

# Implementation of Management Strategies for Diabetes and Hypertension

## From Local to Global Health in Cardiovascular Diseases

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Diabetes and hypertension are chronic conditions that are growing in prevalence as major causal factors of cardiovascular disease (CVD). The need for chronic-illness surveillance, population-risk management, and successful treatment interventions are crucial for reducing the burden of future CVD. Addressing these problems will require population-risk stratification, task-sharing and -shifting, and community-as well as network-based care. Information technology tools also provide new opportunities for identifying those at risk and for implementing comprehensive approaches to achieving the goal of improved health locally, regionally, nationally, and globally. This article discusses ongoing efforts at one university health center in the implementation of management strategies for diabetes and hypertension at the local, regional, national, and global levels.

Although cardiovascular disease (CVD)-related mortality has significantly declined in Western countries over the past several decades due to a combination of disease prevention and improved acute care, it remains the leading cause of death [1]. Moreover, as developing countries successfully manage infectious diseases, the prevalences of chronic conditions, such as diabetes mellitus and hypertension, are increasing and progressively pose major public health problems worldwide. Both diabetes and hypertension can be successfully treated with a variety of effective and relatively inexpensive therapies, yet control of these conditions remains far from ideal. Even in developed countries such as the United States, a substantial number of patients with diabetes and hypertension do not reach their targeted hemoglobin A1c levels or blood pressure (BP) goals [2,3]. Effective approaches to addressing substantial cardiovascular health needs and health disparities must go beyond conventional specialty-oriented cardiovascular care. Thus, the need for population-disease surveillance, risk management, and durable treatment intervention are crucial for reducing the burden of future CVD across communities. Successful alteration of the impact of diabetes and hypertension will require concepts typically applied for global health, including population-risk stratification, task-sharing and -shifting, community- and network-based care, and the successful application of information-technology tools. In this article, we will highlight ongoing efforts involving Duke University in the implementation of strategies for managing diabetes and hypertension at the local, regional, national, and global levels.

### LOCAL PERSPECTIVES

The southeastern region of the United States has particularly poor outcomes in terms of longevity and functional

status. Excessive rates of obesity, diabetes, and hypertension are coupled with high rates of stroke, heart failure, renal failure, and sudden death. North Carolina is located in a region commonly referred to as the “stroke belt” or the “diabetes belt,” terms coined to reflect particularly high prevalences of these conditions and their risk factors. Durham County, the home of Duke University and its academic health and science system, has rates of death and nonfatal cardiovascular events that are only slightly better than the North Carolina averages. The counties surrounding Durham County are heterogeneous, with lower-than-average rates of adverse outcomes in affluent counties but very high rates in poorer, rural counties. There are also substantial disparities in health on the basis of sex, race, and ethnicity [4].

The adoption of electronic health records (EHRs) has provided a unique opportunity for conducting population health surveillance and management. Over a decade ago, campus collaborations between the Duke University School of the Environment and the Duke University Health System facilitated the conceptualization of a data environment in which every patient receiving care in the health system and living in the local community could be characterized in multiple dimensions, including the dimensions of social, economic, and environmental contributors to health [5]. Whole neighborhoods and populations can be characterized by summing and integrating the patient-level information.

In 2006, when Duke received one of the original Clinical and Translational Science awards, a large community-engagement program, Durham Health Innovations, was initiated and is supported by grant funds and institutional support. We developed a plan for community-based health improvement by asking teams to form with a focus on a health problem of importance. Teams were intentionally composed of both Duke and community

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members. A consortium of 10 teams evolved to address health issues across the lifespan. Each team developed a set of core priorities for action that evolve around several central themes, including: 1) developing a single medical record for the county, 2) locating care as close as possible to home, work, or school, and 3) tailoring care to match the needs of every patient. Teams spent considerable time considering incentives that drive contemporary health care practices and saw the use of electronic information as a promising vehicle for unifying the conventional health care delivery system and social forces for achieving better population health. In addition, teams viewed the use of electronic information as a critically important means of reducing redundant, erroneous, and unnecessary care as well as of preventing expensive hospitalizations precipitated by uncoordinated care.

A grant from the Bristol Myers Squibb Foundation (BMS-F) enabled taking the concepts started by Durham Health Innovations to address diabetes care at the neighborhood and population levels. The plan has included identifying each patient with diabetes in Durham County, characterizing the patient's risks for poor medical outcomes and high financial cost, and developing an intervention plan to match the level of risk (Figure 1). A robust effort to identify all people in the health system and county with type II diabetes using the Health System Enterprise Data Warehouse, “computable phenotypes” demonstrated that the estimate of the proportion of a population with type II diabetes could vary by up to 2-fold, depending on the specific algorithm used from a suite of commonly used “computable phenotype” definitions [6].

Using the composite of medical information in the EHR and geospatially mapped information about homes and neighborhoods, each patient is assigned a score reflecting

their risk for a poor health outcome (e.g., unnecessary hospitalization). For high-risk patients, a tailored, individualized care plan is developed by a multidisciplinary team, including a physician, nurse—practitioner, social worker, and dietician. Patients at moderate risk are targeted through care-delivery quality improvement in medical practices and clinics throughout the county. Low-risk patients benefit from a broad set of neighborhood and public health interventions (e.g., health fairs) aimed at improving awareness, facilitation of exercise, and appropriate dietary behaviors.

A crucial element of the BMS-F project is the development of community-engaged plans for improving neighborhood health, with a focus on high-risk neighborhoods. Using geospatial mapping, areas with a high prevalence of high-risk patients have been located. Relationships have been developed with community leaders and grass-roots organizations, and a specific plan has been developed for each neighborhood. The overall goal is to develop an environment that is conducive to successful diabetes self-management. Interventions are underway for the more than 22,900 people with type II diabetes living in Durham County and include neighborhood activities to mobilize resources that address environmental (e.g., areas for exercise), social (e.g., resources for education and support for medication adherence), and health care (e.g., improving transportation to local health care services) determinants of diabetes outcomes.

In order to further address the problems of diabetes and hypertension, it is important to examine all of the modifiable factors. For example, suboptimal risk-factor control can be attributed to multiple interrelated patient, provider, and system failures. Some of these factors include inefficiencies in the conventional clinician—patient interaction, provider inertia, misaligned incentives for disease management, and a failure to successfully engage patients in their health management [7]. As a part of our ongoing efforts to implement best practices, we frequently evaluate clinician-specific performance in our local community and then provide feedback aimed at changing behavior. Unfortunately, we have discovered that often feedback alone as an intervention has a limited impact on BP control rates, although it does prompt greater provider attention to BP measurements [8].

As another part of our ongoing innovations in the care of chronic diseases such as hypertension, we have advocated for a number of transformative strategies for using technology to support care interventions. For example, we have partnered with the American Heart Association to develop an online, Web-based patient care platform, known as Heart360, to support patient engagement and telemedicine interventions in hypertension. This system allows patients to record heart health data, including BP information, and to share these data with their providers to both promote patient engagement and self-management and to stimulate more timely treatment intensification [9].

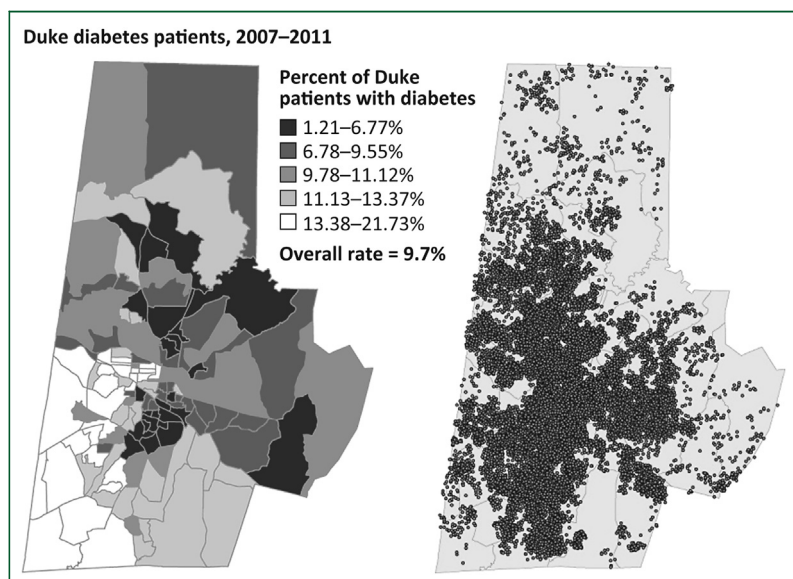


FIGURE 1. Spatial pattern of diabetic patients in Durham County, NC.

Another recommendation has been the use of collaborative health care teams to augment risk-factor control; in part this helps to reduce clinical inertia and also leverages community health workers to raise awareness and to maximize contact points with at-risk patients [10]. Health literacy interventions have also been studied to improve medication adherence [11]. A randomized trial of tailored case management for diabetes and hypertension management is ongoing in Duke community clinics that combine multiple approaches to improving patient health [12].

### REGIONAL PERSPECTIVES

Additional funding through the Centers for Medicare & Medicaid Services demonstration program provided an opportunity to extend initial BMS-F initiatives to a total of 4 southeastern U.S. counties, including Durham and Cabarrus/Kannapolis Counties in NC as well as Mingo County, WV, and Quitman County, MS. Through this expanded program, we have developed a multicounty consortium, the Southeastern Diabetes Initiative, which employs similar principles to leverage EHR data as a means of informing the deployment of tailored services to match population health needs on a county-wide basis.

Through the use of aggregated EHR data for population health risk assessment and management, we have identified large gaps in quality of care and redundancy in procedure and technology use. Patients often receive expensive cardiovascular procedures in large urban hospitals, but then they are sent back to underserved environments where follow-up care may be inadequate. There are many opportunities for improving the health of underserved rural southeastern populations through improved integration of health care delivery across geographic regions, including the mobilization of health care services closer to patients' communities (e.g., through the use of better information to organize health care services by multidisciplinary health professionals and community health workers).

Resource investment in improving the health of Kannapolis and Cabarrus County, NC, residents, 1 of the 4 counties engaged as a part of the Southeastern Diabetes Initiative, has further extended the reach of efforts to improve regional population health. In 2005, philanthropist David H. Murdock announced the formation of the North Carolina Research Campus. As a part of this initiative, he funded the Murdock study, a large-scale molecular epidemiology study oriented toward the definition of health and disease focused on nutrition and exercise. The study now has over 11,000 participants and was built on the principles of broad community inclusion and engagement. This study provides an opportunity for measuring not only deep phenotypes of health and disease in a southeastern community but also the impact of local patient, community, and health system interventions.

Thus, we have developed regional programs engaging community—health system partnerships, leveraging EHR

data, and using the principles of geospatial science to identify health-improvement priorities and to guide resource utilization for population health management. We have also developed strategies to deploy tailored interventions that directly respond to specific patient and community health needs. Through funded projects, we have demonstrated the feasibility of implementing these approaches across broad geographic regions, including in communities with limited resources. In addition to demonstrating the generalizability of our approach, programs have spurred more detailed, large-scale, community-based epidemiological studies on health. The application of similar models holds great promise for improving health across other U.S. geographical regions.

### NATIONAL PERSPECTIVES

According to recent estimates, the United States ranks poorly (30th to 70th overall) in health and health care delivery compared with most other economically developed countries [13–15]. In the United States in 1976 to 1980 and 2007 to 2010, the prevalence of diabetes increased from 4.7% to 11.2% in men and from 5.7% to 8.7% in women [16]. Among patients with CVD, the increasing prevalence of diabetes will lead to a large population with additional difficulties in preventing secondary cardiovascular events [17]. In a recent survey of the Action Registry—Get With The Guidelines (GWTG), an ongoing voluntary acute myocardial infarction quality-improvement registry now involving more than 1,000 U.S. hospitals, it was observed that 30% of acute myocardial infarction patients had diabetes on admission, and another 15% of nondiabetics had measured hemoglobin A1c levels >6.5%, potentially meeting the criteria for newly diagnosed diabetes [18]. As this population grows, it will be critically important to address ongoing questions on best therapies for the management of diabetes that will lead to not only improved glycemic control but also improved cardiovascular outcomes.

Similarly, hypertension is a growing problem in the United States, with a large population at risk for CVD. In an analysis of data from the National Health and Nutrition Examination Survey, the prevalence of uncontrolled hypertensive patients (those requiring 3 or more medications) increased from 16% in 1998 to 2004 to 28% in 2005 to 2008 [19]. In 2014, the Guidelines for the Management of High Blood Pressure (JNC 8) were released [20]. Panel members agreed that there was strong evidence to support treating hypertensive persons aged 60 years or older to a BP goal of <150/90 mm Hg and recommended a BP of <140/90 mm Hg for hypertensive patients 30 to 59 years of age, with chronic kidney disease, and/or with diabetes on the basis of expert opinion. We recently re-examined the National Health and Nutrition Examination Survey data to assess the proportion of U.S. adults potentially affected by the recent changes in the recommendations for hypertension management. Extrapolating from these data,

approximately 5.8 million U.S. adults previously classified as needing hypertension therapy are now reclassified as no longer needing it. However, the number of adults above BP goals remains high despite guideline recommendation changes, involving an estimated 28 million adults (10% of adults ages 18 to 59 years and 21% of adults over age 60 years) [2]. Data from INVEST (International Verapamil-Trandolapril Study) demonstrated that in hypertensive patients age  $\geq 60$  years with coronary artery disease, the achievement of a BP target of 140 to  $<150$  mm Hg, as recommended by the JNC 8 panel, was associated with adverse cardiovascular outcomes compared with those who were at the previously recommended target of  $<140$  mm Hg [21]. Indeed, the minority viewpoint from some of the members appointed to the JNC 8 expert panel was that evidence was insufficient to increase the SBP goal from its previous level of  $<140$  mm Hg because of concern that increasing the goal may cause harm by increasing the risk for CVD and partially undoing the remarkable progress in reducing cardiovascular mortality in Americans older than 60 years [22]. In the future, it will be crucial to assess how best to manage this population and prospectively determine whether changes in guideline recommendations alter outcomes adversely.

Although the recognition of the large populations with diabetes and/or hypertension is a step toward prevention, it is crucial to continuously assess how these patients are managed and to evaluate areas for improvement. The Duke Clinical Research Institute has a longstanding history of quality improvement through national registries partnered with professional societies such as the American Heart Association, American Diabetes Association, and the American College of Cardiology. These efforts largely focus on the highest-risk populations that will provide the largest gains in population health. Examples of these efforts include the Action Registry, the American Heart Association's GWTG registry, and the Guideline Advantage Registry [23–25].

To address potential areas of quality improvement, we have consistently demonstrated persistent gaps in care in contemporary national practice across the spectrum of cardiovascular care. In the CRUSADE (Can Rapid Risk Stratification of Unstable Angina Patients Suppress Adverse Outcomes With Early Implementation of the ACC/AHA Guidelines) registry, we observed that acute myocardial infarction patients with insulin-dependent diabetes were less likely to receive key secondary prevention therapies such as heparin and beta-blockers and were less likely to undergo an early invasive treatment strategy compared with nondiabetic patients [26]. Among patients with acute ischemic stroke in the GWTG-Stroke program, diabetic patients are significantly less likely to receive timely fibrinolytic therapy compared with nondiabetics [27]. As efforts have grown substantially toward population health-management strategies, we have partnered with the American Heart Association and the American Diabetes Association to examine data from almost 150,000

outpatients from the Guidelines Advantage registry, focused on harvesting EHRs in the ambulatory practice setting. In that registry, the proportion of patients having optimal BP control ranged from 50% to 75% across practices; a lower likelihood of BP control was observed particularly among racial minority groups [28]. Although patients with diabetes are at a substantially higher risk for cardiovascular morbidity and mortality, this adverse association is compounded by a relative underuse of evidence-based medicine in this patient population. More importantly, this registry serves as a platform for continual assessment of progress toward national goals, such as those promoted by the Million Hearts initiative [29].

As efforts for population surveillance focused on key risk factors of diabetes and hypertension grow, national registries provide an effective platform for extending our ability to apply new evidence to practice. Registries also allow for careful monitoring of any unexpected safety issues as a new therapy diffuses into a population that was under-represented in clinical trials. Increasingly, there are great efforts to implement new therapies due to the prior reports showing a lag of  $>10$  years before the implementation of best evidence [30]. Although speeding the delivery of best evidence into practice is a worthy and necessary goal, a potential risk is having large populations in clinical practice that were not included in clinical trials. To address this dual need for implementing emerging evidence more quickly while surveying for potential unexpected adverse outcomes in these unique populations, national registries linked to Medicare claims offer a promising solution. In multiple studies, our group has used national cardiovascular registries to examine the comparative effectiveness and safety of therapies in understudied populations such as older patients or patients with multiple comorbidities, including diabetes and hypertension [31]. As access to more real-time data, such as the Medicare Data Enclave, improves, the power to simultaneously assess the diffusion of new therapies using registries and to survey longitudinal outcomes becomes an important element in delivering high-quality care in an expedient, effective, and safe fashion.

## GLOBAL PERSPECTIVES

Duke University has a number of global health initiatives, and our major efforts in diabetes and hypertension are centered in China and Kenya. Both efforts have received funding from the National Heart Lung and Blood Institute in response to a solicitation to create Centers of Excellence (COE) in noncommunicable disease research in low- and middle-income countries (LMICs) [32]. Duke University was awarded a COE in partnership with the George Institute in China and an additional COE with Moi University in Kenya. The COEs are distinctive in 2 main ways: 1) they undertake research into approaches to preventing or treating chronic diseases alongside developing a clinical research infrastructure and research training programs, and

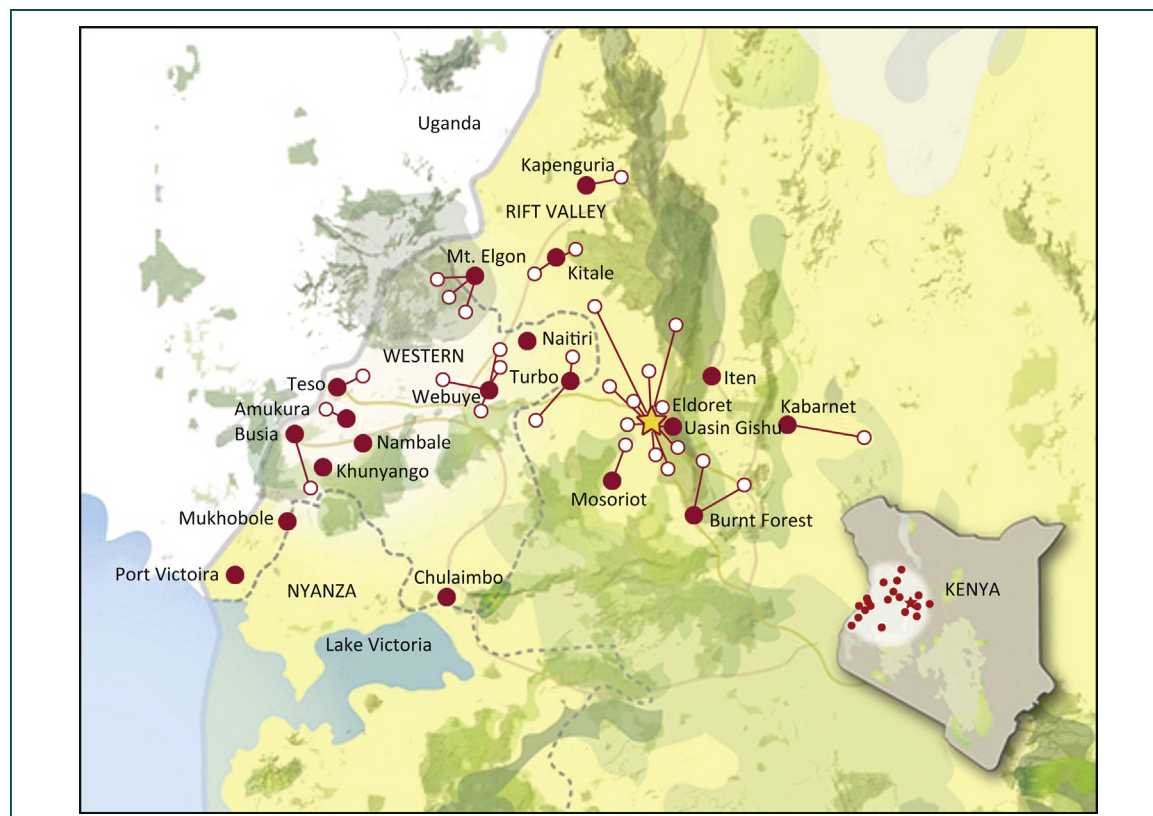
2) they have become a new global research network for noncommunicable diseases based in LMICs [33].

The China COE is focused on hypertension, which is the single most important determinant of CVD in China [34]; its importance is greatest in rural and northern regions, where salt consumption and the incidence of stroke are both high. It has been estimated that each 2% rise in population BP levels in China results in an additional 500,000 strokes and other major cardiovascular events each year [35]. The COE is currently in the analysis phase of a large-scale, cluster randomized controlled study in 5 provinces and 120 villages. Sixty intervention villages received general health education advising reduced salt consumption, specific health education targeting reduced salt intake in patients with a high risk for CVD, and a food-supply strategy designed to promote the sale of a reduced-sodium, added-potassium salt substitute through village convenience stores. Sixty control villages received no intervention and continued their usual practices. The 24-hour urine sodium, BP, 24-hour urine potassium, and urine sodium:potassium ratio are being analyzed in 2,400 patients in intervention and control villages [36].

The Kenya COE exemplifies another major global health effort in chronic CVD management. It is especially

notable for its multidisciplinary, multi-university approach to achieving the tripartite academic mission. Moi University, located in western Kenya (Figure 2), has a >25-year relationship with over a dozen North American medical schools, led by Indiana University [37]. The goal of this collaboration—the Academic Model Providing Access to Healthcare—is to leverage the power of the academic foundation to support service, teaching, and research. In keeping with the Academic Model Providing Access to Healthcare, Duke University took a lead role in achieving the missions as they relate to CVDs [38]. The COE in cardiovascular and pulmonary disease leverages the administrative, health care, research, and personnel infrastructure already in place through the human immunodeficiency virus program and enabled the team to avoid “reinventing the wheel” for diseases such as hypertension and diabetes [39].

Owing to the evidence gaps regarding chronic CVDs in Kenya, the research program of the COE encompasses a variety of methodological approaches, including surveillance, epidemiology, trials, and implementation science. Although the eventual goal was to tackle primary prevention and care for hypertension, diabetes, and other non-communicable diseases, there were important knowledge



**FIGURE 2.** Map of the academic model providing access to health care catchment area and clinic locations in western Kenya.

gaps to address. These included observational descriptions of these diseases in western Kenya, as there was evidence that determinants of hypertension and diabetes might be sufficiently different from those in upper-middle income countries. In addition, the magnitude of the need for clinical cardiovascular expertise required directing efforts toward building facilities, training health care personnel, and working with partnering institutions and industry to procure the equipment necessary for delivering appropriate cardiovascular care alongside research, training, and education. The attention to improving cardiovascular clinical care infrastructure and services is in some ways unique among the COEs, and these efforts have largely been supported by philanthropy via the Hubert-Yeargan Center for Global Health at Duke University [40].

Epidemiological surveillance systems for CVD are poor in LMICs such as Kenya owing to the low rate of cardiovascular research and productivity [41]. The initial thrust of the research endeavor in the Kenya COE has therefore been focused on gathering basic information on the nature and degree of cardiovascular and pulmonary diseases in the region. As hypertension is one of the most common cardiovascular risk factors in sub-Saharan Africa and treatment rates are suboptimal, the next phase of research has focused on identifying context-specific risk factors and treatment approaches for hypertension [42–44]. Delivering context-specific interventions in hypertension in western Kenya has required an accurate description of the burden and severity of disease as most estimates for Kenya are based on extrapolation. The COE's research program has resulted in knowledge regarding appropriate screening strategies and the burden of hypertension and target organ damage in rural and periurban settings in western Kenya [45,46].

Heart failure, often secondary to hypertension, is one of the most common admission diagnoses in western Kenya [47]. In addition to describing the etiologies of heart failure in western Kenya for the first time using contemporary echocardiography, the team also piloted a training method for nonphysician health care workers to employ handheld echocardiography in remote settings for diagnosing the most common cardiac disorders in the region. Relocating echocardiographic services to rural settings in low- and middle-income countries offers the opportunity for early diagnosis and avoids unnecessary late presentations of advanced disease. In a similar vein, the COE is involved in closing the “know–do gap” in the areas of hypertension and CVDs [48].

The foundation of the COE has also fostered productive partnerships that leverage the perspectives and unique strengths of many institutions. Hypertension and mobile-communication technology in the health arena (mHealth) characterize the current focus of these efforts owing to the burden of disease and the untapped and yet unproven potential of mHealth for noncommunicable diseases in sub-Saharan Africa [49]. By virtue of a project led by the Icahn School of Medicine at Mount Sinai University (New York, NY, USA), the chronic disease—management

program at Moi University has embarked on a program to optimize linkage and retention to antihypertensive care in rural Kenya [50]. This program will test the hypothesis that community health workers armed with a tailored behavioral communication strategy and a smart-phone–based tool linked to an EHR can increase linkage and retention of a hypertensive patient to a care program and ultimately reduce BP among these patients. In addition to community health workers, investigators are also exploring a task-sharing approach to hypertension treatment, with nurse-led interventions employing mHealth [51]. The results of these activities have the potential to affect how evidence-based care is delivered to patients with chronic non-communicable diseases in rural settings in sub-Saharan Africa and globally.

## SUMMARY

Diabetes and hypertension are growing chronic health problems that are major contributors to CVD. At an academic medical center, we have made substantial efforts at the local, regional, national, and global levels to implement improved care for these diseases through research and education in order to reduce the burden of CVD in our patients and in their communities. Partnerships with other medical centers, government, and industry, in combination with technologies such as geospatial mapping, EHRs, and mobile-communication tools, have been successful. In the future, the integration of these efforts may contribute to the translation of improved health in local and global health settings.

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