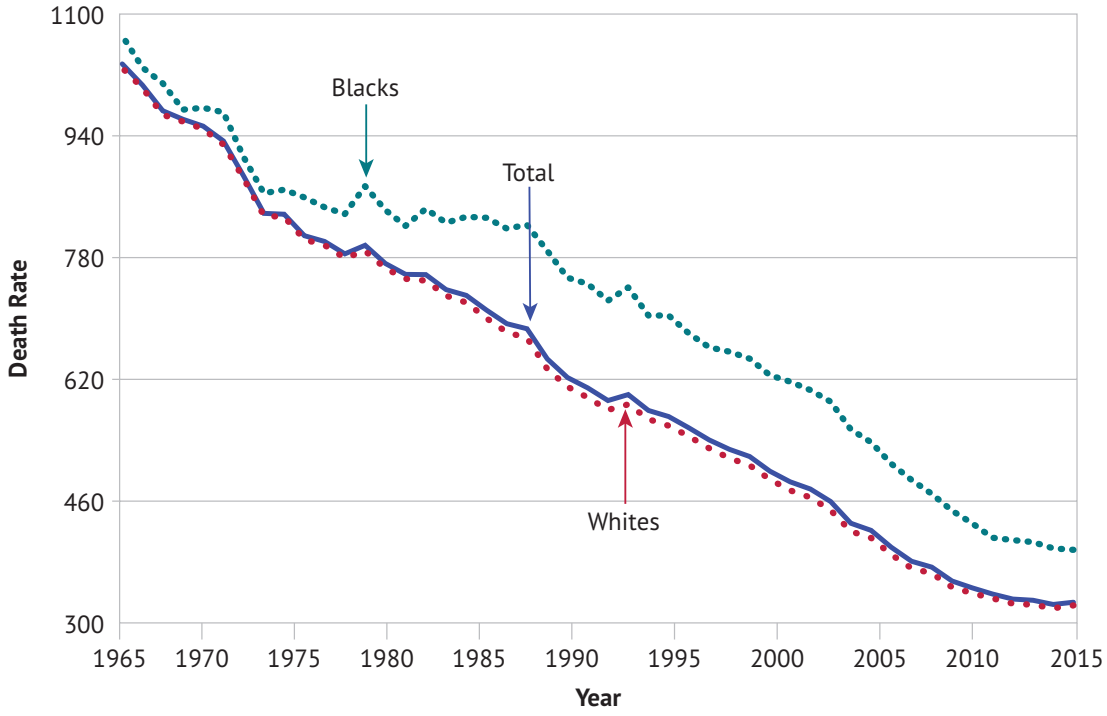
Bhargava, M., Ikram, M. & Wong, T. How does hypertension affect your eyes? *J Hum Hypertens*. 2012;26(2):71-83.

Hypertension and Heart Disease

Left unchecked, hypertension can cause structural and functional damage to the heart and vascular system over time that can ultimately lead to dysfunction.[73,74,75,76] It is a leading risk factor for heart disease, which is the leading cause of death in the U.S., accounting for about one in every four deaths.[77] Nationally, the heart disease death rate declined at a rate of about 2.4% per year from the 1960s to the 1970s, with little difference between racial and ethnic groups. In the 1970s, deaths began to decline more slowly for non-Hispanic blacks than for non-Hispanic whites **(Figure 3)**.[78] This disparity persists today, and death rates continue to be higher among non-Hispanic blacks.[78]

Similar disparities in heart disease rates exist across the U.S. From 1973 to 2010, the concentration of counties with high rates of heart disease deaths shifted from the Northeast to the South, with a nearly twofold increase in geographic inequality among counties.[79] Since 2011, the rate of premature death from heart disease has remained stagnant among U.S. adults aged 25–64 years, and in 2017, heart disease still accounted for almost one in five deaths in this age group.[63]

Figure 3. Heart Disease Death Rates and Annual Percentage Changes Among Adults Aged ≥35 Years, by Race, United States, 1968–2015



Note: Rate is age standardized to the 2000 U.S. standard population.

Source: Van Dyke M, Greer S, Odom E, et al. Heart Disease Death Rates Among Blacks and Whites Aged ≥35 Years — United States, 1968–2015. *MMWR Surveill Summ* 2018;67(No. SS-5):1–11. DOI: http://dx.doi.org/10.15585/mmwr.ss6705a1

Hypertension and Stroke

Hypertension is a leading risk factor for stroke, which is the third leading cause of death for women and the fifth leading cause for men, as well as the leading cause of adult disability, in the U.S.[80] In 2018, stroke accounted for nearly 150,000 deaths, representing about one in every six U.S. deaths.[77] About one in four strokes is recurrent, and recurrent strokes are generally associated with a higher 30-day death rate (about 41%) compared to primary strokes (about 22%).[81] Hypertension is recognized as the most important risk factor for stroke, and this condition is commonly present for all types of strokes.[82,83] Sustained levels of elevated blood pressure may damage the lining of blood vessel walls, which weakens them and makes them more vulnerable to blockages and rupture, particularly in the brain.[84] Variability in blood pressure levels and episodic hypertension may also increase stroke risk.[85]

Stroke is largely preventable if hypertension is treated.[86] Overall, hypertension treatment trials have shown that treatment results in reduced risk of stroke.[87] Initiating antihypertensive treatment for primary or secondary stroke prevention is important for risk reduction.[88,89] Although stroke incidence has been declining over the past several decades,[2,90] disparities exist in stroke risk, incidence, and mortality.[91,92] Stroke incidence is higher in the southeastern U.S., an area commonly referred to as the "Stroke Belt,"[93] and among non-Hispanic blacks and Hispanics compared to non-Hispanic whites.[62,92,94,95] Non-Hispanic blacks are five times more likely than non-Hispanic whites to experience a stroke at age 45 years.[91] This disparity may be due in part to differences in the prevalence of hypertension and control in these populations, as well as the differential effect of hypertension.[96] For each 10-mmHg increase in systolic blood pressure, stroke risk increases by 8% for non-Hispanic whites but by 24% for non-Hispanic blacks, which indicates that hypertension is a bigger contributor to stroke risk for the latter group.[96]

Hypertension and Cognitive Impairment

Hypertension has been associated with various cognitive outcomes, including executive dysfunction, slowing of mental processing speed, and memory deficits as well as cognitive impairment and major neurocognitive disorder (dementia).[97,98,99,100] Uncontrolled hypertension during midlife (aged 45–65 years) raises the risk of cognitive impairment and dementia later in life.[101,102] Not only is sustained hypertension harmful for cognition, but more variability in blood pressure is also associated with dementia in some populations.[103] Hypertension is associated with the severity of "diffuse white matter disease," a very common condition that is easily detectable as hyperintensities on brain MRI scans. Persons with diffuse white matter disease are at increased risk of developing cognitive impairment.[104] In the first interventional trial of its size and scope to examine a modifiable risk factor for dementia, the SPRINT MIND study established that intensively lowering blood pressure in participants (≥50 years) with vascular risk factors decreased their risk for developing mild cognitive impairment by approximately 20% and reduced progression of white matter hyperintensities on brain scans.[105,106] Less is understood about the cognitive effects of hypertension among those aged 65 years or older, though the elderly individuals in the SPRINT MIND trial did benefit from aggressive blood pressure control.[101,105] A general scientific consensus is emerging that blood pressure control can play an important role in reducing the risk of cognitive decline and possibly dementia, and improving hypertension control at every age is an important safeguard for vascular health and, in turn, brain health.[101,107,108]

Hypertensive Disorders in Pregnancy

Hypertensive disorders of pregnancy are increasingly common and are among the leading causes of maternal and neonatal disease and death in the U.S.[109,110,111] Some women have hypertension before becoming pregnant (chronic hypertension), while others develop it for the first time during pregnancy (gestational hypertension). Preeclampsia is high blood pressure with signs of problems with the kidneys, liver, or other organs (or multiple organs) that starts during pregnancy or the postpartum period and can be superimposed on chronic hypertension.[112]

About nine in 100 delivery hospitalizations include a diagnosis of a hypertensive disorder.[113] Hypertensive disorders with onset during pregnancy are responsible for 7.8% of all pregnancy-related deaths.[114,115] Associations have been reported between having a history of hypertensive disorders in

pregnancy and a risk of future coronary heart disease, heart failure, stroke, hypertension, diabetes, abnormal heart rhythms, end-stage kidney disease, and cardiomyopathy.[109] Gestational hypertension is present in about 2%–3% of pregnancies and preeclampsia in about 3% of pregnancies.[113,116,117,118] Some disorders, such as gestational hypertension and preeclampsia, usually resolve in the postpartum period (defined as up to 12 weeks after delivery),[119,120] but these conditions may increase a woman's chances of having hypertension later in life, as well as her risk of heart disease.[121] Hypertensive disorders of pregnancy can also cause serious adverse outcomes for infants, including fetal or neonatal disease or death and low birth weight.[119,122] Disparities in hypertensive disorders of pregnancy have been identified, and additional research is needed to better appreciate the causes and implications.[123] However, control of hypertensive disorders improves outcomes for the mother and infant.[112]

Hypertension and Kidney Disease

Hypertension and chronic kidney disease (CKD) are interrelated conditions, meaning that hypertension can both cause and result from CKD.[124] High consumption of salt and low consumption of water in the general U.S. population may contribute to the development of both conditions.[125] Hypertension is one of the leading risk factors for developing CKD and a major contributor to the progression of kidney disease.[126] Hypertension is more common in people with kidney disease, and control is more difficult in people with CKD. About 31% of adults with blood pressure >130/80 mmHg are estimated to have CKD, and most do not know that they have it.[127,128,129]

Uncontrolled hypertension can cause arteries around the kidneys to narrow, weaken, or harden, leading to kidney damage and kidney failure.[130] Individuals with CKD have a lower blood pressure threshold at which kidney damage may occur compared to people without CKD.[131] They are also at higher risk of heart disease, stroke, and death.[126,132] Disparities by sex and by racial and ethnic group have been reported in the incidence, treatment, and progression of CKD, as well as in the control of hypertension in adults with CKD.[124,133] Non-Hispanic blacks are 3.3 times more likely and Hispanics and American Indians and Alaska Natives 1.7 times more likely to develop kidney failure compared to non-Hispanic whites.[134] The reason for these disparities is unclear, with some research pointing to the higher rates of diabetes and hypertension among these racial and ethnic groups compared to non-Hispanic whites.[135,136]

Strategy B. Recognize the substantial economic costs of uncontrolled hypertension.

Uncontrolled hypertension is costly—both to individuals and to the nation. In the U.S., total medical costs associated with hypertension, including health care services and medications, are estimated to be $131 billion to $198 billion each year.[137,138,139] By 2035, total direct and indirect costs are expected to exceed an estimated $220 billion a year.[140] Increases in costs associated with hypertension are also projected to be higher for Hispanics and non-Hispanic blacks than for non-Hispanic whites.[140] At the individual level, health care services are about $2,500 more per year for people with hypertension compared to those without this condition and over $4,000 more per year for people who also have diabetes.[137]

The cost of hypertension also extends beyond the health care setting. From 2008 to 2011, absenteeism from work associated with hypertension cost employers an estimated $10.3 billion per year, equaling about $300 per employee per year.[141] In contrast, the cost of hypertension management is lower than the long-term costs associated with its many complications.[142]

The majority of people with hypertension require medication—often more than one medication—to achieve control. Nearly all first-line medications used to manage hypertension are widely available and available in generic form. A one-year supply of antihypertensive medication costs about $350, including costs paid by both the insurer and the individual.[139] However, with about 650 million prescriptions filled annually, total spending on medication alone is about $29 billion, including $3.4 billion that is directly paid by individuals.[139] These estimates are expected to increase after the most recent national guidelines modified the definition of hypertension in adults in 2017, which increased the number of people recommended to take medication to achieve control.[8]

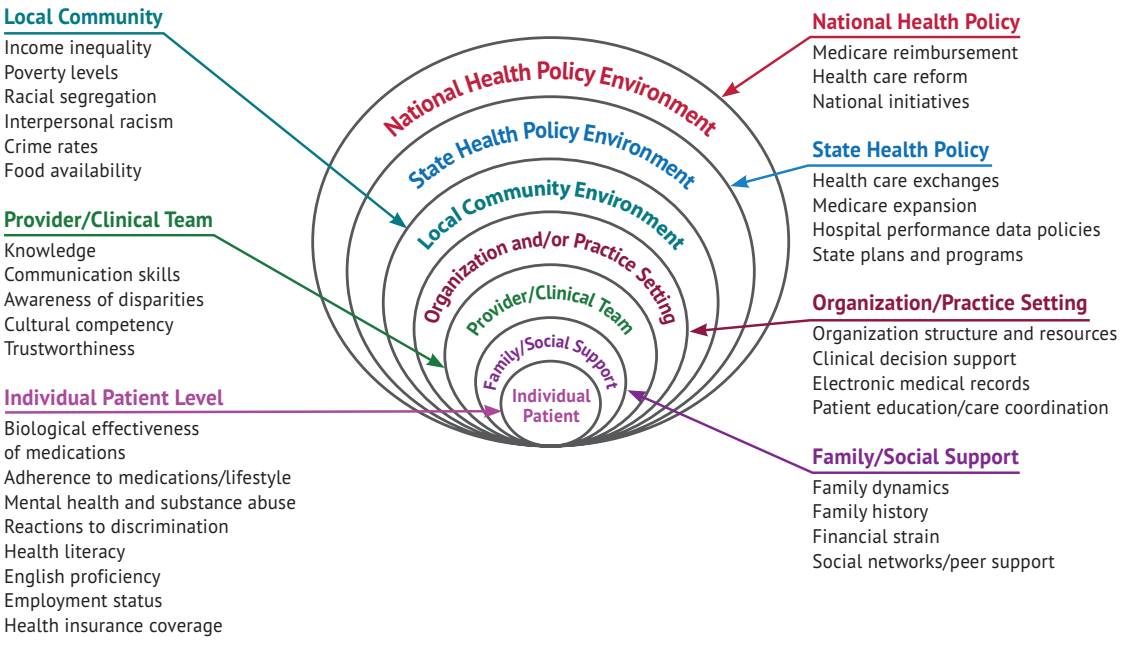
Strategy C. Eliminate disparities in the treatment and control of hypertension.

Early and consistent access to health care can reduce or prevent hospitalizations and poor outcomes related to hypertension. However, as noted in Section 2, disparities exist in hypertension control, the adoption of healthy behaviors, and the presence of risk factors.[143,144,145] As noted by Geoffrey Rose in his book *The Strategy of Preventive Medicine*, "the primary determinants of disease are mainly economic and social, and therefore its remedies must also be economic and social."[146] Factors that influence these disparities include inequalities in the distribution of social, economic, and environmental conditions needed for health. Collectively, these factors are referred to as social determinants of health, or "conditions in the environment in which people are born, live, learn, work, play, worship, and age that affect a wide range of health, functioning, and quality-of-life outcomes and risks."[147] These factors can be the primary drivers of health because they affect biology, physiology, health behaviors, health factors, clinical management, clinical outcomes, and community health.[47,148]

Multiple factors contribute to disparities in hypertension, and these factors are influenced at multiple levels, including by individual patient factors, family and social support, health care providers and clinical teams, health care organization and practice settings, local communities, and state and national health policies **(Figure 4)**.

Reducing disparities in hypertension control likely requires greater commitment to eliminating differences in access to quality health care while also addressing a variety of social factors that influence overall health.[47] Culturally competent best practices that support individuals, their families, and clinicians

Figure 4. Multilevel Influences on Disparities in Hypertension Prevention and Control



Source: Mueller M, Purnell TS, Mensah GA, Cooper LA. Reducing racial and ethnic disparities in hypertension prevention and control: what will it take to translate research into practice and policy? *Am J Hypertens.* 2015;28(6):699–704.

> ***"There is no known biological reason why every population should not be as healthy as the best.... The primary determinants of disease are mainly economic and social, and therefore its remedies must also be economic and social."***
>
> —Geoffrey Rose, author of *The Strategy of Preventive Medicine*

within unique communities are needed.[149] This may include increasing clinician awareness of disparities in the communities they serve and how their awareness may influence the care provided.[150] A substantial gap exists between our knowledge of what works and what is actually being done to improve hypertension control across diverse communities, although promising examples of effective interventions exist.[15,151,152,153] For example, interventions that incorporate addressing social determinants of health have been shown to help individuals improve both their systolic and diastolic blood pressure.[154] However, limited data are available, and additional research is needed to understand how these factors can be integrated effectively into interventions.

One way to close the gap between knowledge and action is to ensure that the needs of individuals and specific populations drive translation research[155] and that this research systematically evaluates which interventions work for which populations and in which settings[156] and whether they are culturally relevant and sensitive. Affected individuals, clinicians, and communities should be brought into the process early and often to help assess the implementation and adaptation of best practices. Ideally, these partners can help researchers prioritize funding and identify champions that are already using emerging and promising practices in communities facing disparities. We need to re-envision how and where care is provided, particularly in areas where people get health care from a variety of sources, and remove barriers. This approach will require action where people live, work, and play, with a focus on achieving health equity and eliminating disparities.

Goal 2. Ensure That the Places Where People Live, Learn, Work, and Play Support Hypertension Control

Living a heart-healthy lifestyle is a cornerstone of hypertension control,[8] and it can be cultivated through community support. Lifestyle changes that support hypertension control and broader cardiovascular health include increasing physical activity, adopting a healthy diet, not smoking, maintaining a healthy weight, and consuming alcohol in moderation if at all.[8] These actions are more easily implemented when they are part of everyday life. Health is determined in part by where we are born and where we age, as well as the locations where children and adults spend most of their time—school, worksites, and home.[157] The U.S. Department of Health and Human Services' Healthy People initiative recognizes the need for "social, physical, and economic environments that promote attaining full potential for health and well-being for all."[158] Specific objectives designed to promote these environments are included in the Healthy People 2030 national health agenda, alongside objectives promoting improvements in hypertension control. Similarly, the Office of the Surgeon General selected Community Health and Economic Prosperity as a priority area of focus and encourages U.S. businesses to implement solutions to help improve and sustain the health of their communities.[159]

Clinical guidelines for blood pressure management highlight the importance of nonpharmacological interventions and lifestyle change to improving cardiovascular health.[1,8] Current national guidelines recommend that 21 million U.S. adults with hypertension and nearly 30 million with elevated blood pressure make lifestyle changes alone without the addition of medication.[1] A majority of this population has reported trying to make healthy lifestyle changes, including 60% who tried to lose weight in the past year, 39% who tried to reduce their sodium intake, 41% who were inactive and tried to increase their physical activity, and 51% who were current smokers who tried to quit.[26]

When equivalent clinical outcomes are suggested by either behavioral or pharmacologic treatment, individuals with hypertension would prefer to make lifestyle changes over medication treatment.[160] However, lifestyle change can be difficult and may require several conditions to be successful. Examples

of these conditions include continuous engagement by participants, interventions that have been proved effective but are flexible enough to adapt to participants' differing needs, and participants' belief in their own ability to make changes.[160,161] For people with hypertension who need to make lifestyle changes and take medications to achieve control, clinicians should provide continued support to prevent reliance on medication treatment alone and should engage behavioral health specialists when appropriate to support sustained change.[8,162] In addition, clinicians should be equipped during educational training to support the integration and prioritization of lifestyle and behavioral factors that influence control of hypertension and associated chronic diseases.[163]

Community-level strategies that change the environment where people live, work, learn, and play may have the greatest influence on health outcomes.[164,165] When used effectively, these strategies can create an environment where people are more compelled to adopt or continue heart-healthy behaviors. For example, policies that benefit the overall community, such as increasing the availability of low-sodium options in the food supply, can support a heart-healthy diet.[166] Options for buying healthier foods can be expanded in low-income neighborhoods[167] and potentially coupled with educational initiatives, prioritizing improvements in school nutrition programs, and changes in food assistance programs.[168,169] Interventions in school systems can be connected to broader community and family initiatives to confer additional benefit.[170] Community-level strategies designed to improve hypertension control need to be multipronged in order to promote opportunities for healthy choices and address factors such as unequal economic opportunities, unequal access to resources, and insufficient investments in communities.

Strategy A. Promote access to and availability of physical activity opportunities within communities.

Physical activity has broad health benefits, including improvements in measures of cardiovascular health such as blood pressure, blood lipids, and blood glucose and in measures of noncardiovascular health such as mental health, physical strength, balance, and endurance.[171] Physical activity helps people with hypertension lower their blood pressure. Although antihypertensive medications tend to reduce a person's systolic blood pressure more than a structured exercise routine, all types of activity (endurance, resistance, or a combination of both) are effective and may lower systolic blood pressure by more than 8 mmHg among people with hypertension.[172] Despite these benefits, only about half of U.S. adults meet current aerobic physical activity recommendations to get at least 150 minutes of moderate-intensity activity each week. Nearly one in four U.S. adults are inactive and do not get any activity.[173] Sedentary behavior is also associated with increased risks of various chronic diseases and death.[174] Participation in physical activity is a cornerstone of lifestyle change recommendations to control hypertension.[8]

Physical activity can occur in many ways. Organized activities such as recreational sports are available in many communities and can provide both a social and cardiovascular benefit.[175] Nonorganized activities such as running or cycling have similar benefits. Walking has been specifically identified as a public health strategy to increase participation in physical activity, because it is an easy way to begin and maintain an active lifestyle throughout life.[176] Children and families can walk to and from school.[177,178,179] Employers can adopt worksite programs and policies that promote walking to improve the health of their employees, which may also reduce health care costs and improve productivity among working-age adults.[180] Among older adults, who have the highest prevalence of hypertension, structured walking programs can reduce mobility disability.[181] Walking is multipurpose—it improves health and can be used for transportation to get to work or other destinations while also providing an opportunity to socialize. Social supports, such as peer support programs, have been effective in encouraging walking and other forms of activity.[182]

The built environment, safety, and participation in physical activity are closely associated.[32,33,34,35] Walkable communities are often safer because of design features such as crossing signals, pedestrian and bike routes, and speed reduction features to slow vehicles.[183] Adults and children are more likely to

walk in a safe environment than in an unsafe environment.[33,34,35] Safety from traffic or crime—perceived or actual—has been associated with physical activity, particularly in low-income neighborhoods.[184,185,186] Highly walkable neighborhoods promote both walkability and social cohesion, and both of these elements may help older adults meet physical activity recommendations.[187]

Instituting policies or supporting recognized strategies that enable the creation of healthy and safe physical environments can enhance the sustainability of interventions designed to promote physical activity. For example, in the Complete Streets approach, city planners design streets to ensure safe access for drivers, pedestrians of all physical abilities, transit users, and bicyclists.[188] National initiatives such as Active People, Healthy Nation℠; Million Hearts®; Safer People, Safer Streets; and Safe Routes to School recommend that communities create activity-friendly routes to everyday destinations, including worksites, schools, and places where people shop, to support participation in physical activity. This evidence-based approach combines interventions designed to improve transportation systems with those designed to improve land use and community design. The goal is to promote safety and convenience while making physical activity options available to people of all abilities.[189,190,191,192]

Strategy B. Promote access to and availability of healthy food options within communities.

Population-level strategies that create healthy nutrition environments are also important to hypertension control and in the elimination of disparities in the consumption of a healthy diet. Unhealthy dietary patterns are linked to increases in hypertension, obesity, and other negative health outcomes related to cardiovascular disease.[193,194] The *2015–2020 Dietary Guidelines for Americans* includes recommendations for food composition and emphasizes a healthy eating pattern that includes a variety of vegetables; whole fruits; grains (whole grains at least half of the time); fat-free or low-fat dairy; a variety of protein sources, including seafood, lean meat, legumes, nuts and seeds; and healthy oils.[195] It also recommends limiting saturated fats, trans fats, added sugars, and excess sodium.[195] A commonly used dietary strategy to lower sodium intake is the Dietary Approaches to Stop Hypertension (DASH) eating plan, which has strong evidence for its ability to lower blood pressure.[196] Disparities in hypertension are associated with a number of factors, and the higher burden of hypertension among non-Hispanic blacks may be in part driven by increased salt sensitivity, highlighting the importance of dietary intervention in hypertension management.[197,198]

These healthy eating patterns are appropriate throughout life, meaning that everyone, from children to older adults, can benefit from healthy food and beverage choices. Highly processed and prepackaged foods are often selected because they are fast or "easy" to obtain, but they may contain excessive fat or sodium, which may contribute to hypertension and other cardiovascular or chronic conditions.[195] Most U.S. adults consume more than the recommended sodium limit of less than 2,300 mg per day.[199] Programs such as the Sodium Reduction in Communities Program, the National Salt and Sugar Reduction Initiative, and Million Hearts® seek to increase the availability of low-sodium options in the U.S. food supply.[166,191,200] This goal can be met through healthy procurement policies and nutrition standards for packaged and prepared foods and meal preparation practices that reduce the amount of sodium and increase the offerings of healthy foods in the institutional food settings.[201] Increasing awareness of healthy eating patterns and ensuring access to nutritious, affordable, and high-quality food options for all residents should be a priority for communities.

Strategy C. Promote links between clinical services and community programs.

Every effort should be made to use community resources that support hypertension control. The desired connections to vital community resources can be bolstered when an emphasis is placed on linking community resources and clinical services. Key activities include increasing access to community resources, collaborating with community health workers and lay health partners, and using population health management tools. These activities support referral of individuals to resources outside of the primary care setting for blood pressure management services, as well as to physical activity, nutrition,

and pharmacist-based interventions, including medication therapy management.[1] Lessons learned from partners that have successfully established clinical and community links can be shared and replicated.[202]

Identifying community resources and improving clinicians' awareness of them may help promote lifestyle changes among people with hypertension. This sharing of the responsibility of care with community organizations may lead to a more effective use of existing resources and better care delivery. Awareness of community resources has been linked to referrals among clinicians, and this increased awareness can promote the use of evidence-based interventions in local communities.[203] For example, the U.S. Preventive Services Task Force recommends offering or referring adults who are overweight or have obesity and have additional cardiovascular disease risk factors (e.g., hypertension) to intensive behavioral counseling interventions to promote a healthy diet and physical activity for cardiovascular disease prevention.[204,205] Although active participation in this type of intervention has been proven effective, people's ability to access and use these services may be limited by multiple factors in both clinical and community settings. Simply referring individuals for services, without considering barriers to access, may limit the benefit of the intervention.

Some programs have recommended developing an inventory of community resources in collaboration with local partners as a way to better link clinical care and community supports.[206] Targeting other settings where adults spend significant portions of their day may also be helpful, and this approach can help link clinical and community settings. For example, employers can support hypertension control by providing health-related educational services, promoting self-measured blood pressure monitoring and medication adherence, and giving employees places and time to be active in the workplace. These policies may result in a healthier workforce.[207]

Whatever approach is used, simply referring individuals for traditional lifestyle change services may be too limited. Clinicians should screen families to find out if they have barriers to receiving this type of care.[208] Because of the time constraints in the clinical environment, systems must be in place to help clinicians meet this recommendation. Diverse clinical and community partnerships (e.g., linkage of screening programs in dental practices or community establishments such as barbershops with health systems managing hypertension) may improve links to the many programs and supports available across communities.

Goal 3. Optimize Patient Care for Hypertension Control

Patients receiving clinical care for uncontrolled hypertension need the best care possible to support medication initiation, intensification, and adherence and to help them make needed lifestyle changes. Health care settings need to implement standardized hypertension care across their health care teams. *Clinical inertia* (also called therapeutic inertia) happens when a clinician does not initiate or intensify therapy in a patient who has not achieved therapeutic goals.[209,210] This problem is especially common in chronic disease care, including hypertension control.[211] Early models of clinical inertia suggest that 70% of it is due to physician and health system factors related to time constraints, reactive versus proactive care, inefficient electronic health record workflows, and underused care teams, while 30% is due to patient factors such as denial of disease and medication attitudes and adherence.[210,212] Strategies that target both clinical and patient factors can help overcome clinical inertia.

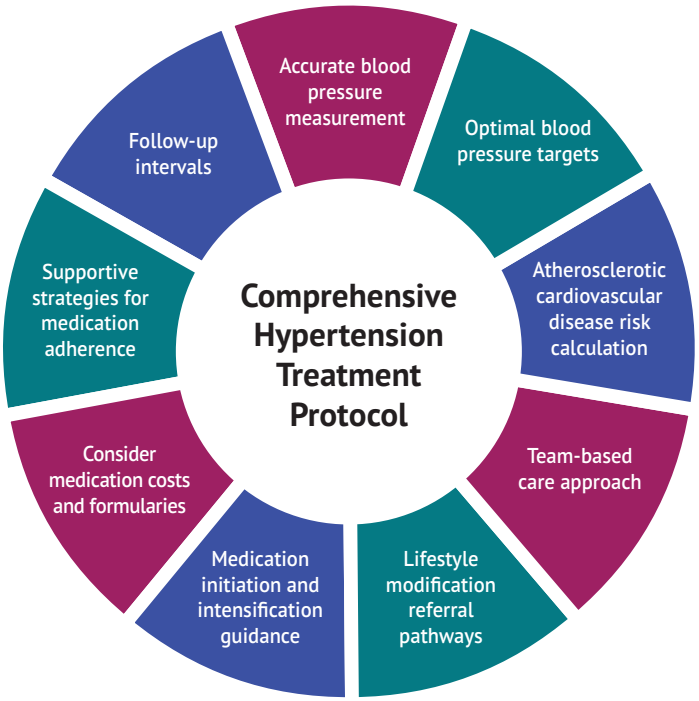
Studies suggest that younger adults are less likely than older adults to have their hypertension diagnosed and treated,[213] that younger men are much less likely to have their hypertension controlled than their female counterparts or older adults,[4] and that non-Hispanic blacks develop hypertension at younger ages and with worse severity than non-Hispanic whites.[214] Despite strong indications to do so, clinicians and their patients may hesitate to initiate a medication treatment that could be lifelong. Simulation modeling research has shown that hypertension control could be improved through additional treatment (i.e., intensification) alone, even in the absence of improved medication adherence or follow-up visit interval.[215]

Strategy A. Advance the use of standardized treatment approaches and guideline-recommended care.

Standardized treatment protocols, also called care pathways and algorithms, can help overcome clinical inertia (i.e., failure to set targets and advance care to reach goals) and organize care. Treatment protocols can help identify patients eligible for clinical management, reduce variations and disparities in care, prompt medication initiation and intensification, standardize timely patient follow-up, reinforce lifestyle counseling and referrals, and empower all members of the clinical team to engage in patient management.[216] Health care systems that have demonstrated improvements in hypertension control and other chronic disease indicators often attribute part of their success to the use of protocols.[14,15] Clinical efficiencies may also create opportunities for clinicians to develop more extensive relationships with patients or encourage shared decision making between the clinical team and patients, both of which have been associated with positive outcomes.[217,218] When systems are assessed to look for efficiencies and ways to improve, opportunities to enhance the clinician–patient relationship should also be considered.[217,219]

A comprehensive hypertension treatment protocol has multiple elements, including optimal blood pressure targets, a team-based care approach, lifestyle modification referral pathways, medication initiation and intensification guidance, and follow-up intervals **(Figure 5)**.[220] Where allowed by law, medication change protocols for nurses, pharmacists, and other team members are recommended to ensure that each team member's activities within his or her scope of practice are being maximized.[221] Treatment protocols provide guidance when the science that supports a specific treatment is clear and

Figure 5. Characteristics of a Comprehensive Treatment Protocol for Hypertension Management



Source: Figure adapted from Centers for Disease Control and Prevention. *Hypertension Control Change Package*. 2nd ed. Atlanta, GA: Centers for Disease Control and Prevention, U.S. Dept of Health and Human Services; 2020.

there is consensus from the care team; they are not meant to supersede clinical judgment but may support consistent receipt of care across all groups.[216] Modifications to the health system to better manage hypertension can also be used to improve care of other chronic diseases.

Treatment protocols should also include guidance on how to measure blood pressure accurately, which is necessary for effective management. Inaccurate measurements are frequently related to errors in technique or improper equipment selection.[222,223] Standardized protocols are needed to guide selection of proper equipment (e.g., a validated and regularly calibrated device, appropriate cuff size for arm), to guide assessment (e.g., resting period before measurement, seated position, feet on floor), and for staff training.[224,225] Other forms of measurement (e.g., ambulatory blood pressure measurement, self-monitored blood pressure) may be more appropriate to detect different patterns of hypertension (e.g., white coat hypertension, masked hypertension) and are useful tools in regular clinical practice.[224,225] Such a focus on blood pressure control in health care systems can lead to success in eliminating racial/ethnic disparities in hypertension.[226]

Strategy B. Promote the use of health care teams to manage hypertension.

At the center of the health care team is the patient, who should be empowered to be the advocate for their health. Each individual should know their own blood pressure number and its ramifications for their own long-term health and be encouraged to work with their clinicians to bring their blood pressure under control. Clinicians have ever-increasing demands to see more patients, capture data in electronic health records, meet administrative criteria, and report on quality metrics, all while delivering patient-centered care. To meet these demands, clinicians will need to use multidisciplinary care teams for hypertension control effectively.[227] This team approach is central to holistic care models such as the Patient-Centered Medical Home.[228] Nurse practitioners and physician assistants already provide advanced primary care services in many medical settings. Nurses, pharmacists, and community health workers can also play unique and important roles in care delivery, and strong evidence supports their use for hypertension control in particular.[229,230] Teams may consist of diverse members (e.g., dietitians, mental health providers) and expand into diverse settings (e.g., dental practices) depending on access and availability. If all team members perform at the highest level of their training and licensure, patients with complex health problems and acute concerns can receive the care they need from clinicians with advanced training while other team members support chronic disease management.

Nurses are versatile team members who can play a range of roles to support hypertension care and increase patient satisfaction.[231,232] They can educate patients on blood pressure medications, medication adherence strategies, and self-measured blood pressure monitoring; counsel patients and help them build skills for lifestyle changes; intensify medication therapy using a standardized protocol; and lead population health management and quality improvement activities.[230,233,234]

Pharmacists can also be integral members of the hypertension care team. They can educate patients as part of medication therapy management, which includes services that help patients take medications as directed by their clinical team. This approach has been shown to improve medication adherence.[229,235,236,237] Clinicians can coordinate with pharmacists directly through large health systems or in the community through collaborative practice agreements. Including pharmacists in community-based efforts to improve hypertension control among underserved populations through active medication management has also proved promising and could be implemented in an alternative care model to enhance traditional primary care.[151,152]

Community health workers, also known as patient navigators and promotoras or promotores de salud in Spanish, are lay health advisors who promote health and prevent disease in their own community.[238] Strong evidence supports their inclusion in care teams to improve hypertension control.[238] Because community health workers may live in or have a close understanding of the communities they serve, they can often reach underserved populations and may be effective in addressing hypertension-related health

disparities. They can help with a broad range of linguistically and culturally appropriate health promotion and disease prevention strategies, including outreach, blood pressure screening, informal counseling, education, and social support. Interventions that include community health workers have been deemed cost-effective for cardiovascular disease prevention, which includes hypertension control.[239] Licensed clinicians can partner with community health workers to improve support for patients with hypertension, through either direct employment or volunteer agreements.[238]

Strategy C. Empower and equip patients to use self-measured blood pressure monitoring and medication adherence strategies.

Patients should be empowered to know their blood pressure numbers to encourage active engagement in management and goal setting. Evidence from numerous systematic reviews and meta-analyses show that self-measured blood pressure monitoring, with co-interventions that include counseling, telephone support, or telemonitoring, is an effective way to manage hypertension.[8,240,241,242,243,244,245] Self-measured blood pressure monitoring also has been shown to improve medication adherence and help reduce clinical inertia, and it is supported by clinical guidelines for confirming a diagnosis of hypertension.[246,247]

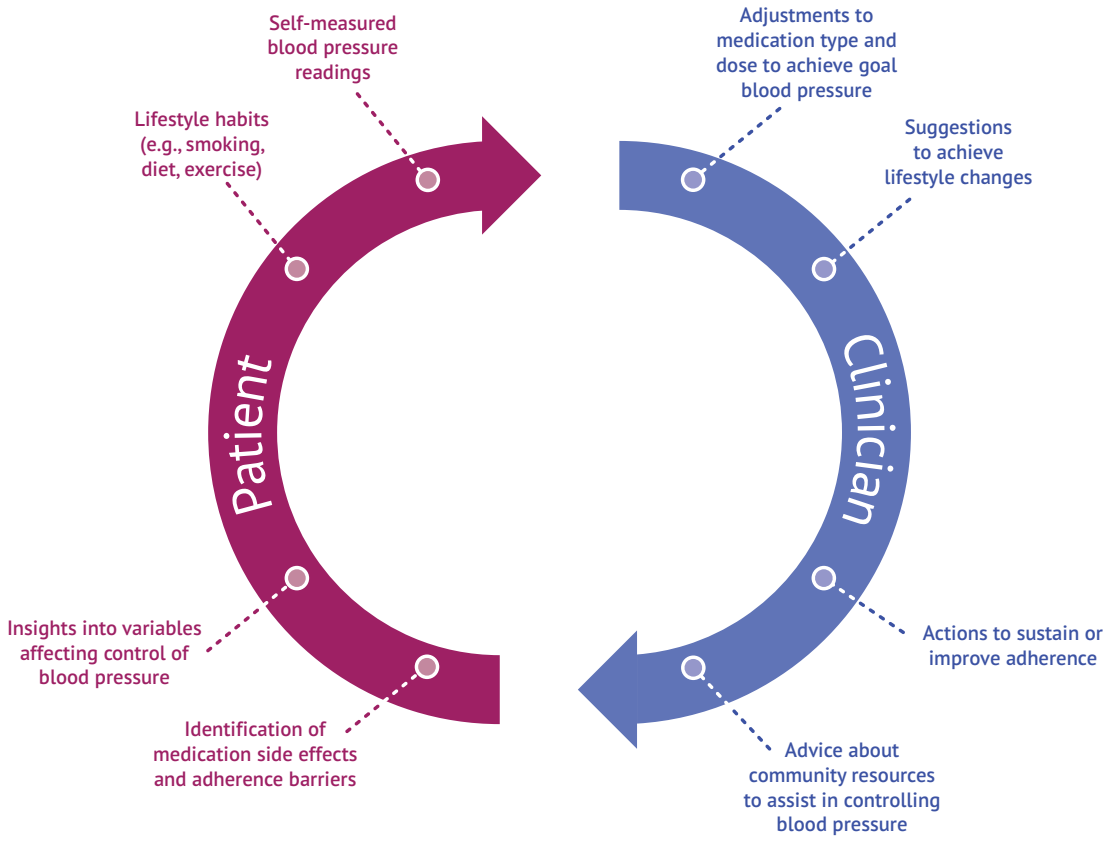
Ideal self-measured blood pressure monitoring begins with teaching a patient how to select a validated home blood pressure monitor with an appropriate cuff size, comparing the home monitor with an office monitor to check its accuracy, providing a protocol for monitoring that includes duration and frequency, and identifying how patients will return readings to the clinical team.[248] Ideally, the patient transmits their readings, medication side effects, and challenges with lifestyle changes electronically to the clinical team. A clinician can then read and interpret the home readings and electronically transmit back medication changes or lifestyle change advice.[249] This feedback loop enhances patient engagement in care and provides timely information to the clinical team to improve care **(Figure 6)**. Investing in effective, integrated, and secure data-sharing systems across both clinical and community settings and using technology to help patients manage their own care reduce barriers to comprehensive care.[19,250] If electronic transfer of information is not available to patients, more basic techniques (e.g., logbooks) can be utilized to record information.

Guidance documents exist to help clinicians, public health professionals, and payers implement self-measured blood pressure monitoring among patients, but studies have shown that only about 40% of people with hypertension do so.[251,252,253,254,255,256] This percentage is likely an overestimate, because it does not reflect real-world challenges to people measuring and reporting their own blood pressure. Limited published data indicate that self-measured blood pressure monitoring is frequently recommended by clinicians, but policies and systems needed for ideal implementation are not in place.[257,258] The wide availability of free blood pressure machines in pharmacies, grocery stores, and other businesses offers another opportunity for everyone to know their blood pressure. However, the accuracy of store-based devices needs to be regularly calibrated in a standardized manner and customized to different arms sizes to avoid the provision of misinformation.[259]

> ***"Drugs don't work in patients who don't take them."***
>
> —C. Everett Koop, former U.S. Surgeon General

There are many evidence-based or promising practices that clinical teams and patients can use to improve medication adherence. Yet nonadherence, or not taking medications for hypertension control as prescribed, is common.[260,261,262] Whenever possible, clinicians should prescribe in a way that simplifies patient medication regimens, minimizes patient cost, and reduces other barriers related to how medications are obtained. One evidence-based strategy for improving adherence is reducing or eliminating co-payments, which can be achieved by using a patient's insurance formulary and selecting generic formulations whenever appropriate.[21] Medication regimens can also be simplified through fixed-dose combination pill prescriptions (where two or more medications are included in a single pill), longer-duration prescriptions (90 days vs. 30 days), and lower dosing frequency (one time a day vs. two or more times a day).[263,264]

Figure 6. Feedback Loop Supporting Effective Use of Self-Measured Blood Pressure Monitoring



Source: Centers for Disease Control and Prevention. **Self-Measured Blood Pressure Monitoring: Actions Steps for Clinicians**.

The use of electronic prescribing may reduce the likelihood that patients will lose or not fill prescriptions. This approach also takes advantage of existing pharmacy reminder and automated refill systems. Medication synchronization, where prescriptions are assembled to allow for a single pickup from the pharmacy, are more convenient for patients and may increase adherence to medication regimens, especially complicated regimens.[265]

The care team can also recommend that patients use reminders systems such as labeled pill containers or cell phone apps to ensure that prescribed medications are taken as directed.[266] Patient education on how and why medications should be taken as prescribed is critical for improving adherence, and potential side effects should be discussed. Disparities exist in medication adherence even when access to medications is equitable, with poorer adherence among non-Hispanic blacks compared to non-Hispanic whites.[39] Because these differences are intertwined with social determinants of health and cultural beliefs, strategies that emphasize the importance of maintaining medication routines and address patients' belief systems may need to be used.[39,145]

Strategy D. Recognize and reward clinicians and health systems that excel in hypertension control.

Clinical teams understand how uncontrolled hypertension can increase a patient's risk of disease and death. Given the current demands of typical patient visits, where clinicians may be focused on addressing acute issues, delivering vaccines, or addressing numerous other chronic conditions, continued diligence in improving and maintaining hypertension control may be challenging. One approach to help clinicians and health systems focus on hypertension control is to track their performance and provide incentives for effective management, such as pay-for-quality initiatives and recognition programs.

Formal measurement of clinical quality can be used to bolster accountability. Clinical quality measures for hypertension control can be embedded into systems to track performance. Hypertension control measures, such as those developed by the National Quality Forum (NQF) or included in the National Committee for Quality Assurance's Healthcare Effectiveness Data and Information Set, have been commonly used. For example, NQF 0018 defines hypertension control as the percentage of patients aged 18–85 years who had a diagnosis of hypertension and whose blood pressure was adequately controlled (reduced to <140/90 mmHg) during the measurement year.[267] This measure is included in the Health Resources and Services Administration's Uniform Data System, several pay-for-quality initiatives from the Centers for Medicare & Medicaid Services, and various clinical data registries.[268]

Performance on hypertension control measures can also be used for recognition programs. Formal and informal recognition may improve hypertension control by highlighting exemplars in the field, which gives them public recognition, reinforces their performance, and demonstrates to others that achieving a high level of hypertension control is possible.[12] Formal recognition programs include CDC's Million Hearts® Hypertension Control Challenge, the American Medical Association and American Heart Association's Target: BP™ initiative,[13] and the Health Resources and Services Administration's Health Center Program.[269] These programs recognize clinicians, health systems, and community health centers for high performance, defined as at least 70% to 80% (depending on the program) of patients having their blood pressure under control. Specific examples of high-performing health systems have been documented and can be utilized to replicate success in other communities.[12]

Section 3. Sector-Specific Actions

Proven strategies to effectively manage hypertension are readily available, and groups throughout the country have had success implementing them.[6,7] However, the efforts of many sectors are needed to ensure that these strategies reach people in every community and population group. This section provides an overview of the sectors that can work together to promote hypertension control. It describes each sector's potential role in improving hypertension control nationally, as well as the benefit of bringing multiple sectors together in these efforts. One-page guides were developed for some sectors to highlight the health, economic, and societal reasons why hypertension control is important to each sector. These guides provide specific actions that sector members can take, as well as resources to support their efforts.

Multilevel and multisector interventions designed to improve chronic disease care are guided by a framework called the Chronic Care Model.[270] When applied to hypertension control, the individual with hypertension is at the center of the model, because individuals must take an active role in managing their own condition to reduce their risk of heart disease, stroke, and other outcomes and maximize their quantity and quality of life.[271] However, multiple intrinsic and extrinsic factors exist that can make it hard for individuals to control their blood pressure.[272,273,274] Some groups may face particular challenges in achieving hypertension control. For example, younger adults have the highest percentages of underdetection and underdiagnosis of hypertension, as well as the highest percentages of nonadherence to recommended treatment, likely because of infrequent interaction with the health care system.[213,273,274] Other demographic groups (e.g., non-Hispanic blacks) also have low rates of hypertension control for several reasons, many of which are potentially modifiable.[3,275,276] Examples include being in clinical and community environments that are not conducive to getting guideline-recommended hypertension management care or supportive of healthy lifestyle behaviors.[275,277]

To help overcome barriers to care, the federal government, as well as state and local governments, can use the multiple sectors they work within to create environments that are conducive to helping people control their hypertension. For example, governments can fund and conduct research,[278,279,280] support programs,[281,282] and adopt policy and system approaches[27] that help ensure that people with hypertension have access to community and clinical resources that encourage healthy lifestyle behaviors and provide the best care. Because governments have competing demands for finite resources, external groups seeking support for their efforts must make the health and economic case for investing in hypertension control, including what actions will have the highest return on investment if they are funded.[283]

Public health professionals, health care professionals, and their professional associations and societies can work together to make the case for investing in hypertension control by describing the problems associated with uncontrolled hypertension.[1,3] They can also identify the groups at highest risk[1,3] and highlight the resources needed in the communities and individuals they serve.[63] However, each of these sectors can face challenges helping people control their hypertension. For example, health care professionals may be confused by conflicting clinical guidelines, including differences in the criteria recommended for diagnosis and treatment of hypertension.[284] They may find it hard to prioritize hypertension management as part of the daily demands of providing comprehensive care during short visits.[213,285] They may not use the correct techniques to measure their patients' blood pressure[17,223,224] or to initiate or intensify treatment as needed to achieve and maintain hypertension control.[286,287] These problems may be addressed by encouraging clinicians to follow clinical guidelines[8] that are cost-effective, evidence-based, and focused on achieving control across all populations, including patients with known disparities. Public health and health care professionals can also hold each other and the organizations they work with accountable for providing guideline-recommended care and achieving high rates of control, and they can celebrate their successes to raise awareness.[6,7]

Health care practices, health centers, and health systems can help their health care professionals overcome challenges and prioritize hypertension control. They can provide the necessary resources to ensure that patients with hypertension are accurately diagnosed, treated according to national guidelines, and able to control their condition. They can use system approaches that have been proven to deliver hypertension management services effectively, such as protocols to standardize patient care;[17,216] timely, high-quality clinical data to track and encourage high performance;[14,288] and multidisciplinary care teams that take advantage of the training and skills of various disciplines to provide comprehensive care.[229,235] One challenge to establishing care teams, however, is that reimbursement models are not always in place to support their use, especially when teams include nontraditional members such as pharmacists and community health workers.[289] Despite these challenges, system-level changes can better position care teams for success and result in sustainable change.

Health plans and managed care organizations can help address these and other potential barriers related to care reimbursement by implementing payment models that reinforce the use of guideline-based, high-value care.[8,290] In addition to adequately reimbursing team-based care interventions, health plans and managed care organizations can reduce or eliminate patient costs for lifestyle change programs such as the National Diabetes Prevention Program[291] and for medications that make adherence easier, such as fixed-dose combination pills.[21,292] They can also adopt and promote the use of updated billing codes for reimbursement of services related to self-measured blood pressure monitoring to improve hypertension diagnosis and management.[224,240,293] In addition, they can continue to use meaningful clinical quality measures that support hypertension control and provide incentives for high performance.[294,295]

To further reinforce use of these practices, employers and health plan purchasers can ensure that hypertension control is an important part of the health care benefits offered to their employees and members. These benefits can include comprehensive coverage for appropriate and affordable prescribed medications, lifestyle change programs, and blood pressure monitoring inside and outside of the clinical setting.[27] Employers and health plan purchasers—either individually or through participation in community coalitions—can also actively support broad application of clinical quality improvement efforts in hypertension control in their communities to guide public policy and community development efforts conducive to chronic disease prevention and management.[296,297]

Academic institutions and researchers can identify areas in need of further study and conduct research to fill the gaps. These may include addressing research gaps in areas such as management of different hypertension phenotypes. They can then use their findings to develop relevant resources and tools that can be used by different sectors to improve hypertension control among the populations they serve. Nongovernmental health organizations can support many of the activities described in previous sections, including convening experts to develop clinical guidelines,[8] identifying high performers in clinical management,[13,298] and ensuring that hypertension control remains a national priority. Community-based organizations and public–private partnerships, including minority-serving and faith-based organizations, can ensure that the scientific findings and resources developed by other sectors are translated into useable tools that serve the unique needs of their communities.[299,300,301,302,303,304] For example, community development corporations can help educate business and civic leaders about the importance of chronic disease prevention and management, including hypertension control, to both the physical and economic health of the local community.[57,305] Foundations, at both the national and local levels, can support this work by providing the funds needed to identify and expand best practices across communities.[302]

Although *Call to Action Guides* were not created for the following sectors, they still play important roles in supporting hypertension control across the U.S. For example, pharmacies should not simply be considered a way to distribute medication. Community-based pharmacists can support hypertension management in meaningful ways, including being integral members of care teams through collaborative practice agreements with local health care practices and health systems.[235,236,237,306,307] They can provide medication therapy management services to reconcile medication regimens, support adherence, and

recommend or make adjustments to medications to help patients lower their blood pressure.[236,237] Pharmacies may offer free use of blood pressure machines, placing them in a central position to offer hypertension education and link to clinical care teams. Dental practices can support the identification of those with hypertension who may not regularly visit a health care provider by integrating blood pressure assessment during intake. Practices should ideally be linked with diverse community health care providers to support access to health systems that can diagnose and manage hypertension.[308] Health care technology companies can support adherence by developing interoperable technological solutions that encourage patients to follow their treatment regimens, encourage healthy lifestyle behaviors, integrate self-measured blood pressure monitoring into clinical management, and support other modes of care delivery through telehealth.[259,309,310,311]

The pharmaceutical industry can support many of the medication-related efforts described in previous sections, and it can continue to develop new medications and treatments that decrease blood pressure and lower cardiovascular disease risk across diverse populations.[307]

The media can also support hypertension control. For example, if used effectively, social media can provide experiential, emotional, and social support to improve management of chronic conditions such as hypertension.[312] Simple, repetitive messages work best, which aligns with fact that hypertension can be reduced to a number that is easily and routinely measured. Large-scale mass media campaigns have been shown to improve healthy behaviors and connect people with resources that support healthy behaviors.[313] This approach could be used to improve hypertension control, and campaigns could be tailored to specific communities at high risk.[301] The food industry can work to increase the availability of healthy foods, including lower-sodium options for consumers. The gradual and voluntary reduction of sodium in commercially packaged and prepared foods may result in gradual gains, and proposed guidelines have been developed by the U.S. Food and Drug Administration.[314]

From a health and economic perspective, people need access to quality housing, transportation, education, and employment for communities to prosper.[57] Housing organizations can support hypertension management by coordinating services for residents through community health centers, transportation services, and social services.[315] Transportation systems can align with community land use and design interventions to make it safe and easy for people to be physically active and have access to quality health care services.[32,189,316] Educational institutions, including primary and secondary education, can provide information about the harms of uncontrolled hypertension and how behaviors early in life can influence a person's lifelong blood pressure trajectory and risk of heart disease, stroke, and other negative health outcomes.[9,317,318] They can also help to promote participation in physical activity and create environments that foster healthy behaviors—for example, by providing healthy food options in their facilities.

A Vision for the Future

In 2010, the Institute of Medicine declared that hypertension prevention and control in the U.S. were in a state of neglect.[27] Since then, the prevalence of hypertension has remained relatively unchanged.[4,64] In addition, recent progress in hypertension control has stalled, and a significant portion of people with hypertension do not have the condition under control, regardless of the threshold used.[1]

The good news is that lifesaving gains are possible. To improve hypertension control across the U.S. and for all populations, we need broadscale, multisector, culturally sensitive, and diverse interventions. This future can only be realized if significant changes are made at national, state, and community levels to support lifestyle behaviors that we know can improve hypertension control—including physical activity and a healthy diet. Community changes support improvements in the clinical setting. We can learn from providers who successfully control hypertension among the patients in their clinics and use this knowledge to replicate and expand effective interventions. However, changes in health care systems also require a supportive environment, including expanded reimbursement for management tools, enhanced links between community programs and clinical services, and the integrated use of health technology and data systems. Novel interventions and new research are also needed to reach all populations affected by hypertension.

Although hypertension control estimates at the national level have stagnated, our efforts cannot. Many strategic partners have devoted ample energy to advancing hypertension control across our nation. This *Call to Action* seeks to further support those efforts by presenting specific goals and strategies and making sector-specific recommendations for action.

Together, we've got this!

References

1. Ritchey MD, Gillespie C, Wozniak G, et al. Potential need for expanded pharmacologic treatment and lifestyle modification services under the 2017 ACC/AHA Hypertension Guideline. *J Clin Hypertens (Greenwich)*. 2018;20(10):1377–1391.
2. Pahigiannis K, Thompson-Paul AM, Barfield W, et al. Progress toward improved cardiovascular health in the United States. *Circulation*. 2019;139(16):1957–1973.
3. Wall HK, Ritchey MD, Gillespie C, et al. Vital Signs: prevalence of key cardiovascular disease risk factors for Million Hearts 2022 – United States, 2011–2016. *MMWR Morb Mortal Wkly Rep*. 2018;67(35):983–991.
4. Fryar CD, Ostchega Y, Hales CM, Zhang G, Kruszon-Moran D. Hypertension prevalence and control among adults: United States, 2015–2016. *NCHS data brief*. 2017(289):1–8.
5. Foti K, Auerbach J, Magnan S. Improving hypertension control population-wide in Minnesota. *J Public Health Manag Pract*. 2018;24(5):432–439.
6. Young A, Ritchey MD, George MG, Hannan J, Wright J. Characteristics of health care practices and systems that excel in hypertension control. *Prev Chronic Dis*. 2018;15:E73. Accessed June 7, 2020. doi: 10.5888/pcd15.170497.
7. Ritchey MD, Hannan J, Wall HK, George MG, Sperling LS. Notes from the field: characteristics of Million Hearts Hypertension Control Champions, 2012–2019. *MMWR Morb Mortal Wkly Rep*. 2020;69:196–197.
8. Whelton PK, Carey RM, Aronow WS, 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: Executive Summary: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *Hypertension*. 2018;71(6):1269–1324.
9. Jackson SL, Zhang Z, Wiltz JL, et al. Hypertension among youths — United States, 2001–2016. *MMWR Morb Mortal Wkly Rep*. 2018;67:758–762.
10. White PH, Cooley WC. Supporting the health care transition from adolescence to adulthood in the medical home. 2018;142(5):e20182587.
11. Juonala M, Magnussen CG, Berenson GS, et al. Childhood adiposity, adult adiposity, and cardiovascular risk factors. *N Engl J Med*. 2011;365(20):1876–1885.
12. Million Hearts. Hypertension Control Champions website. 2020; **https://millionhearts.hhs.gov/partners-progress/champions/index.html**. Accessed January 27, 2020.
13. American Health Association. Target: BP. Recognition Program website. 2020; **https://targetbp.org/recognition-program/**. Accessed January 27, 2020.
14. Jaffe MG, Young JD. The Kaiser Permanente Northern California story: improving hypertension control from 44% to 90% in 13 Years (2000 to 2013). *J Clin Hypertens (Greenwich)*. 2016;18(4):260–261.
15. Shaw KM, Handler J, Wall HK, Kanter MH. Improving blood pressure control in a large multiethnic California population through changes in health care delivery, 2004–2012. *Prev Chronic Dis*. 2014;11:E191. Accessed Oct 30. doi: 10.5888/pcd11.140173.
16. Fletcher RD, Amdur RL, Kolodner R, et al. Blood pressure control among US veterans: a large multiyear analysis of blood pressure data from the Veterans Administration health data repository. *Circulation*. 2012;125(20):2462–2468.
17. Egan BM, Sutherland SE, Rakotz M, et al. Improving hypertension control in primary care with the measure accurately, act rapidly, and partner with patients protocol. *Hypertension (Dallas)*. 2018;72(6):1320–1327.
18. Pfoh ER, Martinez K, Vakharia N, Rothberg M. Impact of a system-wide quality improvement initiative on blood pressure control: a cohort analysis. *BMJ Qual Saf*. 2019.
19. Milani RV, Lavie CJ, Bober RM, Milani AR, Ventura HO. Improving hypertension control and patient engagement using digital tools. *Am J Med*. 2017;130(1):14–20.

20. Shaikh U, Petray J, Wisner DH. Improving blood pressure screening and control at an academic health system. *BMJ Open Qual.* 2020;9(1):e000614. **https://bmjopenquality.bmj.com/content/bmjqir/9/1/e000614.full.pdf**. doi: 10.1136/bmjoq-2018-000614.

21. The Community Guide. Cardiovascular disease: reducing out-of-pocket costs for cardiovascular disease preventive services for patients with high blood pressure and high cholesterol website. 2012; **https://www.thecommunityguide.org/findings/cardiovascular-disease-reducing-out-pocket-costs-cardiovascular-disease-preventive-services**. Accessed January 30, 2020.

22. Egan BM, Li J, Small J, Nietert PJ, Sinopoli A. The growing gap in hypertension control between insured and uninsured adults: National Health and Nutrition Examination Survey 1988 to 2010. *Hypertension.* 2014;64(5):997–1004.

23. Fang J, Zhao G, Wang G, Ayala C, Loustalot F. Insurance status among adults with hypertension-the impact of underinsurance. *J Am Heart Assoc.* 2016;5(12).

24. Magnani JW, Mujahid MS, Aronow HD, et al. Health literacy and cardiovascular disease: fundamental relevance to primary and secondary prevention: a scientific statement from the American Heart Association. *Circulation.* 2018;138(2):e48–e74. Accessed Jul 10. doi: 10.1161/cir.0000000000000579.

25. Ogedegbe G. Barriers to optimal hypertension control. *J Clin Hypertens (Greenwich).* 2008;10(8):644-646.

26. Jackson SL, Park S, Loustalot F, et al. Characteristics, behaviors, and barriers among adults recommended for lifestyle modification by the 2017 ACC/AHA hypertension guideline (poster). Academy Health Annual Research Meeting; June 2019, 2020; Washington, DC.

27. Institute of Medicine (US) Committee on Public Health Priorities to Reduce and Control Hypertension. *A Population-Based Policy and Systems Change Approach to Prevent and Control Hypertension.* Washington (DC): National Academies Press (US); 2010.

28. Wright JS, Wall HK, Ritchey MD. Million Hearts 2022: small steps are needed for cardiovascular disease prevention. *JAMA.* 2018;320(18):1857-1858.

29. Bauer UE, Briss PA, Goodman RA, Bowman BA. Prevention of chronic disease in the 21st century: elimination of the leading preventable causes of premature death and disability in the USA. *Lancet.* 2014;384(9937):45–52.

30. Khatib R, Schwalm JD, Yusuf S, et al. Patient and healthcare provider barriers to hypertension awareness, treatment and follow up: a systematic review and meta-analysis of qualitative and quantitative studies. *PLoS One.* 2014;9(1):e84238. doi: 10.1371/journal.pone.0084238.

31. Stevens A, Courtney-Long E, Gillespie C, Armour BS. Hypertension among US adults by disability status and type, National Health and Nutrition Examination Survey, 2001–2010. *Prev Chronic Dis.* 2014;11:E139. **http://dx.doi.org/10.5888/pcd11.140162**. doi: 10.5888/pcd11.140162.

32. Smith M, Hosking J, Woodward A, et al. Systematic literature review of built environment effects on physical activity and active transport - an update and new findings on health equity. *Int J Behav Nutr Phys Act.* 2017;14(1):158.

33. Bennett GG, Mcneill LH, Wolin KY, et al. Safe to walk? Neighborhood safety and physical activity among public housing residents. *PLoS Med.* 2007;4(10):1599–1607.

34. Foster S, Knuiman M, Hooper P, Christian H, Giles-Corti B. Do changes in residents' fear of crime impact their walking? Longitudinal results from RESIDE. *Prev Med.* 2014;62:161–166.

35. Mcdonald NC. The effect of objectively measured crime on walking in minority adults. *Am J Health Promot.* 2008;22(6):433–436.

36. Rozario SS, Masho SW. The associations between mental health status, hypertension, and hospital inpatient visits in women in the United States. *Am J Hypertens.* 2018;31(7):804–810.

37. Moise N, Davidson KW, Chaplin W, Shea S, Kronish I. Depression and clinical inertia in patients with uncontrolled hypertension. *JAMA Intern Med.* 2014;174(5):818–819.

38. Bairey Merz CN, Andersen H, Sprague E, et al. Knowledge, attitudes, and beliefs regarding cardiovascular disease in women: The Women's Heart Alliance. *J Am Coll Cardiol.* 2017;70(2):123–132.

39. Saha S, Freeman M, Toure J, et al. Racial and ethnic disparities in the VA health care system: a systematic review. *J Gen Intern Med.* 2008;23(5):654–671.

40. Miller WR, Lasiter S, Bartlett Ellis R, Buelow JM. Chronic disease self-management: a hybrid concept analysis. *Nurs Outlook.* 2015;63(2):154–161.

41. Whitehead M, Dahlgreen G. *Levelling up (part 1): a discussion paper on concepts and principles for tackling social inequalities in health.* Liverpool, UK 2006.

42. Centers for Disease Control and Prevention. Health equity website. 2020; **https://www.cdc.gov/healthequity/index.html**. Accessed June 4, 2020.

43. Centers for Disease Control and Prevention. Health equity website. *National Center for Chronic Disease Prevention and Health Promotion (NCCDPHP)* 2020; **https://www.cdc.gov/chronicdisease/healthequity/index.htm**. Accessed March 3, 2020.

44. Healthy People 2010. Secretary's advisory committee on health promotion and disease prevention objectives for 2010 website. **https://www.healthypeople.gov/2020/about/foundation-health-measures/Disparities**. Accessed March 31, 2020.

45. Carter-Pokras O, Baquet C. What is a "health disparity"? *Public Health Rep.* 2002;117(5):426–434.

46. Lackland DT. Racial differences in hypertension: implications for high blood pressure management. *Am J Med Sci.* 2014;348(2):135–138.

47. Havranek EP, Mujahid MS, Barr DA, et al. Social determinants of risk and outcomes for cardiovascular disease: a scientific statement from the American Heart Association. *Circulation.* 2015;132(9):873–898.

48. Rodriguez F, Ferdinand KC. Hypertension in minority populations: new guidelines and emerging concepts. *Adv Chronic Kidney Dis.* 2015;22(2):145–153.

49. Thorpe RJ, Jr., Brandon DT, Laveist TA. Social context as an explanation for race disparities in hypertension: findings from the Exploring Health Disparities in Integrated Communities (EHDIC) Study. *Soc Sci Med.* 2008;67(10):1604–1611.

50. Liu MY, Li N, Li WA, Khan H. Association between psychosocial stress and hypertension: a systematic review and meta-analysis. *Neurol Res.* 2017;39(6):573–580.

51. Kershaw KN, Diez Roux AV, Burgard SA, et al. Metropolitan-level racial residential segregation and black-white disparities in hypertension. *Am J Epidemiol.* 2011;174(5):537–545.

52. Morenoff JD, House JS, Hansen BB, et al. Understanding social disparities in hypertension prevalence, awareness, treatment, and control: the role of neighborhood context. *Soc Sci Med.* 2007;65(9):1853–1866.

53. Cuevas AG, Williams DR, Albert MA. Psychosocial factors and hypertension: a review of the literature. *Cardiol Clin.* 2017;35(2):223–230.

54. Krieger N, Sidney S. Racial discrimination and blood pressure: the CARDIA Study of young black and white adults. *Am J Public Health.* 1996;86(10):1370–1378.

55. Brondolo E, Rieppi R, Kelly KP, Gerin W. Perceived racism and blood pressure: a review of the literature and conceptual and methodological critique. *Ann Behav Med.* 2003;25(1):55–65.

56. Paulose-Ram R, Gu Q, Kit B. Characteristics of U.S. adults with hypertension who are unaware of their hypertension, 2011-2014. *NCHS Data Brief.* 2017(278):1–8.

57. Bauer UE. Community Health and Economic Prosperity: an initiative of the Office of the Surgeon General. *Public Health Rep.* 2019;134(5):472–476.

58. Chow N, Fleming-Dutra K, Gierke R EA, Team. CC-R. Preliminary estimates of the prevalence of selected underlying health conditions among patients with Coronavirus Disease 2019 — United States, February 12–March 28, 2020. *MMWR Morb Mortal Wkly Rep.* 2020;69:382–386.

59. Sperling LS. The future of cardiovascular prevention: unprecedented times. 2020;141(24):1946–1947.

60. Yang Q TX, Schieb L, Et Al. Vital Signs: recent trends in stroke death rates — United States, 2000 – 2015. *MMWR Morb Mortal Wkly Rep.* 2017;66:933–939.

61. Older people projected to outnumber children for first time in U.S. history [news release]. 2018; **https://www.census.gov/newsroom/press-releases/2018/cb18-41-population-projections.html**. Accessed February 13, 2020.

62. Virani SS, Alonso A, Benjamin EJ, et al. Heart disease and stroke statistics-2020 update: a report from the American Heart Association. *Circulation*. 2020;141(9):e139–e596. Accessed Mar 3. doi: 10.1161/cir.0000000000000757.

63. Ritchey MD, Wall HK, George MG, Wright JS. US trends in premature heart disease mortality over the past 50 years: Where do we go from here? *Trends Cardiovasc Med.* 2020;30(6):364–374.

64. Muntner P, Hardy ST, Fine LJ, et al. Trends in blood pressure control among US adults with hypertension, 1999-2000 to 2017-2018. *JAMA*. 2020. doi: 10.1001/jama.2020.14545.

65. Million Hearts. Estimated hypertension prevalence, treatment, and control among U.S. adults website. 2020; **https://millionhearts.hhs.gov/data-reports/hypertension-prevalence.html**. Accessed March 6, 2020.

66. Zhou B, Danaei G, Stevens GA, et al. Long-term and recent trends in hypertension awareness, treatment, and control in 12 high-income countries: an analysis of 123 nationally representative surveys. *The Lancet.* 2019;394(10199):639–651.

67. Cooper T. Hypertension; the silent killer. *J Pract Nurs*. 1973;23(11):23–25.

68. Arboix A. Hypertension and the acute phase of intracerebral haemorrhage: more evidence of the 'silent killer'. *Eur J Neurol.* 2018;25(8):1007–1008.

69. Rapport RS. Hypertension. Silent killer. *N J Med*. 1999;96(3):41–43.

70. Ahuja R, Ayala C, Tong X, Wall HK, Fang J. Public awareness of health-related risks from uncontrolled hypertension. *Prev Chronic Dis.* 2018;15:E40. Accessed Apr 5. doi: 10.5888/pcd15.170362.

71. CDC WONDER Online Database website. About Underlying Cause of Death 1999–2017. Centers for Disease Control and Prevention; 2019. **http://wonder.cdc.gov/ucd-icd10.html**. Accessed February 28 2020.

72. Yano Y, Reis JP, Colangelo LA, et al. Association of blood pressure classification in young adults using the 2017 American College of Cardiology/American Heart Association blood pressure guideline with cardiovascular events later in life. *JAMA*. 2018;320(17):1774–1782.

73. Beevers G, Lip GY, O'Brien E. ABC of hypertension: the pathophysiology of hypertension. *BMJ*. 2001;322(7291):912–916.

74. Kokubo Y, Matsumoto C. Hypertension is a risk factor for several types of heart disease: review of prospective studies. *Adv Exp Med Biol*. 2017;956:419–426.

75. Nwabuo CC, Vasan RS. Pathophysiology of hypertensive heart disease: beyond left ventricular hypertrophy. *Curr Hypertens Rep.* 2020;22(2):11.

76. Sander D, Kukla C, Klingelhöfer J, Winbeck K, Conrad B. Relationship Between Circadian Blood Pressure Patterns and Progression of Early Carotid Atherosclerosis. *Circulation*. 2000;102(13):1536–1541.

77. Xu JQ, Murphy SL, Kochanek KD, Arias E. Mortality in the United States, 2018. *NCHS Data Brief* 2020. Accessed February 12, 2020.

78. Van Dyke M, Greer S, Odom E, Al. E. Heart disease death rates among blacks and whites aged ≥35 Years — United States, 1968–2015. *MMWR Surveill Summ*. 2018;67(5):1–11.

79. Casper M, Kramer Michael R, Quick H, et al. Changes in the geographic patterns of heart disease mortality in the United States. *Circulation*. 2016;133(12):1171–1180.

80. CDC WONDER Database. About Underlying Cause of Death, 1999–2018. Centers for Disease Control and Prevention, U.S. Dept of Health and Human Services; 2020. **http://wonder.cdc.gov/ucd-icd10.html**. Accessed March 30, 2020.

81. Hardie K, Hankey GJ, Jamrozik K, Broadhurst RJ, Anderson C. Ten-year risk of first recurrent stroke and disability after first-ever stroke in the Perth Community Stroke Study. *Stroke*. 2004;35(3):731–735.

82. O'donnell MJ, Xavier D, Liu L, et al. Risk factors for ischaemic and intracerebral haemorrhagic stroke in 22 countries (the INTERSTROKE study): a case-control study. *Lancet*. 2010;376(9735):112–123.

83. *Hypertension and Stroke: pathophysiology and management*. Humana Press; 2011.

84. Moskowitz MA, Lo EH, Iadecola C. The science of stroke: mechanisms in search of treatments. *Neuron*. 2010;67(2):181–198.

85. Rothwell PM, Howard SC, Dolan E, et al. Prognostic significance of visit-to-visit variability, maximum systolic blood pressure, and episodic hypertension. *Lancet*. 2010;375(9718):895–905.

86. Rapsomaniki E, Timmis A, George J, 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(9932):1899–1911.

87. Turnbull F, Neal B, Ninomiya T, et al. Effects of different regimens to lower blood pressure on major cardiovascular events in older and younger adults: meta-analysis of randomised trials. *BMJ*. 2008;336(7653):1121–1123.

88. Thompson AM, Hu T, Eshelbrenner CL, et al. Antihypertensive treatment and secondary prevention of cardiovascular disease events among persons without hypertension: a meta-analysis. *JAMA*. 2011;305(9):913–922.

89. Group. PC. Randomised trial of a perindopril-based blood-pressure-lowering regimen among 6,105 individuals with previous stroke or transient ischaemic attack. *Lancet*. 2001;358(9287):1033–1041.

90. Madsen TE, Khoury JC, Leppert M, et al. Temporal trends in stroke incidence over time by sex and age in the GCNKSS. *Stroke*. 2020;51(4):1070–1076.

91. Howard G, Cushman M, Howard VJ, et al. Risk factors for intracerebral hemorrhage: the REasons for Geographic and Racial Differences in Stroke (REGARDS) study. *Stroke*. 2013;44(5):1282–1287.

92. Kleindorfer DO, Khoury J, Moomaw CJ, et al. Stroke incidence is decreasing in whites but not in blacks: a population-based estimate of temporal trends in stroke incidence from the Greater Cincinnati/Northern Kentucky Stroke Study. *Stroke*. 2010;41(7):1326–1331.

93. Howard G, Howard VJ. Twenty years of progress toward understanding the stroke belt. *Stroke*. 2020;51(3):742-750.

94. Gardener H, Sacco RL, Rundek T, et al. Race and ethnic disparities in stroke incidence in the Northern Manhattan Study. *Stroke*. 2020;51(4):1064–1069.

95. Morgenstern LB, Smith MA, Lisabeth LD, et al. Excess stroke in Mexican Americans compared with non-Hispanic Whites: the Brain Attack Surveillance in Corpus Christi Project. *Am J Epidemiol*. 2004;160(4):376–383.

96. Howard G, Lackland DT, Kleindorfer DO, et al. Racial differences in the impact of elevated systolic blood pressure on stroke risk. *JAMA Intern Med*. 2013;173(1):46–51.

97. Gąsecki D, Kwarciany M, Nyka W, Narkiewicz K. Hypertension, brain damage and cognitive decline. *Curr Hypertens Rep*. 2013;15(6):547–558.

98. Ding J, Davis-Plourde KL, Sedaghat S, et al. Antihypertensive medications and risk for incident dementia and Alzheimer's disease: a meta-analysis of individual participant data from prospective cohort studies. *Lancet Neurol*. 2020;19(1):61–70.

99. Gottesman RF, Albert MS, Alonso A, et al. Associations between midlife vascular risk factors and 25-year incident dementia in the Atherosclerosis Risk in Communities (ARIC) cohort. *JAMA Neurol*. 2017;74(10):1246–1254.

100. Yano Y, Griswold M, Wang W, et al. Long-term blood pressure level and variability from midlife to later life and subsequent cognitive change: The ARIC Neurocognitive Study. *J Am Heart Assoc*. 2018;7(15):e009578. Accessed Aug 7. doi: 10.1161/jaha.118.009578.

101. Iadecola C, Yaffe K, Biller J, et al. Impact of hypertension on cognitive function: a scientific statement from the American Heart Association. *Hypertension.* 2016;68(6):e67–e94. doi: 10.1161/hyp.0000000000000053.

102. Norton S, Matthews FE, Barnes DE, Yaffe K, Brayne C. Potential for primary prevention of Alzheimer's disease: an analysis of population-based data. *Lancet Neurol.* 2014;13(8):788–794.

103. Yoo JE, Shin DW, Han K, et al. Blood pressure variability and the risk of dementia: a nationwide cohort study. *Hypertension.* 2020;75(4):982–990.

104. Caunca MR, Simonetto M, Cheung YK, et al. Diastolic blood pressure is associated with regional white matter lesion load. *Stroke.* 2020;51(2):372–378.

105. Williamson JD, Pajewski NM, Auchus AP, et al. Effect of intensive vs standard blood pressure control on probable dementia: a randomized clinical trial. *JAMA.* 2019;321(6):553–561.

106. Group. TSMIFTSR. Association of intensive vs standard blood pressure control with cerebral white matter lesions. *JAMA.* 2019;322(6):524–534.

107. National Academies of Sciences EaMHaMDBOHSPCOPDaCI. *Preventing Cognitive Decline and Dementia: A Way Forward*. Washington (DC): National Academies Press (US); 2017.

108. Livingston G, Sommerlad A, Orgeta V, et al. Dementia prevention, intervention, and care. *Lancet.* 2017;390(10113):2673–2734.

109. Umesawa M, Kobashi G. Epidemiology of hypertensive disorders in pregnancy: prevalence, risk factors, predictors and prognosis. *Hypertens Res.* 2017;40(3):213–220.

110. Petersen EE, Davis NL, Goodman DEA. Vital Signs: pregnancy-related deaths, United States, 2011–2015, and strategies for prevention, 13 States, 2013–2017. *MMWR Morb Mortal Wkly Rep.* 2019;68(18):423–429.

111. Bramham K, Parnell B, Nelson-Piercy C, et al. Chronic hypertension and pregnancy outcomes: systematic review and meta-analysis. *BMJ.* 2014;348:g2301.

112. The American College of Obstetricians and Gynecologists. Gestational hypertension and preeclampsia. *Practice Bulletin*. 2020; **https://www.acog.org/clinical/clinical-guidance/practice-bulletin/articles/2020/06/gestational-hypertension-and-preeclampsia**. Accessed June 5, 2020.

113. Centers for Disease Control and Prevention. Data on selected pregnancy complications in the United States website. 2019; **https://www.cdc.gov/reproductivehealth/maternalinfanthealth/pregnancy-complications-data.htm#hyper**. Accessed February 28, 2020.

114. Hirshberg A, Srinivas SK. Epidemiology of maternal morbidity and mortality. *Semin Perinatol.* 2017;41(6):332–337.

115. Petersen EE, Davis NL, Goodman DEA. Racial/ethnic disparities in pregnancy-related deaths — United States, 2007–2016. *MMWR Morb Mortal Wkly Rep.* 2019;68:762–765. **https://www.cdc.gov/mmwr/volumes/68/wr/mm6835a3.htm**.

116. Lo JO, Mission JF, Caughey AB. Hypertensive disease of pregnancy and maternal mortality. *Curr Opin Obstet Gynecol.* 2013;25(2):124–132.

117. Wallis AB, Saftlas AF, Hsia J, Atrash HK. Secular trends in the rates of preeclampsia, eclampsia, and gestational hypertension, United States, 1987–2004. *Am J Hypertens.* 2008;21(5):521–526.

118. Kuklina EV, Ayala C, Callaghan WM. Hypertensive disorders and severe obstetric morbidity in the United States. *Obstet Gynecol.* 2009;113(6):1299–1306.

119. ACOG Practice Bulletin no. 202: gestational hypertension and preeclampsia. *Obstet Gynecol.* 2019;133(1):e1–e25. Accessed Jan. doi: 10.1097/aog.0000000000003018.

120. ACOG committee opinion no. 736 summary: optimizing postpartum care. *Obstet Gynecol.* 2018;131(5):949–951.

121. Stuart JJ, Tanz LJ, Missmer SA, et al. Hypertensive disorders of pregnancy and maternal cardiovascular disease risk factor development: an observational cohort study. *Ann Intern Med.* 2018;169(4):224–232.

122. Riise HKR, Sulo G, Tell GS, et al. Hypertensive pregnancy disorders increase the risk of maternal cardiovascular disease after adjustment for cardiovascular risk factors. *Int J Cardiol.* 2019;282:81–87.

123. Irizarry OC, Levine LD, Lewey J, et al. Comparison of clinical characteristics and outcomes of peripartum cardiomyopathy between African American and non–African American women. *JAMA Cardiology.* 2017;2(11):1256–1260.

124. Horowitz B, Miskulin D, Zager P. Epidemiology of hypertension in CKD. *Adv Chronic Kidney Dis.* 2015;22(2):88–95.

125. Qian Q. Salt, water and nephron: mechanisms of action and link to hypertension and chronic kidney disease. *Nephrology (Carlton).* 2018;23 Suppl 4:44–49.

126. Cha RH, Lee H, Lee JP, Kim YS, Kim SG. The influence of blood pressure patterns on renal outcomes in patients with chronic kidney disease: The long-term follow up result of the APrODiTe-2 study. *Medicine (Baltimore).* 2020;99(8):e19209. Accessed Feb. doi: 10.1097/md.0000000000019209.

127. Crews DC, Plantinga LC, Miller ER, et al. Prevalence of chronic kidney disease in persons with undiagnosed or prehypertension in the United States. *Hypertension.* 2010;55(5):1102–1109.

128. Prevention. CFDCA. Chronic Kidney Disease in the United States, 2019 website. 2019; **https://www.cdc.gov/kidneydisease/publications-resources/2019-national-facts.html?utm_source=miragenews&utm_medium=miragenews&utm_campaign=news**. Accessed March 13, 2020.

129. United States Renal Data System. 2018 USRDS Annual Data Report: Volume 1: CKD in the United States. 2018. **https://www.usrds.org/media/2282/2018_volume_1_ckd_in_the_us.pdf**.

130. Mensah GA, Croft JB, Giles WH. The heart, kidney, and brain as target organs in hypertension. *Cardiol Clin.* 2002;20(2):225–247.

131. Bidani AK, Griffin KA. Pathophysiology of hypertensive renal damage: implications for therapy. *Hypertension.* 2004;44(5):595–601.

132. Parikh NI, Hwang SJ, Larson MG, et al. Cardiovascular disease risk factors in chronic kidney disease: overall burden and rates of treatment and control. *Arch Intern Med.* 2006;166(17):1884–1891.

133. Ricardo AC, Yang W, Sha D, et al. Sex-related disparities in CKD progression. *J Am Soc Nephrol.* 2019;30(1):137–146.

134. United States Renal Data System. 2019 ADR Reference Tables website. 2019; **https://www.usrds.org/annual-data-report/**.

135. National Institutes of Diabetes and Digestive and Kidney Diseases. Race, ethnicity, & kidney disease website. 2014; **https://www.niddk.nih.gov/health-information/kidney-disease/race-ethnicity**. Accessed February 28, 2020.

136. Saran R, Robinson B, Abbott KC, et al. US Renal Data System 2016 annual data report: epidemiology of kidney disease in the United States. *Am J Kidney Dis.* 2017;69(3 Suppl 1):a7–a8.

137. Wang G, Zhou X, Zhuo X, Zhang P. Annual total medical expenditures associated with hypertension by diabetes status in U.S. Adults. *Am J Prev Med.* 2017;53(6s2):s182–s189. Accessed Dec. doi: 10.1016/j.amepre.2017.07.018.

138. Kirkland EB, Heincelman M, Bishu KG, et al. Trends in healthcare expenditures among US adults with hypertension: national estimates, 2003-2014. *J Am Heart Assoc.* 2018;7(11).

139. Ritchey M, Tsipas S, Loustalot F, Wozniak G. Use of pharmacy sales data to assess changes in prescription- and payment-related factors that promote adherence to medications commonly used to treat hypertension, 2009 and 2014. *PLoS One.* 2016;11(7):e0159366. **https://doi.org/10.1371/journal.pone.0159366**. doi: 10.1371/journal.pone.0159366.

140. Rti International. *Projections of cardiovascular disease prevalence and costs: 2015–2035.* Research Triangle Park, NC: RTI International;2016. RTI project number 021480.003.001.001.

141. Asay GRB, Roy K, Lang JE, Payne RL, Howard DH. Absenteeism and employer costs associated with chronic diseases and health risk factors in the US workforce. *Prev Chronic Dis.* 2016;13.

142. Moran AE, Odden MC, Thanataveerat A, et al. Cost-effectiveness of hypertension therapy according to 2014 guidelines. *N Engl J Med.* 2015;372(5):447–455.

143. Redmond N, Baer HJ, Hicks LS. Health behaviors and racial disparity in blood pressure control in the national health and nutrition examination survey. *Hypertension.* 2011;57(3):383–389.

144. Selby K, Michel M, Gildengorin G, et al. Disparities in hypertension control across and within three health systems participating in a data-sharing collaborative. *J Am Board Fam Med.* 2018;31(6):897–904.

145. Ferdinand KC, Yadav K, Nasser SA, et al. Disparities in hypertension and cardiovascular disease in blacks: the critical role of medication adherence. *J Clin Hypertens (Greenwich).* 2017;19(10):1015–1024.

146. Rose GA. *The Strategy of Preventive Medicine.* Oxford, England: Oxford University Press; 1992.

147. Healthy People 2020. Social determinants of health website. 2020; **https://www.healthypeople.gov/2020/topics-objectives/topic/social-determinants-of-health**. Accessed January 31, 2020.

148. Centers for Disease Control and Prevention. *Division for Heart Disease and Stroke Prevention, Science Handbook.* September 25, 2019.

149. Centers for Disease Control and Prevention. CDC Convened Hypertension Control Meeting: Sector Leader Panel: Opportunity Knocks for Hypertension Control. In. Atlanta, GA: Centers for Disease Control and Prevention; 2019.

150. Kendrick J, Nuccio E, Leiferman JA, Sauaia A. Primary care providers perceptions of racial/ethnic and socioeconomic disparities in hypertension control. *Am J Hypertens.* 2015;28(9):1091–1097.

151. Victor RG, Lynch K, Li N, et al. A cluster-randomized trial of blood-pressure reduction in black barbershops. *N Engl J Med.* 2018;378(14):1291–1301.

152. Victor RG, Blyler CA, Li N, et al. Sustainability of blood pressure reduction in black barbershops. *Circulation.* 2019;139(1):10–19.

153. Kosoko-Lasaki O, Ekundayo OT, Smith J, et al. Urban minority community safety and its impact on physical activity: The Center for Promoting Health and Health Equity-Racial and Ethnic Approaches to Community Health (CPHHE-REACH) Initiative. *J Natl Med Assoc.* 2019;111(3):334–344.

154. Mcclintock HF, Bogner HR. Incorporating patients' social determinants of health into hypertension and depression care: a pilot randomized controlled trial. *Community Ment Health J.* 2017;53(6):703–710.

155. Green LW, Ottoson JM, Garcia C, Hiatt RA. Diffusion theory and knowledge dissemination, utilization, and integration in public health. *Annu Rev Public Health.* 2009;30:151–174.

156. Lobb R, Colditz GA. Implementation science and its application to population health. *Annu Rev Public Health.* 2013;34:235–251.

157. World Health Organization. Commission on social determinants of health, 2005-2008 website. **https://www.who.int/social_determinants/thecommission/en/**. Accessed February 14, 2020.

158. Healthy People. Healthy People 2030 framework: what is the Healthy People 2030 framework? website. **https://www.healthypeople.gov/2020/About-Healthy-People/Development-Healthy-People-2030/Framework**. Accessed February 14, 2020.

159. Office of the Surgeon General. Surgeon General Priority: Community Health and Economic Prosperity website. 2020; **https://www.hhs.gov/surgeongeneral/priorities/community-health-economic-security/index.html**. Accessed February 4, 2020.

160. Jarbol DE, Larsen PV, Gyrd-Hansen D, et al. Determinants of preferences for lifestyle changes versus medication and beliefs in ability to maintain lifestyle changes. A population-based survey. *Prev Med Rep.* 2017;6:66–73.

161. Stead M, Craigie AM, Macleod M, et al. Why are some people more successful at lifestyle change than others? Factors associated with successful weight loss in the BeWEL randomised controlled trial of adults at risk of colorectal cancer. *Int J Behav Nutr Phys Act.* 2015;12:87–87.

162. Korhonen MJ, Pentti J, Hartikainen J, et al. Lifestyle changes in relation to initiation of antihypertensive and lipid lowering medication: a cohort study. *J Am Heart Assoc.* 2020;9(4):e014168. **https://www.ahajournals.org/doi/abs/10.1161/JAHA.119.014168**. doi: doi:10.1161/JAHA.119.014168.

163. Trilk J, Nelson L, Briggs A, Muscato D. Including lifestyle medicine in medical education: rationale for American College of Preventive Medicine/American Medical Association resolution 959. *Am J Prev Med.* 2019;56(5):e169–e175. doi: 10.1016/j.amepre.2018.10.034.

164. Centers for Disease Control and Prevention. Health impact in 5 years website. **https://www.cdc.gov/policy/hst/hi5/**. Accessed November 19, 2019.

165. Frieden TR. A framework for public health action: the health impact pyramid. *Am J Public Health.* 2010;100(4): 590–595.

166. Centers for Disease Control and Prevention. Sodium Reduction in Communities Program (SRCP) website. 2020; **https://www.cdc.gov/dhdsp/programs/sodium_reduction.htm**. Accessed March 13, 2020.

167. Hollis-Hansen K, Vermont L, Zafron ML, Seidman J, Leone L. The introduction of new food retail opportunities in lower-income communities and the impact on fruit and vegetable intake: a systematic review. *Transl Behav Med.* 2019;9(5):837–846.

168. Block JP, Subramanian SV. Moving beyond "food deserts": reorienting United States policies to reduce disparities in diet quality. *PLoS Med.* 2015;12(12):e1001914–e1001914. **https://pubmed.ncbi.nlm.nih.gov/26645285**. doi: 10.1371/journal.pmed.1001914.

169. Pearson-Stuttard J, Bandosz P, Rehm CD, et al. Reducing US cardiovascular disease burden and disparities through national and targeted dietary policies: A modelling study. *PLoS Med.* 2017;14(6):e1002311. Accessed Jun. doi: 10.1371/journal.pmed.1002311.

170. Lewallen TC, Hunt H, Potts-Datema W, Zaza S, Giles W. The Whole School, Whole Community, Whole Child model: a new approach for improving educational attainment and healthy development for students. *J Sch Health.* 2015;85(11):729–739.

171. 2018 Physical Activity Guidelines Advisory Committee. *2018 Physical Activity Guidelines Advisory Committee Scientific Report.* Washington, DC: Department of Health and Human Services;2018.

172. Naci H, Salcher-Konrad M, Dias S, et al. How does exercise treatment compare with antihypertensive medications? A network meta-analysis of 391 randomised controlled trials assessing exercise and medication effects on systolic blood pressure. *Br J Sports Med.* 2019;53(14):859–869.

173. Centers for Disease Control and Prevention. 2008 Physical Activity Guidelines for Americans: trends in meeting the 2008 Physical Activity Guidelines, 2008—2018 website. 2018; **https://www.cdc.gov/physicalactivity/downloads/trends-in-the-prevalence-of-physical-activity-508.pdf**. Accessed February 13, 2020.

174. Katzmarzyk PT, Powell KE, Jakicic JM, et al. Sedentary behavior and health: update from the 2018 Physical Activity Guidelines Advisory Committee. *Med Sci Sports Exerc.* 2019;51(6):1227–1241.

175. Khan KM, Thompson AM, Blair SN, et al. Sport and exercise as contributors to the health of nations. *Lancet.* 2012;380(9836):59–64.

176. U.S. Department of Health and Human Services. *Step It Up! The Surgeon General's Call to Action to Promote Walking and Walkable Communities.* Washington, D.C.: U.S. Dept of Health and Human Services; 2015.

177. National Center for Safe Routes to School. Safe Routes website. **http://www.saferoutesinfo.org/**. Accessed April 6, 2020.

178. National Center for Safe Routes to School. *Trends in Walking and Bicycling to School from 2007 to 2012* Chapel Hill, NC: University of North Carolina Highway Safety Research Center; 2013.

179. National Center for Safe Routes to School and Pedestrian and Bicycle Information Center. *The Walking School Bus: Combining Safety, Fun and the Walk to School.* Chapel Hill, NC: University of North Carolina Highway Safety Research Center; 2010.

180. Pelletier KR. A review and analysis of the clinical and cost-effectiveness studies of comprehensive health promotion and disease management programs at the worksite: update VIII 2008 to 2010. *J Occup Environ Med.* 2011;53(11):1310–1331.

181. Pahor M, Guralnik JM, Ambrosius WT, et al. Effect of structured physical activity on prevention of major mobility disability in older adults: the LIFE study randomized clinical trial. *JAMA.* 2014;311(23):2387–2396.

182. The Community Guide. Physical activity: social support interventions in community settings website. 2001; **https://www.thecommunityguide.org/findings/physical-activity-social-support-interventions-community-settings**. Accessed March 16, 2020.

183. Pollack KM, Bailey MM, Gielen AC, et al. Building safety into active living initiatives. *Prev Med.* 2014;69 Suppl 1:S102–105. Accessed Dec. doi: 10.1016/j.ypmed.2014.08.010.

184. Sallis JF, Floyd MF, Rodríguez DA, Saelens BE. Role of built environments in physical activity, obesity, and cardiovascular disease. *Circulation*. 2012;125(5):729–737.

185. Casagrande SS, Whitt-Glover MC, Lancaster KJ, Odoms-Young AM, Gary TL. Built environment and health behaviors among African Americans: a systematic review. *Am J Prev Med.* 2009;36(2):174–181.

186. Foster S, Giles-Corti B. The built environment, neighborhood crime and constrained physical activity: an exploration of inconsistent findings. *Prev Med.* 2008;47(3):241–251.

187. Gebauer S, Schootman M, Xian H, Xaverius P. Neighborhood built and social environment and meeting physical activity recommendations among mid to older adults with joint pain. *Prev Med Rep.* 2020;18:101063.

188. U.S. Department of Transportation. Complete streets website. 2015; **https://www.transportation.gov/mission/health/complete-streets**. Accessed March 4, 2020.

189. The Community Guide. Physical activity: built environment approaches combining transportation system interventions with land use and environmental design website. **https://www.thecommunityguide.org/findings/physical-activity-built-environment-approaches**. Accessed March 16, 2020.

190. Centers for Disease Control and Prevention. About active people, healthy nation website. 2020; **https://www.cdc.gov/physicalactivity/activepeoplehealthynation/about-active-people-healthy-nation.html**. Accessed March 4, 2020.

191. Million Hearts. Million Hearts website. 2020; **https://millionhearts.hhs.gov/**. Accessed March 4, 2020.

192. The Community Guide. Physical activity: interventions to increase active travel to school website. 2019; **https://www.thecommunityguide.org/content/tffrs-physical-activity-interventions-increase-active-travel-school**. Accessed March 16, 2020.

193. Anand SS, Hawkes C, De Souza RJ, et al. Food consumption and its impact on cardiovascular disease: importance of solutions focused on the globalized food system: a report from the workshop convened by the World Heart Federation. *J Am Coll Cardiol*. 2015;66(14):1590–1614.

194. Lim SS, Vos T, Flaxman AD, et al. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet.* 2012;380(9859):2224–2260.

195. U.S. Department of Health and Human Services and U.S. Department of Agriculture. *2015–2020 Dietary Guidelines for Americans. 8th Edition*. Washington, DC: U.S. Dept of Health and Human Services and U.S. Dept of Agriculture; 2015.

196. Chiavaroli L, Viguiliouk E, Nishi SK, et al. DASH dietary pattern and cardiometabolic outcomes: an umbrella review of systematic reviews and meta-analyses. *Nutrients.* 2019;11(2).

197. Richardson SI, Freedman BI, Ellison DH, Rodriguez CJ. Salt sensitivity: a review with a focus on non-Hispanic blacks and Hispanics. *J Am Soc Hypertens.* 2013;7(2):170–179.

198. Zilbermint M, Hannah-Shmouni F, Stratakis CA. Genetics of hypertension in African Americans and others of African descent. *Int J Mol Sci.* 2019;20(5).

199. Quader ZS, Zhao L, Gillespie C, Al. E. Sodium intake among persons aged ≥2 Years — United States, 2013–2014 *MMWR Morb Mortal Wkly Rep.* 2017;66:324–238. doi: **http://dx.doi.org/10.15585/mmwr.mm6612a3**.

200. New York City Health. National salt and sugar reduction initiative website. **https://www1.nyc.gov/site/doh/health/health-topics/national-salt-sugar-reduction-initiative.page**. Accessed April 2, 2020.

201. Centers for Disease Control and Prevention. Healthy Food Service Guidelines website. **https://www.cdc.gov/obesity/strategies/food-serv-guide.html**. Accessed August 5, 2020.

202. Felipe RA, Plescia M, Peterman E, et al. A public health framework to improve population health through health care and community clinical linkages: the ASTHO/CDC Heart Disease and Stroke Prevention Learning Collaborative. *Prev Chronic Dis.* 2019;16:E124. Accessed Sep 12. doi: 10.5888/pcd16.190065.

203. Omura JD, Watson KB, Loustalot F, Fulton JE, Carlson SA. Primary care providers' awareness of physical activity-related intensive behavioral counseling services for cardiovascular disease prevention. *Am J Health Promot.* 2019;33(2):208–216.

204. U.S. Preventive Services Task Force. Healthful diet and physical activity for cardiovascular disease prevention in adults with cardiovascular risk factors: behavioral counseling website. 2014; **https://www.uspreventiveservicestaskforce.org/Page/Document/UpdateSummaryFinal/healthy-diet-and-physical-activity-counseling-adults-with-high-risk-of-cvd**. Accessed March 13, 2020.

205. Lefevre ML. Behavioral counseling to promote a healthful diet and physical activity for cardiovascular disease prevention in adults with cardiovascular risk factors: U.S. Preventive Services Task Force Recommendation Statement. *Ann Intern Med*. 2014;161(8):587–593.

206. Centers for Disease Control and Prevention. Developing community-clinical linkages for WISEWOMAN Ppograms website. 2014; **https://www.cdc.gov/wisewoman/docs/ww_brief_developing_community-clinical_linkages.pdf**. Accessed March 13, 2020.

207. Centers for Disease Control and Prevention. *What could be addressed in an evidence-informed state workplace health promotion law?* Atlanta, GA: Division for Heart Disease and Stroke Prevention; 2017.

208. Joshi K, Smith S, Bolen SD, et al. Implementing a produce prescription program for hypertensive patients in safety net clinics. *Health Promot Pract.* 2019;20(1):94–104.

209. Phillips LS, Branch WT, Cook CB, et al. Clinical inertia. *Ann Intern Med.* 2001;135(9):825–834.

210. Allen JD, Curtiss FR, Fairman KA. Nonadherence, clinical inertia, or therapeutic inertia? *J Manag Care Pharm*. 2009;15(8):690–695.

211. Milman T, Joundi RA, Alotaibi NM, Saposnik G. Clinical inertia in the pharmacological management of hypertension: a systematic review and meta-analysis. *Medicine (Baltimore)*. 2018;97(25):e11121. Accessed Jun. doi: 10.1097/md.0000000000011121.

212. O'connor PJ, Sperl-Hillen JaM, Johnson PE, Rush WA, Biltz G. Advances in patient safety clinical inertia and outpatient medical errors. In: Henriksen K, Battles JB, Marks ES, Lewin DI, eds. *Advances in patient safety: from research to implementation (volume 2: concepts and methodology).* Rockville (MD): Agency for Healthcare Research and Quality (US); 2005.

213. Johnson HM, Thorpe CT, Bartels CM, et al. Undiagnosed hypertension among young adults with regular primary care use. *J Hypertens.* 2014;32(1):65–74.

214. Thomas SJ, Booth JN, 3rd, Dai C, et al. Cumulative incidence of hypertension by 55 years of age in Blacks and Whites: The CARDIA Study. *J Am Heart Assoc.* 2018;7(14).

215. Bellows BK, Ruiz-Negron N, Bibbins-Domingo K, et al. Clinic-based strategies to reach United States Million Hearts 2022 blood pressure control goals. *Circ Cardiovasc Qual Outcomes.* 2019;12(6):e005624.

216. Go AS, Bauman MA, Coleman King SM, et al. An effective approach to high blood pressure control: a science advisory from the American Heart Association, the American College of Cardiology, and the Centers for Disease Control and Prevention. *J Am Coll Cardiol.* 2014;63(12):1230–1238.

217. Kelley JM, Kraft-Todd G, Schapira L, Kossowsky J, Riess H. The influence of the patient-clinician relationship on healthcare outcomes: a systematic review and meta-analysis of randomized controlled trials. *PLoS One*. 2014;9(4):e94207. doi: 10.1371/journal.pone.0094207.

218. Hoffmann TC, Montori VM, Del Mar C. The connection between evidence-based medicine and shared decision making. *JAMA.* 2014;312(13):1295–1296.

219. L. Paget, P. Han, S. Nedza, et al. Patient-clinician communication: basic principles and expectations. *NAM Perspectives Discussion Paper.* 2011. doi: **https://doi.org/10.31478/201106a**.

220. Centers for Disease Control and Prevention. *Hypertension control change package (2nd ed.)*. Atlanta, GA: Centers for Disease Control and Prevention; 2020.

221. Shaw RJ, Mcduffie JR, Hendrix CC, et al. Effects of nurse-managed protocols in the outpatient management of adults with chronic conditions: a systematic review and meta-analysis. *Ann Intern Med*. 2014;161(2):113–121.

222. Kallioinen N, Hill A, Horswill MS, Ward HE, Watson MO. Sources of inaccuracy in the measurement of adult patients' resting blood pressure in clinical settings: a systematic review. *J Hypertens*. 2017;35(3):421–441.

223. Rakotz MK, Townsend RR, Yang J, et al. Medical students and measuring blood pressure: Results from the American Medical Association Blood Pressure Check Challenge. *J Clin Hypertens (Greenwich)*. 2017;19(6):614–619.

224. Muntner P, Shimbo D, Carey Robert M, et al. Measurement of blood pressure in humans: a scientific statement from the American Heart Association. *Hypertension*. 2019;73(5):e35–e66. doi: 10.1161/HYP.0000000000000087.

225. Pickering TG, Hall JE, Appel LJ, et al. Recommendations for blood pressure measurement in humans and experimental animals: part 1: blood pressure measurement in humans: a statement for professionals from the Subcommittee of Professional and Public Education of the American Heart Association Council on High Blood Pressure Research. *Circulation*. 2005;111(5):697–716.

226. Bartolome RE, Chen A, Handler J, Platt ST, Gould B. Population care management and team-based approach to reduce racial disparities among African Americans/Blacks with hypertension. *Perm J*. 2016;20(1):53–59.

227. Mitchell P, Wynia M, Golden R, et al. Core principles & values of effective team-based health care. 2012.

228. American Academy of Family Physicians, American College of Physicians, American Osteopathic Association. *Joint principles of the patient-centered medical home*. Washington, D.C. 2007.

229. Proia KK, Thota AB, Njie GJ, et al. Team-based care and improved blood pressure control: a community guide systematic review. *Am J Prev Med*. 2014;47(1):86–99.

230. Carter BL, Rogers M, Daly J, Zheng S, James PA. The potency of team-based care interventions for hypertension: a meta-analysis. *Arch Intern Med*. 2009;169(19):1748–1755.

231. Bengtson A, Drevenhorn E. The nurse's role and skills in hypertension care: a review. *Clin Nurse Spec*. 2003;17(5):260–268.

232. Carter BL, Bosworth HB, Green BB. The hypertension team: the role of the pharmacist, nurse, and teamwork in hypertension therapy. *J Clin Hypertens (Greenwich)*. 2012;14(1):51–65.

233. Himmelfarb CRD, Commodore-Mensah Y, Hill MN. Expanding the role of nurses to improve hypertension care and control globally. *Ann Glob Health*. 2016;82(2):243–253.

234. Mills KT, Obst KM, Shen W, et al. Comparative effectiveness of implementation strategies for blood pressure control in hypertensive patients: a systematic review and meta-analysis. *Ann Intern Med*. 2018;168(2):110–120.

235. Overwyk KJ, Dehmer SP, Roy K, et al. Modeling the health and budgetary impacts of a team-based hypertension care intervention that includes pharmacists. *Med Care*. 2019;57(11):882–889.

236. The Community Guide. Cardiovascular disease: tailored pharmacy-based interventions to improve medication adherence website. 2019; **https://www.thecommunityguide.org/findings/cardiovascular-disease-tailored-pharmacy-based-interventions-improve-medication-adherence**. Accessed January 28, 2020.

237. Viswanathan M, Kahwati LC, Golin CE, et al. Medication therapy management interventions in outpatient settings: a systematic review and meta-analysis. *JAMA Intern Med*. 2015;175(1):76–87.

238. The Community Guide. Cardiovascular disease: interventions engaging community health workers website. *Guide to Community Preventive Services* 2015; **https://www.thecommunityguide.org/findings/cardiovascular-disease-prevention-and-control-interventions-engaging-community-health**. Accessed January 30, 2020.

239. Jacob V, Chattopadhyay SK, Hopkins DP, et al. Economics of community health workers for chronic disease: findings from community guide systematic reviews. *Am J Prev Med*. 2019;56(3):e95–e106. doi: 10.1016/j.amepre.2018.10.009.

240. Uhlig K, Patel K, Ip S, Kitsios GD, Balk EM. Self-measured blood pressure monitoring in the management of hypertension: a systematic review and meta-analysis. *Ann Intern Med*. 2013;159(3):185–194.

241. Community Preventive Services Task Force. Self-measured blood pressure monitoring improves outcomes: recommendation of the Community Preventive Services Task Force. *Am J Prev Med.* 2017;53(3):e115–e118. doi: 10.1016/j.amepre.2017.03.003.

242. Tucker KL, Sheppard JP, Stevens R, et al. Self-monitoring of blood pressure in hypertension: a systematic review and individual patient data meta-analysis. *PLoS Med.* 2017;14(9):e1002389. doi: 10.1371/journal.pmed.1002389.

243. Duan Y, Xie Z, Dong F, et al. Effectiveness of home blood pressure telemonitoring: a systematic review and meta-analysis of randomised controlled studies. *J Hum Hypertens*. 2017;31(7):427–437.

244. Sheppard JP, Tucker KL, Davison WJ, et al. Self-monitoring of blood pressure in patients with hypertension-related multi-morbidity: systematic review and Individual patient data meta-analysis. *Am J Hypertens*. 2020;33(3):243–251.

245. Siu AL. Screening for high blood pressure in adults: U.S. Preventive Services Task Force recommendation statement. *Ann Intern Med.* 2015;163(10):778–786.

246. Fletcher BR, Hartmann-Boyce J, Hinton L, Mcmanus RJ. The effect of self-monitoring of blood pressure on medication adherence and lifestyle factors: a systematic review and meta-analysis. *Am J Hypertens*. 2015;28(10):1209–1221.

247. Agarwal R, Bills JE, Hecht TJ, Light RP. Role of home blood pressure monitoring in overcoming therapeutic inertia and improving hypertension control: a systematic review and meta-analysis. *Hypertension*. 2011;57(1):29–38.

248. American Medical Association. Controlling high BP. Self-measured blood pressure: best practices website. 2018; **https://www.ama-assn.org/system/files/2019-01/smbp-best-practices.pdf**. Accessed January 27, 2020.

249. Centers for Disease Control and Prevention. Self-measured blood pressure monitoring: actions steps for clinicians website. 2014; **https://www.cdc.gov/dhdsp/pubs/guides/best-practices/smbp.htm**.

250. The Community Guide. Cardiovascular disease: interactive digital interventions for blood pressure self-managment website. 2017; **https://www.thecommunityguide.org/findings/cardiovascular-disease-interactive-digital-interventions-blood-pressure-self-management**. Accessed February 21, 2020.

251. Ostchega Y, Berman L, Hughes JP, Chen TC, Chiappa MM. Home blood pressure monitoring and hypertension status among US adults: the National Health and Nutrition Examination Survey (NHANES), 2009-2010. *Am J Hypertens.* 2013;26(9):1086–1092.

252. Ostchega Y, Zhang G, Kit BK, Nwankwo T. Factors associated with home blood pressure monitoring among US adults: National Health and Nutrition Examination Survey, 2011-2014. *Am J Hypertens.* 2017;30(11):1126–1132.

253. Ayala C, Tong X, Keenan NL. Regular use of a home blood pressure monitor by hypertensive adults—HealthStyles, 2005 and 2008. *J Clin Hypertens (Greenwich)*. 2012;14(3):172–177.

254. Breaux-Shropshire TL, Brown KC, Pryor ER, Maples EH. Prevalence of blood pressure self-monitoring, medication adherence, self-efficacy, stage of change, and blood pressure control among municipal workers with hypertension. *Workplace Health Saf.* 2012;60(6):265–271.

255. Poon IO, Etti N, Lal LS. Does the use of home blood pressure monitoring vary by race, education, and income? *Ethn Dis.* 2010;20(1):2–6.

256. Viera AJ, Cohen LW, Mitchell CM, Sloane PD. High blood pressure knowledge among primary care patients with known hypertension: a North Carolina Family Medicine Research Network (NC-FM-RN) study. *J Am Board Fam Med*. 2008;21(4):300–308.

257. Jackson SL, Ayala C, Tong X, Wall HK. Clinical implementation of self-measured blood pressure monitoring, 2015-2016. *Am J Prev Med.* 2019;56(1):e13–e21. doi: 10.1016/j.amepre.2018.06.017.

258. Woolsey S, Brown B, Ralls B, Friedrichs M, Stults B. Diagnosing hypertension in primary care clinics according to current guidelines. *J Am Board Fam Med.* 2017;30(2):170–177.

259. Van Durme DJ, Goldstein M, Pal N, Roetzheim RG, Gonzalez EC. The accuracy of community-based automated blood pressure machines. *J Fam Pract.* 2000;49(5):449–452.

260. Bosworth HB, Granger BB, Mendys P, et al. Medication adherence: a call for action. *Am Heart J.* 2011;162(3): 412–424.

261. Ritchey M, Chang A, Powers C, et al. Vital Signs: disparities in antihypertensive medication nonadherence among medicare part d beneficiaries - United States, 2014. *MMWR Morb Mortal Wkly Rep.* 2016;65(36):967–976.

262. Ho PM, Bryson CL, Rumsfeld JS. Medication adherence: its importance in cardiovascular outcomes. *Circulation.* 2009;119(23):3028–3035.

263. Flack JM, Nasser SA. Benefits of once-daily therapies in the treatment of hypertension. *Vasc Health Risk Manag.* 2011;7:777–787.

264. Taitel M, Fensterheim L, Kirkham H, Sekula R, Duncan I. Medication days' supply, adherence, wastage, and cost among chronic patients in Medicaid. *Medicare Medicaid Res Rev.* 2012;2(3). doi: 10.5600/mmrr.002.03.a04.

265. White ND. Pharmacy medication synchronization service works to improve medication adherence. *Am J Lifestyle Med.* 2016;10(6):385–387.

266. The Community Guide. Cardiovascular disease: mobile Health (mHealth) interventions for treatment adherence among newly diagnosed patients website. 2017; **https://www.thecommunityguide.org/findings/cardiovascular-disease-mobile-health-interventions-treatment-adherence-among-newly-diagnosed-patients**. Accessed January 28, 2020.

267. National Quality Forum. Quality Positioning System (QPS): Measure Description Display Information Controlling High Blood Pressure website. 2013; **http://www.qualityforum.org/QPS/MeasureDetails.aspx?standardID=1236&print=0&entityTypeID=1**. Accessed June 2, 2020.

268. Million Hearts. Clinical quality measure alignment website. 2019; **https://millionhearts.hhs.gov/data-reports/cqm/measures.html**. Accessed January 27, 2020.

269. Health Resources and Services Administration. AHRQ *Data Spotlight: hypertension control in Health Resources and Services Administration health centers*. 2020. AHRQ Publication No. 19(20)-0069.

270. Wagner EH. Chronic disease management: what will it take to improve care for chronic illness? *Eff Clin Pract.* 1998;1(1):2–4.

271. Kaboli PJ, Howren MB, Ishani A, et al. Efficacy of patient activation interventions with or without financial incentives to promote prescribing of thiazides and hypertension control: a randomized clinical trial. *JAMA Network Open.* 2018;1(8):e185017–e185017. doi: 10.1001/jamanetworkopen.2018.5017.

272. Mensah GA. Commentary: hypertension phenotypes: the many faces of a silent killer. *Ethn Dis.* 2019;29(4): 545–548.

273. Wozniak G, Khan T, Gillespie C, et al. Hypertension control cascade: a framework to improve hypertension awareness, treatment, and control. *J Clin Hypertens (Greenwich).* 2016;18(3):232–239.

274. Chang TE, Ritchey MD, Park S, et al. National rates of nonadherence to antihypertensive medications among insured adults with hypertension, 2015. *Hypertension.* 2019;74(6):1324–1332.

275. Mueller M, Purnell TS, Mensah GA, Cooper LA. Reducing racial and ethnic disparities in hypertension prevention and control: what will it take to translate research into practice and policy? *Am J Hypertens.* 2015;28(6):699–716.

276. He J, Muntner P, Chen J, et al. Factors associated with hypertension control in the general population of the United States. *Arch Intern Med.* 2002;162(9):1051–1058.

277. Carey RM, Muntner P, Bosworth HB, Whelton PK. Prevention and control of hypertension. *J Am Coll Cardiol.* 2018;72(11):1278–1293.

278. Agency for Healthcare Research and Quality. About EvidenceNOW: background and stories from the field website. 2019; **https://www.ahrq.gov/evidencenow/about/index.html**. Accessed February 21, 2020.

279. Whelton PK, Einhorn PT, Muntner P, et al. Research needs to improve hypertension treatment and control in African Americans. *Hypertension*. 2016;68(5):1066–1072.

280. Kitt J, Fox R, Tucker KL, Mcmanus RJ. New approaches in hypertension management: a review of current and developing technologies and their potential impact on hypertension care. *Curr Hypertens Rep*. 2019;21(6):44.

281. Jones DW, Hall JE. The national high blood pressure education program: thirty years and counting. *Hypertension*. 2002;39(5):941–942.

282. Frieden TR, Berwick DM. The "Million Hearts" initiative—preventing heart attacks and strokes. *N Engl J Med*. 2011;365(13):e27. Accessed Sep 29. doi: 10.1056/NEJMp1110421.

283. Mccullough J. *The Return on Investment of Public Health System Spending*. AcademyHealth; June 2018.

284. Lackland DT, Carey RM, Conforto AB, et al. Implications of recent clinical trials and hypertension guidelines on stroke and future cerebrovascular research. *Stroke*. 2018;49(3):772–779.

285. Okonofua EC, Simpson KN, Jesri A, et al. Therapeutic inertia is an impediment to achieving the Healthy People 2010 blood pressure control goals. *Hypertension*. 2006;47(3):345–351.

286. Josiah Willock R, Miller JB, Mohyi M, et al. Therapeutic inertia and treatment intensification. *Curr Hypertens Rep*. 2018;20(1):4.

287. Levy PD, Willock RJ, Burla M, et al. Total antihypertensive therapeutic intensity score and its relationship to blood pressure reduction. *J Am Soc Hypertens*. 2016;10(12):906–916.

288. Campbell N, Ordunez P, Jaffe MG, et al. Implementing standardized performance indicators to improve hypertension control at both the population and healthcare organization levels. J *Clin Hypertens (Greenwich)*. 2017;19(5):456–461.

289. Smith CD, Balatbat C, Corbridge S, et al. Implementing optimal team-based care to reduce clinician burnout. *NAM Perspectives*. 2018. **https://nam.edu/wp-content/uploads/2018/09/Implementing-Optimal-Team-Based-Care-to-Reduce-Clinician-Burnout.pdf** doi: 10.31478/201809c.

290. Fendrick AM, Smith DG, Chernew ME. Applying value-based insurance design to low-value health services. *Health Aff (Millwood)*. 2010;29(11):2017–2021.

291. Orchard TJ, Temprosa M, Barrett-Connor E, et al. Long-term effects of the Diabetes Prevention Program interventions on cardiovascular risk factors: a report from the DPP Outcomes Study. *Diabet Med*. 2013;30(1):46–55.

292. Sherrill B, Halpern M, Khan S, Zhang J, Panjabi S. Single-pill vs free-equivalent combination therapies for hypertension: a meta-analysis of health care costs and adherence. *J Clin Hypertens (Greenwich)*. 2011;13(12):898–909.

293. Berg S. New year, new CPT codes for self-measured BP website. 2019; **https://www.ama-assn.org/practice-management/cpt/new-year-new-cpt-codes-self-measured-bp**. Accessed February 24, 2020.

294. Casey DE, Thomas RJ, Bhalla V, et al. 2019 AHA/ACC clinical performance and quality measures for adults with high blood pressure: a report of the American College of Cardiology/American Heart Association Task Force on Performance Measures. *Circ Cardiovasc Quality Outcomes*. 2019;12(11):e000057–e000057. **https://pubmed.ncbi.nlm.nih.gov/31714813**. doi: 10.1161/HCQ.0000000000000057.

295. Walsh J MK, Shojania Kg, Sundaram V, Nayak S, Davies S, Lewis R, Mechanic J, Sharp C, Henne M, Shah B, Chan Jk, Owens Dk, Goldstein Mk. Hypertension Care. Vol. 3 Of: Shojania Kg, Mcdonald Km, Wachter Rm, Owens Dk, Editors. *Closing the Quality Gap: A Critical Analysis of Quality Improvement Strategies. Technical review 9*. Rockville, MD: Agency for Healthcare Research and Quality 2005. AHRQ Publication No. 04-0051-3.

296. Christianson JB. The role of employers in community health care systems. *Health Aff (Millwood)*. 1998;17(4):158–164.

297. Saunders MK. Unleashing new data on health system readiness. *Health Aff (Millwood)*. 2018;37(8):1331. **https://www.healthaffairs.org/doi/abs/10.1377/hlthaff.2018.0791**. doi: 10.1377/hlthaff.2018.0791.

298. Thomas SM, Cassells HB. Quality improvement project for managing elevated blood pressure in a primary care setting. *Integr Blood Press Control*. 2017;10:25–32.

299. Fremont A, Kim AY, Bailey K, et al. One in five fewer heart attacks: impact, savings, and sustainability in San Diego County Collaborative. *Health Aff (Millwood)*. 2018;37(9):1457–1465. **https://www.healthaffairs.org/doi/abs/10.1377/hlthaff.2018.0443**. doi: 10.1377/hlthaff.2018.0443.

300. Pearson TA, Palaniappan LP, Artinian NT, et al. American Heart Association guide for improving cardiovascular health at the community level, 2013 update: a scientific statement for public health practitioners, healthcare providers, and health policy makers. *Circulation*. 2013;127(16):1730–1753.

301. Be There San Diego. Organizational approach to hypertension management using team-based care website. **http://betheresandiego.org/storage/files/btsd-recommedations-01.pdf**. Accessed February 24, 2020.

302. Robert Wood Johnson Foundation. Building a culture of health website. **https://www.rwjf.org/en/how-we-work/building-a-culture-of-health.html**. Accessed February 24, 2020.

303. Healthy Chicago. Healthy Chicago, Healthy Hearts: A local response to the national forum updated public health action plan to prevent heart disease and stroke website. **https://www.chicago.gov/content/dam/city/depts/cdph/CDPH/CDPH_CardiovascularHealthBrochure_v4.pdf**. Accessed February 24, 2020.

304. Ferdinand KC, Patterson KP, Taylor C, et al. Community-based approaches to prevention and management of hypertension and cardiovascular disease. *J Clin Hypertens (Greenwich)*. 2012;14(5):336–343.

305. Hoffman D, Murtzlufft J. *Why Preventing Chronic Disease is Essential - Prevention Works*. Decatur, Ga National Association of Chronic Disease Directors;2018.

306. The Community Guide. Cardiovascular disease: team-based care to improve blood pressure control website. *Systematic Review* 2012; **https://www.thecommunityguide.org/findings/cardiovascular-disease-team-based-care-improve-blood-pressure-control**. Accessed February 24, 2020.

307. Centers for Disease Control and Prevention. *Collaborative practice agreements and pharmacists' patient care services: a resource for pharmacists*. Atlanta, Ga: US Dept. of Health and Human Services, Centers for Disease Control and Prevention; 2013.

308. Mckernan SC, Kuthy RA, Reynolds JC, Tuggle L, Garcia DT. *Medical-dental integration in public health settings: an environmental scan*. Iowa City, IA: University of Iowa Public Policy Center;2018.

309. Dzau VJ, Balatbat CA. Future of hypertension. *Hypertension*. 2019;74(3):450–457.

310. Rehman H, Kamal AK, Morris PB, et al. Mobile Health (mHealth) technology for the management of hypertension and hyperlipidemia: slow start but loads of potential. *Curr Atheroscler Rep.* 2017;19(3):12.

311. Morawski K, Ghazinouri R, Krumme A, et al. Association of a smartphone application with medication adherence and blood pressure sontrol: The MedISAFE-BP randomized clinical trial. *JAMA Intern Med*. 2018;178(6):802–809.

312. Patel R, Chang T, Greysen SR, Chopra V. Social media use in chronic disease: a systematic review and novel taxonomy. *Am J Med.* 2015;128(12):1335–1350.

313. Community Preventive Services Task Force. Tobacco use and secondhand smoke exposure: mass-reach health communication interventions. The Guide to Community Preventive Services website. 2013; **https://www.thecommunityguide.org/findings/tobacco-use-and-secondhand-smoke-exposure-mass-reach-health-communication-interventions**. Accessed July 12, 2019.

314. U.S. Department of Health and Human Services Food and Drug Administration. *Voluntary sodium reduction goals: target mean and upper bound concentrations for sodium in commercially processed, packaged, and prepared foods: guidance for industry*. Rockville, MD: U.S. Department of Health and Human Services; 2016.

315. Henwood BF, Stanhope V, Brawer R, et al. Addressing chronic disease within supportive housing programs. *Prog Community Health Partnersh*. 2013;7(1):67–75.

316. Barrett MA, Miller D, Frumkin H. Parks and health: aligning incentives to create innovations in chronic disease prevention. *Prev Chronic Dis.* 2014;11:E63. **http://dx.doi.org/10.5888/pcd11.130407**. doi: 10.5888/pcd11.130407.

317. Pahkala K, Hietalampi H, Laitinen TT, et al. Ideal cardiovascular health in adolescence: effect of lifestyle intervention and association with vascular intima-media thickness and elasticity (the Special Turku Coronary Risk Factor Intervention Project for Children [STRIP] study). *Circulation*. 2013;127(21):2088–2096.

318. Dudley DA, Cotton WG, Peralta LR. Teaching approaches and strategies that promote healthy eating in primary school children: a systematic review and meta-analysis. *Int J Behav Nutr Phys Act.* 2015;12:28.

Acknowledgement

The Office of the Surgeon General would like to especially thank the leadership team from the Centers for Disease Control and Prevention, Division for Heart Disease and Stroke Prevention:

CAPT Fleetwood Loustalot, FNP, PhD, FAHA

Stephanie Bernard, PhD, MPH

Jacquie Dozier, MLA

Hilary K. Wall, MPH

Erika Fulmer, MHA

Alessandra Capriles, BA

Michael Sells, PhD, MS

CAPT Matthew Ritchey, PT, DPT, OCS, MPH

LCDR Angela Thompson-Paul, PhD, MSPH

In addition, the Office of the Surgeon General would like to thank the many staff members who contributed to this report. Specifically, from the Centers for Disease Control and Prevention: Lauren Owens, MPH; Mary G. George, MD, MSPH, FACS; RADM Betsy Thompson, MD, MSPH, DrPH; Booker Daniels, MPH; and Susan Carlson, PhD. From the Office of the Surgeon General: Janet Wright, MD, FACC.

October 2020