Cardiovascular Complications of Diabetes Mellitus in Sub-Saharan Africa

André Pascal Kengne, MD; Albert G.B. Amoah, MB, ChB (Ghana), PhD, MRCP (UK), FRCP, FWACP; Jean-Claude Mbanya, MD, PhD, MRCP (UK)

Background—Cardiovascular disease, the major cause of mortality and morbidity in modern societies, is set to overtake infectious diseases in the developing world as the most common cause of death. The increasing prevalence of major and emerging cardiovascular risk factors accounts for the growing burden of cardiovascular disease in the world. Diabetes in all its forms is one of the main cardiovascular risk factors. Two of 3 diabetic patients will die as a result of cardiovascular complications, and approximately 30% of patients treated in cardiovascular intensive care units have diabetes.

Methods and Results—This review on the cardiovascular complications of diabetes in sub-Saharan Africa is a bibliographical MEDLINE search of published data over the past 2 decades. Diabetes-related cardiovascular disease complications are considered to be rare in Africa but are on the rise and are regularly associated with classic cardiovascular risk factors. Coronary heart disease may affect 5% to 8% of type 2 diabetic patients and cardiomyopathy, up to 50% of all patients. Close to 15% of patients with stroke have diabetes, and up to 5% of diabetic patients present with cerebrovascular accidents at diagnosis. Peripheral vascular disease prevalence varies across sites from 4% to 28%.

Conclusions—It is obvious that diabetes mellitus and related cardiovascular complications are gaining more importance in sub-Saharan Africa. The relative contribution of putative risk factors is not well defined, and further research is therefore needed. (Circulation. 2005;112:3592-3601.)

Key Words: diabetes mellitus ■ cardiovascular diseases ■ complications ■ Africa, south of the Sahara

The global prevalence of all the leading chronic diseases is increasing, with the greatest burden occurring in developing countries, and this is projected to increase substantially over the next 2 decades.1,2 Indeed, cardiovascular disease is already the leading cause of mortality in some developing countries.3 By 2020, mortality from ischemic heart disease in these countries is expected to increase by 120% for women and 137% for men.4 Projections for the next 2 decades include nearly a tripling of ischemic heart disease and stroke mortality in Latin America, the Middle East, and sub-Saharan Africa. Many developing countries and countries in transition have witnessed a rapid deterioration of their chronic disease risk and mortality profiles.5 Noncommunicable diseases have not simply displaced acute infectious diseases in developing countries. Rather, such countries now experience a polarized and protracted double burden of disease.6 In South Africa, infectious diseases account for 28% of years of lives lost, whereas noncommunicable diseases account for 25%.7 The global number of individuals with diabetes in 2000 was estimated to be 171 million (2.8% of the world’s population), a figure projected to increase in 2030 to 366 million (6.5%), 298 million of whom will live in developing countries.8 Type 2 diabetes and its associated long-term complications continue to accelerate among patients who reside in developing countries. Apart from microvascular complications, cardiovascular disease, with its attendant morbidity and mortality, is on the rise in the developing countries.9 Current evidence suggests that environmental factors are major determinants of the increasing rates of diabetes.10 Overweight and obesity are increasing dramatically and contribute to the burden of diabetes and other chronic health conditions. Indeed, the modern environment promotes behaviors that cause obesity.11,12 With the modernization of cultures taking place all over the world, the standard of living and lifestyle in many sub-Saharan African countries, particularly in urban areas, resembles those of many Western countries, with related epidemiological changes. In fact, obesity rates in some urban areas of Africa are already approaching or equaling those of Western countries.13,14 Chronic health problems such as cardiovascular diseases and diabetes have therefore become at least as important as infectious diseases. This article reviews the cardiovascular complications of diabetes in sub-Saharan Africa.
Sources of Data

The data search used in this review was limited to studies published after 1979. This cutoff was chosen because data collected before 1980 may no longer reflect the current situation of diabetes and related cardiovascular complications. The MEDLINE database and the internet were used for literature search, but also, known African diabetes researchers and clinicians were contacted and requested to provide information on the burden of cardiovascular complications of diabetes for their country or subregion. The MEDLINE search was undertaken for diabetes prevalence and for cardiovascular diseases met in Africa. However, there is now evidence to demonstrate an increasing incidence and prevalence of diabetes mellitus in these populations (Table 1). The estimated prevalence of diabetes in Africa is 1% in rural areas, up to 5% to 7% in urban sub-Saharan Africa, and between 8% and 13% in more developed areas such as South Africa and in populations of Indian origin. The annual incidence of type 1 diabetes mellitus varies from 4 to 10 per 100 000 among the 0- to 19-year-old population in Africa, with a high mortality rate. Although the majority of patients (70% to 90%) present with typical type 2 diabetes, up to 25% are considered to have type 1 diabetes. Among the latter group, it is currently estimated that approximately 15% may represent atypical presentations of diabetes, especially type 1B or ketosis-prone atypical diabetes, and tropical diabetes. The risk factors for diabetes are not markedly different from those reported in other populations.

Currently, the population of sub-Saharan Africa is predominantly rural (34% urban), but by 2025, more than 70% of the population will live in the urban areas. Life expectancy at birth in sub-Saharan Africa will increase from 55 years in 2000 to 69 years in 2025, with urban areas gaining more rapidly than rural areas. The population of sub-Saharan Africa is also aging, with a decline in fertility and an increase in life expectancy. The noncommunicable diseases (NCDs) burden is expected to increase in the next two decades. Current NCD mortality in Africa is estimated to be 41% of all deaths, with diabetes being the third leading cause of death in Africa. Table 1. Prevalence Estimates of Diabetes and Socioeconomic Indicators for Year 2000 in Some Sub-Saharan African Countries

<table>
<thead>
<tr>
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<td>7.1</td>
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<td>1.3</td>
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<tr>
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<td>9.6</td>
<td>1352</td>
<td>1.1</td>
<td>2.1</td>
<td>3.2</td>
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<td>1.8</td>
<td>4.1</td>
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<td>2489</td>
<td>3.1</td>
<td>3.3</td>
<td>6.4</td>
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PPP indicates purchasing power parity.

birth is rapidly increasing. In 1960, life expectancy was approximately 35 years in Cameroon, and by 1990, it had risen to approximately 55 years. These gains in many sub-Saharan African countries have been reversed, however, by the HIV/AIDS epidemic. An aging population together with rapid urbanization will lead to an increase in the prevalence of diabetes such that by the year 2025, the majority of the world diabetes population will be living in the developing countries. By 2025, the prevalence of diabetes in sub-Saharan Africa is expected to more than double the current figures.

The classic symptoms of diabetes in Africa, including polyuria and polydipsia, are similar to those seen elsewhere in the world. However, limited access to health care, the insidious course of type 2 diabetes, and late presentation to health facilities lead to more severe illness and diabetic complications at diagnosis. The majority of patients usually present with sepsis and/or acute diabetes decompensation (diabetic ketoacidosis and hyperosmolar nonketotic states), although a minority are asymptomatic and are therefore picked up at screening. In some cohorts, infection is the mode of presentation of diabetes in up to 22% of cases, sometimes with mucormycosis and deep palmar infections that are rarely seen in developed countries. 

Neuropathic symptoms, foot ulcerations, and stroke are frequent presenting problems that lead to the diagnosis of type 2 diabetes. Approximately 20% to 25% of type 2 diabetic patients at diagnosis already have retinopathy.

### Specific Cardiovascular Diseases in Diabetics in Sub-Saharan Africa

Cardiovascular disease has been considered rare in sub-Saharan Africa. However, both population- and hospital-based studies now provide evidence for an increasing burden of cardiovascular disease in sub-Saharan Africa, with diabetes mellitus as a major contributor. Cardiovascular complications of diabetes, particularly the macrovascular varieties, are the result of chronic hyperglycemia in association with classic and putative cardiovascular risk factors. Macrovascular complications tend to affect the heart (coronary artery disease [CAD]), the central nervous system (cerebrovascular disease), and the lower limbs (peripheral vascular disease).

### Coronary Artery Diseases

The lack of diagnostic facilities limits the study of CAD in sub-Saharan Africa. Coronary angiography and myocardial scintigraphy are available only in a few urban health facilities. The prevalence of ischemic heart disease in diabetic subjects on ECG stress testing is between 5% and 8%, a figure that is much lower than that reported in developed countries. Nevertheless, this represents a real increase given that 2 decades ago, ischemic heart disease in the general population was considered to be rare in Africa. A relatively young population, inadequate diagnostic facilities, and death of other causes or before arrival at a health facility may be partly responsible for the relatively low incidence of ischemic heart disease in sub-Saharan Africa.

Diabetes is a strong risk factor for CAD, and the data available suggest that people of black African origin have a higher rate of CAD than does the general population, although limited data are available for the diabetic population (Table 2). The UKPDS study showed that UK Afro-Caribbean subjects with diabetes had a lower risk for myocardial infarction than white subjects after adjustment for conventional cardiovascular risk factors. In the London cohort of the World Health Organization (WHO) study of vascular disease in subjects with diabetes in the United Kingdom, Afro-Caribbean ethnicity was associated with a lower risk of death of ischemic heart disease relative to white subjects (0.4, 0.2 to 0.9) when adjusted for sex but not when also adjusted for smoking. In the United States, the Atherosclerosis Risk in Communities (ARIC) study showed that diabetes in black subjects conferred a lower relative risk of coronary heart disease than it did in nonblack subjects. Nevertheless, the Charleston Heart Study demonstrated that diabetes in black or white subjects did not increase their risk of death of heart disease. However, this finding may have been attributable to the small numbers of subjects with diabetes.

Data available for African populations show that diabetes is present in more than one third of patients presenting with coronary events (Table 3), and ischemic heart disease is present at the clinical onset of diabetes in up to 4.8% of newly diagnosed patients. In a Ghanaian prospective study of 708 subjects with cardiovascular disease presenting to a national...
TABLE 3. Prevalence (%) of Selected Risk Factors in African Populations With Coronary Artery Diseases

<table>
<thead>
<tr>
<th>Population</th>
<th>Sample</th>
<th>M/F</th>
<th>Diabetes</th>
<th>Hypertension</th>
<th>Hyperlipidemia</th>
<th>Obesity</th>
<th>Smoking</th>
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</thead>
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<tr>
<td>Egypt</td>
<td>290</td>
<td>18/1</td>
<td>32.4</td>
<td>46.9</td>
<td>69.7</td>
<td>46.2</td>
<td>66.6</td>
</tr>
<tr>
<td>Ghana</td>
<td>80</td>
<td>1.3/1</td>
<td>22.5</td>
<td>66.3</td>
<td>8.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cameroon</td>
<td>30</td>
<td>6/1</td>
<td>26</td>
<td>60</td>
<td>43</td>
<td>80</td>
<td>36</td>
</tr>
<tr>
<td>Senegal</td>
<td>77</td>
<td>4/1</td>
<td>40</td>
<td>41</td>
<td>46</td>
<td>27</td>
<td>44</td>
</tr>
<tr>
<td>Kenya</td>
<td>169</td>
<td>5.5/1</td>
<td>38.5</td>
<td>65.4</td>
<td>67.3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cardiomyopathy

Cardiomyopathy is a major complication of diabetes. It is characterized by altered myocardial function in the absence of significant CAD or systemic hypertension. The condition is associated with important clinical consequences, such as increased susceptibility to hypertension-mediated damage, an increased mortality rate after acute myocardial infarction, and progression to symptomatic heart failure. Left ventricular hypertrophy and systolic dysfunction that is often asymptomatic and may lead to congestive heart failure have been described in African diabetic patients. Indeed, up to 50% of patients may present with echocardiographic abnormalities. However, appropriate comparison of ventricular indexes with a matched-background population is still lacking.

Cerebrovascular Diseases

Data on cerebrovascular disease are scarce because of the mortality associated with this complication, the low proportion of patients seen in hospitals, and the lack of death certificates or proper records of cause of death. Recent results from the general population of Tanzania, where morbidity and mortality surveillance has been set up, show that stroke mortality was 3- to 6-fold that of England and Wales, with 4.4% of type 2 diabetic patients presenting with stroke at diagnosis of diabetes. Cerebrovascular diseases account for 15.1% of admissions for cardiovascular disorders in Burkina Faso, and diabetes is present in more than 7.3% of this population. More importantly, from a socioeconomic standpoint, 72% of patients have low incomes, and associated risk factors are poorly controlled. Similar figures were reported in Mauritania, with 8% of patients with stroke having documented diabetes. In a cross-sectional study in the Sudanese diabetic population, the prevalence of cerebrovascular disease was found to be 5.5%.

Among 600 African diabetic subjects from Zambia, Rolfe found 7 with stroke. In a prospective study of 50 hypertensive and 54 normotensive type 2 diabetic Nigerians, stroke-associated deaths occurred in 8 subjects (7.6%), and all the stroke-related deaths occurred in the hypertensive group. In a South African study, subjects with diabetes were 3 to 4 times more likely to present with a stroke than nondiabetic subjects. Furthermore, subjects with diabetes were at a greater risk of permanent cerebral ischemia without prior warning of a transient ischemic event than their nondiabetic counterparts.

Peripheral Vascular Diseases

Peripheral vascular disease prevalence in diabetes in sub-Saharan Africa varies from 1.7% to 28% (Table 4). The relatively high prevalence of Doppler-diagnosed vascular lesions (18% to 28%) contrasts with the low clinical (absence of pulses) prevalence of peripheral vascular disease (4.4% to 8.2%). Lower-limb arterial disease contributes to the development of diabetic foot lesions. It is common to see patients with diabetic foot ulcers as the presenting complaint of diabetes in diabetes clinics in sub-Saharan Africa.
publications from Africa in the past 30 years on the diabetic foot. Lower-extremity amputation in diabetic patients varies from 1.5% to 7%, and approximately 12% of patients admitted to hospital have diabetic foot ulcers. In a cohort of 2250 diabetic patients, the mean age of amputation was 37 years in type 1 and 59 years in type 2 diabetic patients. Sepsis is a major cause of the amputation, and it is also the main cause of mortality. Only 20% of patients undergoing amputation have ischemic gangrene.

Determinants of Cardiovascular Diseases in Diabetes in Sub-Saharan Africa

Causes of Increased Prevalence of Diabetes in Africa

Adoption of Western lifestyles has been established as a consistent theme for the rise in diabetes and noncommunicable diseases in sub-Saharan Africa. African populations are also believed to have undergone some genetic changes that make them more prone to developing diabetes. The common elements of “Westernization” include a diet higher in total calories and fat but lower in fiber and less need to expend energy because of labor-saving devices. Various components of diet have been linked to the prevalence and incidence of type 2 diabetes mellitus, even though the exact dietary composition that causes the greatest risk is not absolutely clear. More than 90% of the adult population in sub-Saharan Africa report an absence of or low physical activity at leisure time. Obesity, which is often associated with type 2 diabetes, is more frequent in blacks in the United States and is on the rise in many sub-Saharan African countries. The evolution of a “thrifty genotype” is postulated to have resulted in a selective survival advantage in times of fluctuating plenty and famine by allowing highly efficient storage of calories in times of plenty. However, this thrifty genotype becomes detrimental when food supplies are constant and abundant and is postulated to have led to an increased prevalence of obesity and type 2 diabetes mellitus in certain populations. Information on the influence of socioeconomic status on diabetes is rare. The potential mechanisms of diabetes and cardiovascular diseases have not been fully addressed in sub-Saharan African populations. However, the few available studies suggest that type 2 diabetes results from the interaction between genetic and environmental factors. More importantly, β-cell dysfunctions and glucose intolerance are more prevalent in offspring of type 2 diabetic parents. The progression from nondiabetes to diabetes is marked by 3 defects that antedate the disease: decreased insulin secretion, decreased insulin action, and decreased glucose effectiveness.

Risk Factors for Cardiovascular Complications

The epidemiological and demographic transitions are associated with many changes in the sub-Saharan African population: first, the increasing prevalence of the classic risk factors for CAD, including smoking, diet high in saturated fat,
hypertension, obesity, diabetes mellitus, dyslipidemia, and lack of physical exercise and regularly reported concurrence of multiple risk factors in the same individual (Table 5). Second, life expectancy in sub-Saharan Africa has risen in the past 50 years. Many more people are therefore exposed to these risk factors for long periods for the complications to develop and for them to experience the clinical syndromes of cardiovascular disease.

Diabetic patients, compared with nondiabetics, are at greater risk of CVDs and always have a poor prognosis after cardiovascular events.62 This has prompted the Adult Treatment Panel III to classify diabetes as a coronary heart disease risk equivalent.63 Part of the increased susceptibility is a result of poor glycemic control, but the contribution of other cardiovascular risks factor is well recognized. Many of these factors, including hyperinsulinemia and hypertension, are more prevalent in diabetic patients even in sub-Saharan Africa.64–66 Type 2 diabetes mellitus is associated with a cluster of lipid abnormalities: elevated plasma triglycerides, reduced HDL cholesterol, and smaller and denser LDLs, which have been associated with an increased risk of cardiovascular disease.67 The incidence of hypertension in patients with diabetes is approximately twofold higher than in age-matched subjects without the disease, and conversely, individuals with hypertension are at increased risk of developing diabetes compared with normotensive persons. Furthermore, up to 75% of cases of CVD in patients with diabetes can be attributed to hypertension.68 Hypertension, which has been linked to increased microvascular complications, is high among black persons with diabetes. Limited access to optimal health care might also be expected to influence the occurrence of complications, but this has not been confirmed by the available data.

The importance of emerging cardiovascular risk factors, such as lipoprotein(a), is gradually being recognized. But its role in diabetic patients so far remains controversial. A study in Tunisia has shown that a lipoprotein(a) level higher than 300 mg/L constitutes a coronary risk factor in type 2 diabetes and contributes, with the other lipid disorders, to the increase of the coronary risk factors in diabetes.69 The coexistence of other chronic diabetes complications, such as diabetic nephropathy, is associated with accelerated cardiovascular complications of diabetes. Peripheral vascular disease in Nigeria is present in 51.7% of diabetic patients with renal complications.70

Major Challenges Associated With Cardiovascular Complications of Diabetes in Sub-Saharan Africa

In Sub-Saharan Africa, the increasing noncommunicable disease burden is compounded by lack of a coherent policy on chronic disease prevention, control, surveillance, and research. Furthermore, inadequate financing and inadequate and dwindling numbers of trained healthcare personnel constitute major barriers to the control of diabetes and its complications (Table 1). Other limitations include the failure to provide key decision makers with clear and up-to-date evidence on the burden of diabetes and other chronic diseases, a lack of understanding of the economic factors that

### Table 5. Prevalence (%) of the Different Components of the Metabolic Syndrome in African Populations

<table>
<thead>
<tr>
<th>Country</th>
<th>Diabetes</th>
<th>Hypertension</th>
<th>Central Obesity</th>
<th>Hypercholesterolemia</th>
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<td>6.5</td>
<td>19</td>
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<td>Women</td>
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<td>42</td>
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<tr>
<td>Tanzania (urban)</td>
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<td>6.5</td>
<td>27.1</td>
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<td>4.6</td>
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</tr>
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<td>12.3</td>
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</table>
influence disease risks, and the current orientation of health systems toward acute care.

The economic cost of diabetes and its complications are unaffordable by most individuals and families in sub-Saharan Africa. Their incomes are insufficient to purchase insulin, oral hypoglycemic agents, and other supplies for the management of diabetes. The limited resources available to sub-Saharan African countries are shared between fighting poverty, implementing education strategies, provision of housing and appropriate sanitation, and the socioeconomic and health burden of fighting the increasing incidence and prevalence of HIV/AIDS. Diabetes poses an additional burden on the limited healthcare delivery system and resources. In addition, a structured and organized diabetes healthcare system is often nonexistent. Many people with diabetes are managed by traditional healthcare providers and general practitioners who are inadequately integrated into the primary care system.

Many key decision makers still believe that diabetes and noncommunicable diseases afflict only the affluent and the elderly and arise only from freely acquired risks and that their control is ineffective and too expensive and should wait until control of infectious diseases is addressed. There is this misconception that risk exposure is solely the responsibility of individuals. However, it is well known that sub-Saharan African countries are facing marketing pressure, with risk exposure habits such as smoking, fast foods, and drinking, which is highly promoted among vulnerable groups like children. At a macroeconomic level, it is often assumed that global economic development increases income and subsequently improves all aspects of health in developing countries. Nevertheless, although greater economic investment and higher incomes among some groups have eased some of the health challenges in developing countries, chronic diseases have been exacerbated.

Acute problems, such as certain infectious diseases, and maternal and child care have been the principal focus of healthcare systems. Although infectious diseases continue to be a threat in many sub-Saharan African countries, their health systems now must address a double burden of chronic and acute diseases. The chronic disease management model is more complex than that required for acute problems, such as many infectious diseases. It entails multiple causes over a lifetime and a more horizontal and integrated approach, with the patient, the family, and the community being active participants.

Response to the Challenges

Governments

Many key groups have responded to the infectious disease burdens of developing nations, but the expanded noncommunicable diseases and diabetes burden are yet to benefit from such consideration. At their Summit in 2000, heads of states of the G8 recognized health as a global challenge, acknowledging that health was the “key to prosperity” and that “poor health drives poverty.” Their agreement to mobilize resources ultimately led to the establishment of a global fund for many infectious diseases, including HIV/AIDS, tuberculosis, and malaria. Such commitments are lacking for diabetes and other chronic diseases. The G77, although supporting the framework on tobacco control, has as their main health focus communicable diseases.

WHO and IDF

Control of noncommunicable diseases has been the concern of member states of WHO for almost 50 years, and many of its functions are directly related. However, with the exception of tobacco control, WHO’s financial resources for noncommunicable disease control are small. The International Diabetes Federation (IDF) in 2001 described the cardiovascular complications of diabetes as a “time bomb,” emphasizing the need for urgent preventive action to avoid their global explosion. Cardiovascular diseases were the focal point of the 12th World Diabetes Day, and an entire publication of the IDF was dedicated to CVD. A diabetes declaration and a Strategic Plan for Diabetes in Africa are under preparation at the regional IDF headquarters and will contribute to increased awareness and possible improvement of the management of diabetes and related conditions in Africa.

Research Institutes

Even though still not optimal, there are growing efforts to focus more research on noncommunicable diseases in Africa. The Fogarty International Center has begun to allocate one third of its resources to chronic disease research and training programs in the developing world. Research funding agencies in South Africa are devoting increasing budgetary resources to chronic diseases. Research activities on diabetes, sponsored by international funding bodies like the World Diabetes Foundation, are taking place in some African countries, including Cameroon, Tanzania, Mali, Mozambique, and the Democratic Republic of Congo. Most often, they are not directly related to cardiovascular complications, but there is no doubt that the results will improve the management of diabetes in general. Many funding bodies, via the IDF, are providing continuous medical training in specialized centers to African scientists in diabetes management.

Toward the Future

It is obvious that diabetes mellitus and related cardiovascular complications are becoming more important in sub-Saharan Africa. However, the relative contribution of putative cardiovascular risk factors in the genesis of the complications is yet to be characterized, through further research. It must be noted that each risk factor has the potential to contribute toward the development of complications. While waiting for more evidence from research to become available, effective interventions must be instituted to address the risk factors. Recommendations can be made for primary and secondary prevention activities for high-risk individuals and communities. Furthermore, the growing burden of diabetes mellitus and associated cardiovascular complications in sub-Saharan Africa requires more commitment and effective leadership by policy makers, advocates, and health professionals.
Awareness and Advocacy
Decision makers need to be fully informed with clear and up-to-date evidence about the burden and the impact of diabetes mellitus and its complications. In addition, the advocacy base for diabetes awareness needs to be expanded. Furthermore, gaps in our knowledge about diabetes control in sub-Saharan Africa should be addressed using a "grand challenges initiative."

Controlling Risk Factors for Diabetes and Cardiovascular Diseases
The role of government is critical to the development and implementation of well-grounded risk-factor control programs such as the WHO’s Framework Convention on Tobacco Control, which also has implications for food policies. Approximately 75% of patients with diabetes identified in community surveys in sub-Saharan Africa do not know that they have diabetes. They often have complications at the time of diagnosis; the estimated duration of type 2 diabetes mellitus from onset to diagnosis is 7 years. Wide-spread screening in the general population cannot be encouraged in sub-Saharan Africa. However, targeted screening to identify individuals with high-risk characteristics should be undertaken.

Health System Realignment
Health systems should be realigned to accommodate the diagnosis and primary and secondary prevention of diabetes and its complications in sub-Saharan Africa. Governments need to support this transformation if they are to realize significant health gains. The potential for secondary prevention of cardiovascular disease and diabetes in developing countries has recently been highlighted, but policy needs to be translated into action. We are now at a critical juncture with respect to the global health agenda. Coordinated and focused emphasis on chronic disease is essential to address the enormity of the burden of those who now survive beyond childhood in sub-Saharan Africa.

Disclosures
None.

References


