Published by Oxford University Press on behalf of the International Epidemiological Association
International Journal of Epidemiology 2011;**40**:885–901
doi:10.1093/ije/dyr050

NON-COMMUNICABLE DISEASES

Non-communicable diseases in sub-Saharan Africa: what we know now

Shona Dalal,[1]* Juan Jose Beunza,[1,2] Jimmy Volmink,[3] Clement Adebamowo,[4,5] Francis Bajunirwe,[6] Marina Njelekela,[7] Dariush Mozaffarian,[1,8] Wafaie Fawzi,[1,9] Walter Willett,[9] Hans-Olov Adami[10,11] and Michelle D Holmes[1,12]

[1]Department of Epidemiology, Harvard School of Public Health, Boston, MA, USA, [2]Department of Preventive Medicine and Public Health, University of Navarra, Pamplona, Spain, [3]Faculty of Health Sciences, Stellenbosch University, Stellenbosch, South Africa, [4]Institute of Human Virology, Abuja, Nigeria, [5]School of Medicine Greenbaum Cancer Center and Institute of Human Virology, University of Maryland, Baltimore, MD, USA, [6]Department of Community Health, Mbarara University Of Science and Technology, Mbarara, Uganda, [7]Department of Physiology, Muhimbili University of Health and Allied Sciences, Dar es Salaam, Tanzania, [8]Division of Cardiovascular Medicine, Brigham and Women's Hospital and Harvard Medical School, Boston, MA, USA, [9]Department of Nutrition, Harvard School of Public Health, Boston, MA, USA, [10]Department of Medical Epidemiology and Biostatistics, Karolinska Institutet, Stockholm, Sweden, [11]Dana Farber/Harvard Cancer Center, Boston, MA, USA and [12]Channing Laboratory, Department of Medicine, Brigham and Women's Hospital and Harvard Medical School, Boston, MA, USA

*Corresponding author. Department of Epidemiology, Harvard School of Public Health, 677 Huntington Avenue, Boston, MA 02115, USA. E-mail: sdalal@hsph.harvard.edu

Accepted 22 February 2011

Background Sub-Saharan Africa (SSA) has a disproportionate burden of both infectious and chronic diseases compared with other world regions. Current disease estimates for SSA are based on sparse data, but projections indicate increases in non-communicable diseases (NCDs) caused by demographic and epidemiologic transitions. We review the literature on NCDs in SSA and summarize data from the World Health Organization and International Agency for Research on Cancer on the prevalence and incidence of cardiovascular diseases, diabetes mellitus Type 2, cancer and their risk factors.

Methods We searched the PubMed database for studies on each condition, and included those that were community based, conducted in any SSA country and reported on disease or risk factor prevalence, incidence or mortality.

Results We found few community-based studies and some countries (such as South Africa) were over-represented. The prevalence of NCDs and risk factors varied considerably between countries, urban/rural location and other sub-populations. The prevalence of stroke ranged from 0.07 to 0.3%, diabetes mellitus from 0 to 16%, hypertension from 6 to 48%, obesity from 0.4 to 43% and current smoking from 0.4 to 71%. Hypertension prevalence was consistently similar among men and women, whereas women were more frequently obese and men were more frequently current smokers.

Conclusions The prevalence of NCDs and their risk factors is high in some SSA settings. With the lack of vital statistics systems, epidemiologic studies with a variety of designs (cross-sectional, longitudinal and interventional) capable of in-depth analyses of risk factors could provide a better understanding of NCDs in SSA, and inform health-care policy to mitigate the oncoming NCD epidemic.

Keywords Chronic, cardiovascular, heart, stroke, diabetes, cancer, hypertension, obesity, prevalence, incidence

Introduction

There is a rising epidemic of non-communicable diseases (NCDs) in sub-Saharan Africa (SSA), that includes cardiovascular disease (CVD), cancer and metabolic diseases such as diabetes and obesity.[1–4] Due to the historic focus on maternal–child health and infectious diseases in SSA, much less research has been conducted on NCDs. However, as in other low- and middle-income regions, individuals in SSA suffer from the dual burdens of infectious diseases and NCDs.[5,6]

Far from being diseases exclusively of the wealthy, NCDs are already, and will continue to be, a significant burden on the world's poor. The epidemiological transition from predominantly infectious to NCDs is already well underway in many low- and middle-income countries, as it is in SSA. In 2004, more than half of all deaths in SSA were caused by infectious conditions, and one-quarter by NCDs (Table 1); by 2030, NCDs will cause 46%.[7] Global Burden of Disease studies suggest that the age-standardized death rates from NCDs is higher in at least four SSA countries (Democratic Republic of the Congo, Nigeria, Ethiopia and South Africa) than in high-income countries.[8] A study in Tanzania also showed that death rates from NCDs are higher in all age groups between 15 and 59 years than in high-income countries.[9]

This burgeoning epidemic of NCDs has several root causes. Decreases in communicable diseases, which disproportionately affect children, lead to greater survival into adulthood and a relative aging of the population. This changing demographic profile of the SSA population is an important factor influencing the future incidence of NCDs in Africa. Currently, the population pyramid of most African countries is cone shaped, with a large base of young people and the median age <20 years, compared with high-income countries where it is usually closer to a cylinder and the median age is >40 years. Population dynamics suggest that the at-risk population for NCDs is likely to increase at a significant rate in SSA compared with high-income countries.[10] While age in of itself is important, the relevant exposure is the life-course accumulation of risk factors that is afforded by longevity.[11,12] Even standardized for age, mortality from NCDs in SSA is projected to increase dramatically in the coming years (Figure 1).

Additional drivers of these epidemics are urbanization and changes in lifestyle associated with economic development.[13–15] These include changes in (i) diet, (ii) physical activity, (iii) smoking, (iv) adiposity and (v) alcohol use. In high-income countries, ~90% of all new diabetes mellitus cases and 70–80% of all new CVD cases are attributable to relatively modest differences in these lifestyle factors.[16–18]

Table 1 Estimated causes of death by region in 2004

Cause	SSA *n* (%)	South Asia *n* (%)	Middle East and North Africa *n* (%)	High-income countries *n* (%)
Population	749 269 486	1 493 430 136	324 542 106	949 817 787
Total deaths	11 661 836 (100)	13 778 271 (100)	2 113 931 (100)	8 007 598 (100)
NCDs	2 903 602 (25)	6 657 479 (48)	1 334 101 (63)	6 997 738 (87)
Malignant and other neoplasms	492 547 (4)	954 033 (7)	181 283 (9)	2 145 643 (27)
Diabetes	174 041 (1)	208 024 (2)	38 890 (2)	216 353 (3)
Nutritional/endocrine disorders	68 677 (1)	21 836 (0)	22 212 (1)	73 961 (1)
Neuropsychiatric disorders	130 078 (1)	250 204 (2)	55 333 (3)	449 819 (6)
Cardiovascular diseases	1 232 261 (11)	3 437 866 (25)	732 389 (35)	2 978 127 (37)
Chronic respiratory diseases	314 184 (3)	934 752 (7)	85 315 (4)	470 787 (6)
Other	491 814 (4)	850 763 (6)	218 678 (10)	663 048 (8)
Communicable diseases	6 475 116 (56)	3 993 359 (29)	298 996 (14)	468 308 (6)
Maternal, perinatal, nutritional	1 436 251 12)	1 651 929 (12)	200 145 (9)	51 477 (1)
Injuries	846 866 (7)	1 475 504 (11)	280 689 (13)	490 076 (6)

Source: WHO. Global Burden of Disease. Projections of mortality and burden of disease, 2002–30[7].
NCD, Non-communicable diseases; SSA, sub-Saharan Africa.

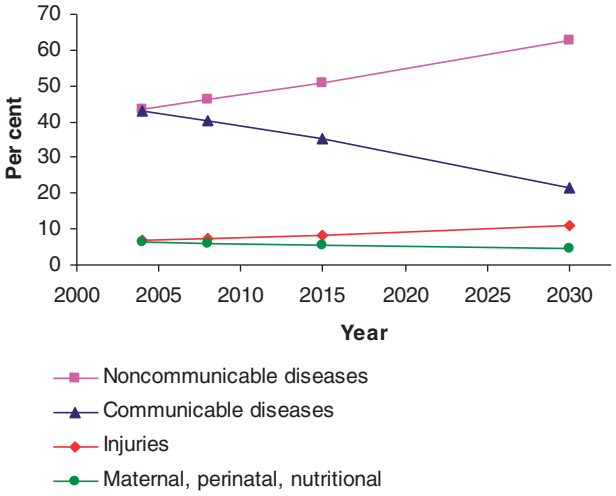

Figure 1 Estimated proportions of age-standardized mortality rates by cause in SSA. SSA mortality estimates were standardized to the WHO World Standard Population. *Source*: WHO. Global Burden of Disease. Projections of mortality and burden of disease, 2002–2030.[7]

Similarly, the INTERHEART study that included nine African nations and 43 other countries found that five risk factors (smoking, hypertension, abdominal obesity, diabetes mellitus and elevated ApoB/ApoA-1 ratio) accounted for 90% of the risk for a first myocardial infarction in the African sites.[14,19]

Other social and environmental changes in SSA also likely play a role such as changes in air quality and early childhood exposures.[15,20] These lead to increased prevalence of NCD risk factors such as hypertension, abdominal obesity and abnormal blood lipids.[1,15,20] If action is not taken, one estimate shows that US$84 billion in lost productivity could occur due to heart disease, stroke and diabetes in the 23 low- and middle-income countries (four of which are in SSA), which would account for 80% of worldwide NCD mortality by 2015.[8]

Thus, NCDs represent a largely 'silent' epidemic in SSA. We review the literature and summarize World Health Organization (WHO), and International Agency for Research on Cancer (IARC) data on NCDs in SSA with the goal of reporting on the burden of NCDs measured by morbidity and mortality and the prevalence of NCD risk factors.

Due to the large scope, we were not able to address neuropsychiatric diseases and chronic lung diseases.

Methods

We searched the Medline database using National Library of Medicine Medical Subject Heading (MeSH) search terms to cover each condition. These were 'heart diseases', 'stroke', 'diabetes mellitus type 2' and 'Neoplasms not Benign Neoplasms' combined with the term 'Africa south of the Sahara'. We used the limit function to limit search results to articles in English and to human studies. In order to identify studies reporting prevalence, incidence and mortality of each condition, we repeated the search excluding review articles (MeSH NOT 'Review'). Data were extracted using a standard form (S.D. extracted data on heart diseases, stroke and cancer, J.J.B. extracted data on diabetes mellitus type 2). We also consulted articles listed in references of retrieved articles and from discussions with colleagues with SSA experience.

Our inclusion criteria were community-based studies conducted in any SSA country that reported on disease or risk factor prevalence, incidence or mortality for each of the key diseases in our investigation (heart diseases, stroke, diabetes mellitus type 2 and cancer). We excluded hospital-based studies as they are not representative of the general population because of widespread lack of health-care access. Hospital-based studies were used to extract data on diabetes mellitus complications. Due to the comparatively small number of studies we did not use criteria for evaluating the quality of the study. We did not restrict our search to specific dates, and made every attempt to obtain older articles (for example, those published in the 1960s and 1970s). We read at a minimum each abstract to screen for relevance, and read in full those which met our inclusion criteria.

We also analysed publicly available WHO Global Burden of Disease and WHO STEPS data sets on estimated and projected causes of death for different world regions and prevalence of diabetes mellitus in SSA. We analysed the International Agency for Research on Cancer (IARC) public databases for cancer incidence and projections for SSA.

Results

Search results for cardiac diseases excluding review papers returned 1494 manuscripts, 1201 of which were in English and limited to human studies dating from 1965. The stroke search yielded 149 manuscripts; 127 met the criteria for language and human studies. Diabetes mellitus search results were 348 overall, with 321 in English and humans. The reported prevalence of heart diseases, stroke and diabetes mellitus from community-based studies are provided in Tables 2–4; all numbers are for crude prevalence unless otherwise noted. Crude and age-standardized cancer incidence from five cancer registries included in the IARC database are presented in Table 7.

Commonly reported risk factors in the literature from community-based studies of CVDs in SSA are reported in Table 5; hypertension, smoking and obesity were the most frequently reported. Half (50%) of these studies were conducted in South Africa. Alcohol use, hypercholesterolaemia and sedentary behaviour were infrequently measured.

Table 2 Literature review of prevalence of heart diseases from community-based studies in SSA

Year	Author	Country	Urban/ Rural	Sample size	Population (age in years)	Outcome	Prevalence (%)	Diagnostic criteria
2008	Mocumbi *et al.*[95]	Mozambique	Rural	1063	Households (22.6)[a]	Endomyocardial fibrosis	20	Echocardiography
2007	Marijon *et al.*[23]	Mozambique	Urban	2170	School children (6–17)	Rheumatic heart disease	3	Echocardiography
2006	Marijon *et al.*[96]	Mozambique	Urban	2170	School children (6–17)	Congenital heart disease	0.2	Echocardiography
1999	Oli, Porteous[97]	Ethiopia	Urban	10 053	School children (10–15)	Rheumatic heart disease	0.6	Echocardiography
1998	Longo-Mbenza *et al.*[98]	DR Congo	Urban	4848	School children (5–16)	Rheumatic heart disease	1.4	Echocardiography
1996	Khalil *et al.*[99]	Sudan	Urban	517	Adults (25–64)	Coronary events	0.1	WHO MONICA
1996	Anabwani, Bonhoeffer[100]	Kenya	Rural	1115	School children (5–15)	Rheumatic heart disease	2.7	Echocardiography
1994	Seedat *et al.*[101]	South Africa	Urban	396	White adults (15–69)	Coronary heart disease	17	Electrocardiography
1992	Ibrahim-Khalil *et al.*[30]	Sudan	Urban	13 332	School children (5–15)	Rheumatic heart disease	1.1	Electrocardiography/X-ray/ Echocardiography
1992	Oli *et al.*[31]	Ethiopia	Rural	3235	School children (13.4)[a]	Rheumatic heart disease	0.5	Examination
1990	Seedat *et al.*[102]	South Africa	Urban	668	Indian adults (15–69)	Coronary heart disease	15.3	Electrocardiography
1989	Anabwani *et al.*[32]	Kenya	Rural	3631	School children (5–15)	Rheumatic heart disease	0.2	Electrocardiography
1984	Rossouw *et al.*[103]	South Africa	Rural	7188	White adults (15–64)	Ischaemic heart disease	18 (m) 13 (f)	Electrocardiography
1979	McLaren *et al.*[104]	South Africa	Urban	12 050	School children (2–18)	Congenital heart disease	0.4	Electrocardiography
1978	Ikeme *et al.*[105]	Ghana	Urban	3745	Adults (15–64)	Cardiovascular events	25	Examination/X-ray/ Electrocardiography
1978	Yazov *et al.*[106]	Ethiopia	Urban	1012	School children (6–20)	Rheumatic heart disease	0.5	Examination/X-ray/ Electrocardiography
1975	McLaren *et al.*[28]	South Africa	Urban	12 050	School children (2–18)	Rheumatic heart disease	0.7	Electrocardiography

DR Congo, Democratic Republic of the Congo; m, male; f, female.
[a]Mean age.

Table 3 Literature review of prevalence of stroke from community-based studies in SSA

Year	Author	Country	Urban/ Rural	Sample Size	Population	Outcome	Prevalence (%)	Diagnostic criteria
2010	Walker *et al.*[35]	Tanzania	Both	216 331	Area residents (all ages)	Stroke incidence	0.1 (u) 0.09 (r)	Q, E, VA
2007	Danesi *et al.*[107]	Nigeria	Urban	13 127	Households (all ages)	Stroke survivor	0.2 (m) 0.07 (f)	Q, E
2004	Connor *et al.*[108]	South Africa	Rural	42 378	Adults ($\geqslant$15 years)	Stroke survivor	0.2 (m) 0.3 (f)	Q, E
2000	Walker *et al.*[109]	Tanzania	Both	11 975	Adults ($\geqslant$15 years)	Stroke mortality	5.5	VA

m, male; f, female; u, urban; r, rural Q, Questionnaire; E, Examination; VA, Verbal Autopsy.

Table 4 Literature review of prevalence of diabetes mellitus from community-based studies in SSA

Year	Author	Country	Population	Urban/ Rural	Sample size	Prevalence (%)	Diagnostic criteria
2003	Nyenwe *et al.*[110]	Nigeria	Adults (>40 years)	Urban	502	6.8 7.7 (m) 5.7 (f) 9.1 (m)[a] 6.3 (f)[a]	WHO (1999) Fasting ($\geqslant$126 mg/dl) + OGTT($\geqslant$200 mg/dl)
2002	Lasky *et al.*[47]	Uganda	Adults (>35 years)	Urban	440	8.1	ADA Fasting ($\geqslant$126 mg/dl) or random ($\geqslant$200 mg/dl)
1999	Levitt *et al.*[111]	South Africa	Adults (>15 years)	Urban	974	10.8[b]	
1997	Ceesay *et al.*[112]	Sierra Leone	Adults ($\geqslant$16 years)	Urban	245	2.4	WHO (1985). Random capillary whole blood $\geqslant$200 mg/dl.
				Rural	256	0	
1997	Mbanya *et al.*[113]	Cameroon	Adults (24–74 years)	Urban	1048	0.9 (m)[b] 0.5 (f)[b]	WHO (1985) Fasting ($\geqslant$140 mg/dl) + OGTT($\geqslant$200 mg/dl)
				Rural	719	0.8 (m)[b] 1.6 (f)[b]	
1993	Levitt *et al.*[48]	South Africa	Adults (>30 years)	Urban	790	8[b]	WHO (1985) Fasting + OGTT
1989	McLarty *et al.*[50]	Tanzania	Adults (>15 years)	Rural	6299	1.1 (m) 0.7 (f) 1.1[a]	WHO (1985) Fasting + OGTT
1987	Teuscher *et al.*[114]	Togo	Area residents	Rural	1381	0	WHO (1985) Random blood + fasting + OGTT
1984	Ahren, Corrigan[115]	Tanzania	Adults ($\geqslant$20 years)	Both Urban Rural	3145	1.6 0.5 1.9	WHO (1980)

m, male; f, female; WHO, World Health Organization; ADA, American Diabetes Association; OGTT, oral glucose tolerance test.
[a]Age adjusted to US population.
[b]Age adjusted to world standard population.

Cardiac diseases

Cardiac diseases and their risk factors are increasing in SSA.[2,13,21] Our review of the literature showed that the prevalence of cardiac diseases, excluding congenital diseases, differed considerably between countries and disease type, ranging from 0.1% for coronary events in Sudan to 20% for endomyocardial fibrosis in rural Mozambique (Table 2). In adults aged $\geqslant$60 years, ischaemic heart disease is already the leading cause of death among men and is second among women.[2] The most important risk factors described in one large case–control study of non-fatal

Table 5 Literature review of prevalence of cardiovascular risk factors from community-based studies in SSA

Year	Author	Country	Urban/ Rural	Sample size	Population (age in years)	Sex[a]	HTN	Obesity	Smoking	DM	Alcohol	HCE	SC
2009	Libhaber *et al.*[116]	South Africa	Urban	377	Adults (>16)		40	43	12	25	22		
2009	Addo *et al.*[92,117]	Ghana	Urban	1015	Civil servants (⩾25)	M		10	6				
						F		36	3				
2008	Cappuccio *et al.*[41]	Eight countries	Both	18 072	Adults (35–64)	M	12–53[b]	0–18					
						F	13–48[b]	1–41[b]					
2008	Addo *et al.*[118]	Ghana	Urban	1015	Civil servants (⩾25)		27[c]						
2008	Pampel[81]	14 countries	Both	1962–7171[b]	Adults (15–49)				8–27[b]				
2008	Barnighausen *et al.*[83]	South Africa	Rural	3574	Adults (25–54)		33	32					
2007	Vorster *et al.*[119]	South Africa	Both	1854	Adults (⩾15)	M			57				
						F			17				
2007	Thorogood *et al.*[120]	South Africa	Rural	402	Adults (>35)	M	44	4[d]	28		58		
						F	42	33[d]	11		13		
2004	Cappuccio *et al.*[121]	Ghana	Both	1013	Adults (40–75)	M	30						
						F	28						
2002	Puoane *et al.*[122]	South Africa	Both	13 827	Adults (⩾15)	M		11					
						F		26					
2001	Njelekela *et al.*[21]	Tanzania	Both	446	Adults (47–57)	M	38	4					
						F	37	22					
1998	Vorster *et al.*[123]	South Africa	Urban	799	Black adults (15–64)	M		7	50				
						F		34	7				
1999	Okesina *et al.*[124]	Nigeria	Rural	500	Area residents (>11)		15	2		3			
1999	Huston *et al.*[125]	Nigeria	Urban	766	Civil servants		19						
1997	Betre *et al.*[126]	Ethiopia	Urban	1436	Young adults (15–24)	M	7	0.7	12		34		
						F		0.6	1				
1995	Mollentze *et al.*[127]	South Africa	Both	1611	Black adults (⩾25)								
					Rural		29			5		13	
					Urban		30			6		6	
1993	Grinbaum *et al.*[128]	DR Congo	Urban	64	Males (20–44)	M	17						
1993	Kitange *et al.*[129]	Tanzania	Both	1467	Young adults (15–19)	M			7	0.3	30		
						F			0.4	0.1			

(continued)

Table 5 Continued

Year	Author	Country	Urban/ Rural	Sample size	Population (age in years)	Sex[a]	HTN	Obesity	Smoking	DM	Alcohol	HCE	SC
1993	Swai *et al.*[130]	Tanzania	Rural	8581	Adults (⩾15)	M	6	0.4	26				
						F	6	1					
1991	Ramaiya *et al.*[131]	Tanzania	Urban	1147	Indian adults (⩾15)		15	13		10			
1991	Steyn *et al.*[132]	South Africa	Urban	986	Black adults (15–64)	M	15		52				
						F	14		8				
1990	Steenkamp *et al.*[133]	South Africa	Rural	7188	White (15–64)	M	25						
						F	27						
1990	Steenkamp *et al.*[134]	South Africa	Rural	6332	White (15–64)							20	
1990	Steyn *et al.*[135]	South Africa	Urban	976	Coloured women (>45)	F	30						
1988	Steenkamp *et al.*[136]	South Africa	Rural	7188	White (15–64)	M			48				
						F			18				
1986	Wyndham *et al.*[137]	South Africa	Urban	3930	White underground miners	M			71				
1985	Steyn *et al.*[138]	South Africa	Urban	976	Coloured adults (15–64)	M	18		56			17	
						F	18		40			17	
1979	Osuntokun *et al.*[139]	Nigeria	Urban	318	Stroke registry (all ages)		68			5			
1978	Yazov *et al.*[106]	Ethiopia	Urban	1012	School children (6–20)								4
1978	Ogunbi *et al.*[29]	Nigeria	Urban	12 755	School children (6–12)								
					Group C								28
					Group G								47
					Betahaemolytic								27
1973	Ikeme *et al.*[140]	Uganda	Rural	412	Adults (⩾45)		34						
1970	Jackson *et al.*[141]	South Africa	Urban	717	Indian Diabetics—Clinic		21	43					
					Community		43	28					
					Non-diabetics		22	15					

DR Congo, Democratic Republic of the Congo; M, male; F, female; HTN, hypertension; DM, diabetes mellitus; HCE, hypercholesterolaemia; SC, *Streptococcus* carrier; Smoking, current smoking; Alcohol, alcohol use.
[a]Where sex is not indicated, result is combined.
[b]Range.
[c]Age adjusted to world standardized population.
[d]Abdominal obesity.

myocardial infarction were diabetes, hypertension, abdominal obesity, smoking and abnormal blood lipids, accounting for 90% of the population attributable fraction.[14] The behavioural and social determinants of these risk factors are also important. Higher income, education, urban living and psychosocial stress each appear to be associated with increased risk of myocardial infarction or its risk factors in SSA.[13,14,22] However, the underlying determinants of these changes are poorly quantified in most SSA countries (Table 5).

While few non-hospital-based studies of cardiac disease risk factors in adults have been conducted in SSA, hypertension prevalence ranged from 6 to 48% overall, and was high in both urban and rural South Africa (Table 5). In both urban and rural locations of Tanzania, Nigeria and Ghana hypertension was in double digits, and in the Democratic Republic of Congo was in an urban setting. Obesity ranged from 0.4% in rural Tanzania to 34% among Black South African women. Smoking prevalence is high among adults in South Africa, ranging from 28 to 71% among men and 7 to 40% among women in studies reporting values for the general population or different sub-populations. Although other countries reported lower smoking prevalence, in Ethiopia and rural Tanzania it was 12 and 26% among men (Table 5). These figures of disparate and likely increasing prevalence of NCD risk factors could be illustrative of changing situations that may be occurring among other groups and in other countries, but for which there is not reliable data.

Africa is additionally burdened by rheumatic heart disease, HIV and other infections that impact cardiovascular outcomes.[23–25] For example, while tuberculosis accounts for <5% of cases of pericarditis in high-income countries, it causes >50% of cases in low- and middle-income countries,[26] and its incidence is rising sharply due to the HIV epidemic.[24] Of all childhood rheumatic heart disease cases worldwide, 42% occur in SSA.[27] Large studies of school children conducted in many SSA countries since the 1970s have shown prevalence of rheumatic heart disease ranging from 0.2 to 3%.[23,28–32] Yet, few countries collect systematic data needed to track trends and although gaining attention, there are few prevention programmes.[25,27]

Stroke

Compared with individuals in high-income countries, there are reports that stroke disproportionately affects Africans with more individuals affected, and at younger ages.[4,33,34] Stroke prevalence differs between African countries and ethnic groups, possibly due to their differing stages in the epidemiologic transition, lifestyle factors and health-care access.[4] Stroke studies from SSA have been largely hospital based,[4,34] apart from the few studies we list in Table 3. In one large study, age-standardized incidence of stroke in rural Tanzania was similar to that seen in high-income countries, and in the urban location was higher than among African Americans in Manhattan.[35]

The high rates of stroke appear related, at least in part, to both high rates of hypertension and its poor treatment and control in SSA. Hypertension is the most important predictor of stroke in SSA, accounting for 51% of the population attributable fraction.[33] One systematic review of 25 studies conducted in 10 SSA countries found that the prevalence of hypertension ranged from 6 to 16%, and was consistently higher in urban areas.[36] We found that hypertension prevalence reported in community-based studies ranged from 6% in rural Tanzania to 68% in a Nigerian stroke registry, and was similar among both men and women (Table 5). Although it is higher among older age groups[36], prevalence ranges from 6 to 22% in South Africa and Ghana have been reported in children, similar to those in the USA and Europe.[37] Several risk factors may be related to hypertension in SSA. Reports of higher sodium intake and salt sensitivity among Black populations need further examination.[38–40] Body mass index (BMI), increasing in SSA, showed varying associations with elevated blood pressure.[41] Awareness and treatment for hypertension are low. In one review, the majority of persons with clinical hypertension had not been previously diagnosed, and of those who had been diagnosed, only 30% were currently on treatment.[36] Treatment studies are currently lacking.

Overweight, obesity and diabetes mellitus

In SSA, there is a complex relationship between underweight and overweight. In South Africa, the prevalence of underweight, stunting and wasting in children is 9, 23 and 3%, respectively.[42] Yet community studies have found approximately one-third of adult women to be obese (Table 5). Other countries such as Nigeria, Ethiopia and Tanzania show lower obesity prevalence (Table 5). Abdominal obesity contributes significantly to CVD in the region.[14]

Diabetes prevalence in Africa varies widely among regions, countries, populations, methods and diagnostic criteria (Table 4). Community directly measured prevalence ranges from 2.5% in STEPS-Seychelles to 16% in STEPS-DRCongo.[43] In rural settings alone, values range from 0% in Togo or Sierra Leona, to 1.9% in STEPS-Algeria. Urban values range from 2.4% in Sierra Leona, to 8.1% in Uganda. There were an estimated 10.8 million diabetic Africans in 2006.[44–48] However, this is likely under-estimated since some rural screening programmes found that up to 85% of cases were undiagnosed.[49,50]

Complications of poorly treated diabetes are common in SSA (Table 6). Prevalence of retinopathy among diabetic patients ranges from 14[51] to 46%[52], and up to 25% have retinopathy at diagnosis.[58] Nephropathy is present in 8[51] to 49%[53] of diabetic

Table 6 Prevalence of complications and risk factors associated with diabetes mellitus from hospital- and community-based studies in SSA

Year	Author	Country	Sample size	CHD	Dfoot	Retino	Nephro	Neuro	HTN	Dyslip	Overweight	Obesity
2010	Kamara, Asiimwe[142]	Uganda	150							52		
2008	Okafor *et al.*[143]	Nigeria	192							89		
2007	Lutale *et al.*[144]	Tanzania	153				10					
2007	Choukem *et al.*[145]	Cameroon	210						67			
2007	Kalk, Joffe[146]	South Africa	448	4								
2006	Siraj *et al.*[147]	Ethiopia	92							47		
2005	Otieno *et al.*[148]	Kenya	211						50	75		
2005	Mwendwa *et al.*[149]	Kenya	100					28	50	40		66
2005	Isezuo, Ezunu [150]	Nigeria	254	2			45		54	72		43
2004	Seyum *et al.*[57]	Eritrea	28 500		14	33			55			
2004	Fadupin *et al.*[151]	Nigeria	212								83	
2004	Agaba *et al.*[53]	Nigeria	99				49					
2004	Makuyana *et al.*[152]	Zimbabwe	109						80	32		32
2004	Alebiosu, Odusan[154]	Nigeria	218						39			
2003	Seyoum *et al.*[155]	Ethiopia	302							16		
2003	Alebiosu, *et al.*[156]	Nigeria	465				41					
2002	Neuhann *et al.*[51]	Tanzania	474		10	14	8	44	25		50	
2002	Wanjohi *et al.*[157]	Kenya	100				26		50			
2002	Rotchford *et al.*[56]	South Africa	253		6	40	46		65			37
2001	Seyoum *et al.*[153]	Ethiopia	303			38						
2001	Ikem *et al.*[158]	Nigeria	132						42			
2000	Ahmed *et al.*[55]	Sudan	120					66				
1997	Rahlenbeck, Gebre-Yohannes[159]	Ethiopia	170				37					
1995	Mugusi *et al.*[160]	Tanzania	146						29			
1995	Ahmed, Elmahadi[161]	Sudan	377						44			34
1993	Lester[54]	Ethiopia	1386			15	9	11	24			
1991	Lester[52]	Ethiopia	1699			46	30	36				
1991	Elmahdi *et al.*[162]	Sudan	413	5		17	9	32				
1988	Rolfe *et al.*[163]	Zambia	600					31				
1988	Rolfe[164]	Zambia	600				24					
1986	Akintewe, Adetuyibi[165]	Nigeria	675						27			29
1983	Lester[166]	Ethiopia	105			38	30	47				

CHD, coronary heart disease; Dfoot, diabetic foot; Retino, retinopathy; Nephro, nephropathy; Neuro, neuropathy; HTN, hypertension; Dyslip, dyslipidaemia

patients, neuropathy in 11[54] to 66%[55] and diabetic foot in 6[56] to 14%[57]. Advanced peripheral organ damage and its interaction with infections could explain why 53% of diabetic patients admitted with diabetic foot ulcer to a Lagos hospital died during admission.[63] Finally, the prevalence of risk factors present in diabetic patients (from hospital cross-sectional studies in Table 6) are hypertension (range 24–80%), dyslypidemia (range 16–89%), overweight (range 50–83%) and obesity (29–66%).

Two characteristics of diabetes in SSA add to its morbidity and mortality. Firstly, the lack of health resources leads to late diagnosis[58,59] and severe vascular complications[60]. Secondly, there is generally poor blood glucose control. Frequent hypoglycaemic and hyperglycaemic episodes occur with irregular meals among poor populations.[61] Prevalence is predicted to increase 80% in 20 years, and the number of affected individuals is expected to reach 18.7 million by 2025.[44] Studies from Tanzania and Cameroon

showed up to a 10-fold increase in diabetes prevalence during the last 10 years.[62,64]

Cancer

Projections for cancer incidence from 2010 to 2030 in SSA show steep increases across all ages (Figure 2). This rise over the coming years will be due to population aging, increases in smoking and obesity, changes in reproductive patterns and the HIV epidemic, which has increased the incidence of Kaposi's sarcoma (KS) for example, by up to 20 times.[3,65,66] Furthermore, WHO data show that the proportion of total cancer deaths is expected to more than double in 20 years.[7] However, we lack an understanding of the true burden and incidence of cancer in SSA. The most recent cancer incidence data from the WHO/IARC database[67] only contains information from five African countries: Egypt, Algeria, Tunisia, Uganda and Zimbabwe (Table 7), and cancer registries cover only 11% of the population overall.[3]

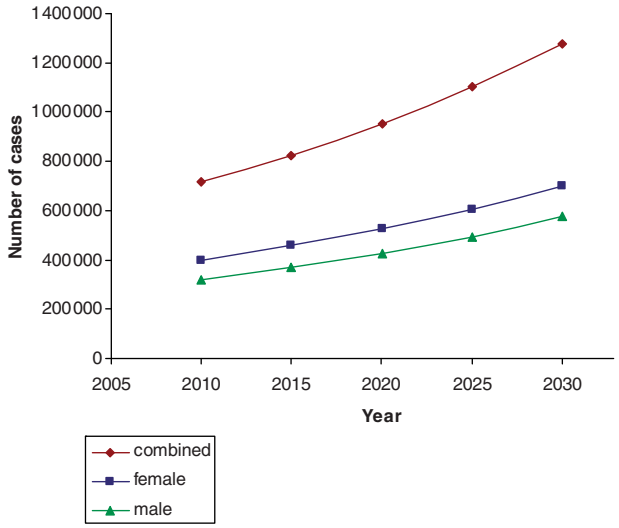

Figure 2 Projections for cancer incidence in Africa among all ages for all cancers excluding non-melanoma skin cancer. *Source*: GLOBOCAN 2008 (IARC).[67]

The cancer types with the highest incidence in Africa are breast, cervix, liver and prostate (Figure 3), although no data were reported for KS. Furthermore, mortality was high. In Africa, 80% of women with breast cancer present at advanced stages;[65] in high-income countries only ~15% do so.[68] Among women in Africa, the lifetime risk of dying from cancer is almost double that of women in high-income countries.[3] Yet, in SSA there is widespread lack of awareness, and access to screening, diagnosis and treatment.[65,69] Research so far has indicated that family history, socio-economic status, geography, race, high BMI, reproductive and hormonal factors are related to breast cancer risk in Africa, but diet does not appear to be.[3,65,70,71] Increased tobacco use will likely increase the incidence of tobacco-related cancers such as lung, oral, oesophagus, pancreas, kidney and bladder, as well as chronic obstructive pulmonary disease (COPD).

Over one-third of cancers in Africa are related to infectious conditions, double the average for the rest of the world.[3] Other known risk factors include Aflatoxin B1, a liver carcinogen produced by molds that commonly contaminates stored staple foods,[65,72] and endemic malaria associated with Burkitt's lymphoma.[3,73]

Despite the projected increases in cancer incidence, Africa has the lowest number of per capita radiotherapy facilities in the world.[65,68] Thirty-three African countries representing a population of 177 million persons have no access to radiotherapy.[68]

Discussion

NCD research in SSA has been negligible compared with that conducted in high-income countries, and the vast majority of published studies have been conducted in hospital or clinic settings. Our search of the literature for studies on prevalence or incidence for heart diseases, stroke, diabetes mellitus type 2, cancer and their risk factors documented results from only 13 of 45 SSA countries. Nevertheless, indications from some community-based studies are that NCDs and their risk factors have high prevalence in

Table 7 Crude and age-standardized cancer incidence rate per 100 000 from cancer registries in Africa, 1998–2002

	Male			Female		
Country	Cases	Crude rate	ASR	Cases	Crude rate	ASR
Tunisia, Centre, Sousse	1512	120.7	159.6	1 093	89.5	106
Zimbabwe, Harare	4435	102.2	205.5	3 866	89	199.4
Egypt, Gharbiah	7170	96.5	162.9	6 765	93.5	121.8
Uganda, Kyadondo (Kampala)	2223	60.6	157.5	2 810	70.9	173.5
Algeria, Setif Wilaya	1998	58.4	94	1 912	56.2	84.7

ASR, age-standardized rate; standardized to world population. All data were reported between 1998–2002 with the exception of Egypt, which was from 1999–2002.[67].

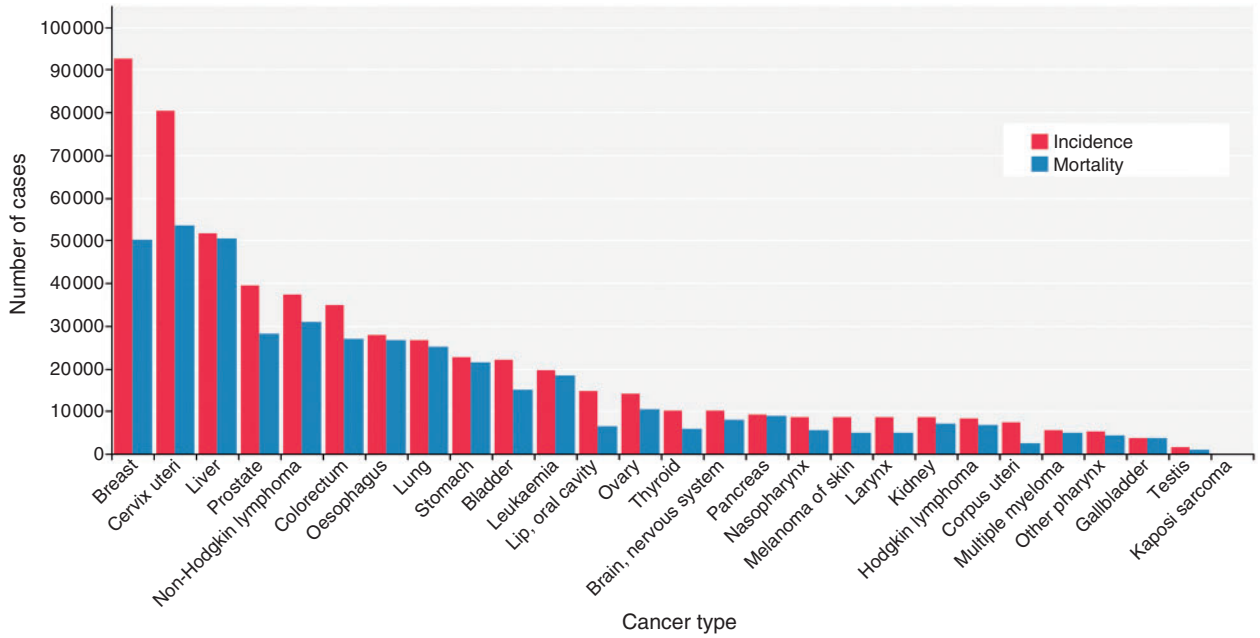

Figure 3 Cancer incidence and mortality in Africa for both sexes by cancer type. *Source*: GLOBOCAN 2008 (IARC).[67]

SSA. The scarcity of this research is likely due to a lack of funding from international organizations, institutions and local governments, as well as a shortage of scientific training and capacity in the core sciences of public health.[74–76] We conclude that action is urgently needed to mitigate the burgeoning epidemic of NCDs in Africa. Because resources for treatment will remain hugely inadequate for the foreseeable future, only primary prevention can protect public health, thereby allowing continued economic development. A wealth of evidence is ready for immediate implementation, such as hepatitis-B and HPV vaccination, tobacco control and comprehensive programmes to prevent obesity. In addition, large-scale research programmes need to investigate the specific causes—environmental and genetic—of NCDs on this gigantic, diverse continent, which is undergoing a rapid transition in lifestyle.

Country-specific estimates of morbidity and mortality due to different risk factors and diseases are invaluable for indicating disease trends and prioritizing the allocation of limited resources. Accurate and reliable assessments on the causes of death at a population level are made difficult by the low access to heath-care services in many SSA countries. Compounding this is a lack of comprehensive, community- or population-based studies on NCDs, their risk factors and etiology. Estimates for SSA compiled by the WHO are often based on very limited data.[5,77] Currently, only sparse data on NCD risk factors such as tobacco use, physical activity, dietary quality and quantity, environmental and social risk factors, early childhood exposures, adiposity, hypertension and lipid levels are available for the region.[1,5,6,21,36,65,78,79]

Nationally representative cross-sectional demographic and health surveys (DHS) are conducted in several SSA countries every 5 years, and some have collected data relevant to NCDs.[80,81] Similarly, community-based longitudinal demographic surveillance sites (DSS), which exist in 12 African nations, collect NCD data in addition to their standard information on births, deaths by verbal autopsy and migrations of defined populations.[82–84] Both the size and national representativeness of these and epidemiologic studies has varied widely, but have provided important information on changes in the major causes of death and indications of disease trends.[14,21,34,36,84,85] For example, data from one DSS cohort in South Africa showed that four of the top five most common causes of death in adults $\geqslant 50$ years are non-communicable conditions.[84] The WHO STEPwise approach to surveillance has attempted to make data on NCDs comparable across countries by supporting standardized questions and protocols to monitor trends. Questionnaires have both short and longer versions and leave flexibility for country-specific information.[86]

Limitations of our review are that our inclusion criteria for manuscripts to those published in English may have missed studies that presented results in another language (notably French or Portuguese). Additionally, we used only the PubMed database for our search which may have excluded publications which were not in this database. Despite these limitations we feel that the data we have presented reflect the comparatively sparse data for NCDs in SSA, although for some countries (e.g. South Africa) good quality data from multiple studies in the community exist.

Addressing the NCD epidemic in SSA

The simultaneous infectious and NCD burden in SSA, as well as lifestyle, cultural and genetic differences, mean that results from high-income countries cannot be applied indiscriminately to the African context.[87] In the absence of vital statistics systems, epidemiologic studies with a variety of designs and capable of in-depth analyses of risk factors and the effects of interventions could provide a better understanding of NCDs in SSA, and provide information critical to health-care policy decision making.[75]

Research priorities for the region should include: (i) better quantification of the NCD burden; (ii) aetiologic evidence for locally important risk factors; (iii) identification of successful interventions for low-income settings; and (iv) the use of innovative technologies to spur research, interventions and treatment. There is a clear need for a comprehensive investigation of the true incidence of CVD, cancer, diabetes mellitus and their risk factors in SSA. Studies conducted in communities rather than in hospitals will provide more accurate estimations by taking into account the population who do not access health services.

Aetiologic studies that examine the relative importance of known and yet unknown risk factors are urgently needed, as they would expand our evidence base for defining at-risk populations and for designing effective primary prevention and treatment programmes. The high prevalence of communicable diseases in SSA presents a unique opportunity to study the interactions between communicable and NCDs, such as the impact of chronic infection on the incidence of NCDs. Furthermore, discoveries made in SSA on environmental and genetic causes of NCDs could have broader global relevance.[87]

Increased diagnoses of NCDs will lead to a corresponding need for health services capacity, which are currently over-stretched, to diagnose and treat these conditions, and for aggressive primary prevention programmes, as late diagnoses lead to poorer health outcomes. Intervention trials for both prevention and treatment of NCDs could further provide data for local priority setting. For example, a community-based trial in Ghana to reduce salt intake resulted in decreased systolic blood pressure, and could be explored more widely.[88] Treatment options for cancer in particular are limited in SSA. Radiotherapy is indicated for 55% of new cancer cases in Africa,[68] but is often unavailable, or prohibitively expensive. In one small study in Nigeria, the few patients who could afford cervical cancer treatment spent almost 30% of their annual income on it.[89]

Thus, primary prevention may be the best way of reducing cancer's burden in SSA. In countries with WHO data, negligible proportions of women have had mammography or PAP smears.[79] Increasing access to Hepatitis B vaccination,[65] Human Papilloma Virus (HPV) testing,[90] HPV vaccination when affordable[91] and ensuring blood and injection safety are important for cancer prevention. Growing awareness, legislative measures (e.g. tobacco taxation) and health promoting messages can encourage healthy behaviour and could attenuate rising cancer incidence in SSA. One study among Ghanaian civil servants found a decrease in smoking prevalence among both men (from 32 to 6%) and women (from 6 to 3%) between 1976 and 2006.[92]

The use of innovative technologies for research, interventions and programme implementation could simplify and facilitate NCD research in SSA. For example, cell phone technology has rapid penetration in the African continent[93] and untapped potential to access influential social networks for beneficial public health messages. The ease and value of this communication has reached the most remote rural villages, even those without electricity. The application of cell phone technology to public health is only nascent and has far-reaching possibilities. Cell phones have been used to help children with diabetes track their glucose levels, physical activity and food intake—in a randomized trial those with the cell phone intervention had better diabetes knowledge and less hyperglycemia than controls.[94] Adoption of healthy behaviour patterns may most effectively occur through reinforcing health-conscious social networks, and with the capacity to easily reach millions of users, there is the potential to easily, quickly and flexibly test many randomized interventions.

Training in all fields of health sciences is urgently needed in SSA. A secondary advantage of conducting epidemiologic research is the scientific training and capacity building that it engenders. Operations research and training, and improved, integrated service delivery should ideally be developed in tandem with epidemiologic research to provide a holistic approach to addressing the myriad, often interacting, communicable and non-communicable conditions in SSA.

In conclusion, the prevalence of NCDs in SSA is high even with probable under-reporting, and will certainly increase in coming years. SSA is at a unique juncture in history where opposites such as infectious and chronic conditions, starvation and overweight, subsistence farming and economic development co-exist. We believe that proactive thinking is essential in order to mitigate the effects of this burgeoning epidemic, and to provide critical data for formulating evidence-based health policy and interventions. Epidemiologic studies that accurately measure disease prevalence, incidence, aetiology, and effective prevention and treatment methods will provide not only much needed public health information for SSA, but could help towards building a strong, sustainable, scientific base for training the next generation of African public health scientists.

Funding

This work was supported by the Dean s Office of the Harvard School of Public Health. The funder played no role in the decision to submit the article or in its preparation. Dr. Beunza was supported by a La Caixa Fellowship.

Conflict of interest: None declared.

KEY MESSAGES

- Available data and projections indicate that the burden of NCDs such as cardiovascular diseases, diabetes mellitus type 2 and cancer is growing in SSA. Yet, there are few community-based studies that examine the NCD prevalence, incidence and risk factors.
- In some African settings the prevalence of NCDs and their risk factors is similar to that seen in developed countries.
- More research is needed in Africa to provide evidence for NCD prevention and treatment to mitigate the oncoming epidemic.

References

[1] Ezzati M, Vander Hoorn S, Lawes CM *et al*. Rethinking the 'diseases of affluence' paradigm: global patterns of nutritional risks in relation to economic development. *PLoS Med* 2005;**2:**e133.

[2] Mensah GA. Ischaemic heart disease in Africa. *Heart* 2008;**94:**836–43.

[3] Parkin DM, Sitas F, Chirenje M *et al*. Cancer in indigenous Africans—burden, distribution and trends. *Lancet Oncol* 2008;**9:**683–92.

[4] Connor MD, Walker R, Modi G, Warlow CP. Burden of stroke in black populations in sub-Saharan Africa. *Lancet Neurol* 2007;**6:**269–78.

[5] Mathers CD, Loncar D. Projections of global mortality and burden of disease from 2002 to 2030. *PLoS Med* 2006;**3:**e442.

[6] Lopez AD, Mathers CD, Ezzati M, Jamison DT, Murray CJ. Global and regional burden of disease and risk factors, 2001: systematic analysis of population health data. *Lancet* 2006;**367:**1747–57.

[7] World Health Organization. *Global Burden of Disease. Projections of mortality and burden of disease, 2002–2030*. http://www.who.int/topics/global_burden_of_disease/en/. (13 May 2009, date last accessed).

[8] Abegunde DO, Mathers CD, Adam T, Ortegon M, Strong K. The burden and costs of chronic diseases in low-income and middle-income countries. *Lancet* 2007;**370:**1929–38.

[9] Unwin N, Setel P, Rashid S *et al*. Noncommunicable diseases in sub-Saharan Africa: where do they feature in the health research agenda? *Bull World Health Organ* 2001;**79:**947–53.

[10] Tourlouki E, Matalas AL, Panagiotakos DB. Dietary habits and cardiovascular disease risk in middle-aged and elderly populations: a review of evidence. *Clin Interv Aging* 2009;**4:**319–30.

[11] Fries JF. Frailty, heart disease, and stroke: the compression of morbidity paradigm. *Am J Prev Med* 2005; **29(5 Suppl 1):**164–68.

[12] Fuster V, Kelly BB (eds). *Promoting cardiovascular health in the developing world: A critical challenge to achieve global health*. Washington, DC: The National Academies Press, 2010.

[13] Vorster HH. The emergence of cardiovascular disease during urbanisation of Africans. *Public Health Nutr* 2002;**5:**239–43.

[14] Steyn K, Sliwa K, Hawken S *et al*. Risk factors associated with myocardial infarction in Africa: the INTERHEART Africa study. *Circulation* 2005;**112:**3554–61.

[15] Adeyi O, Smith O, Robles S. World Bank. *Public policy and the challenge of chronic noncommunicable diseases*. Washington, DC: World Bank, 2007.

[16] Hu FB, Manson JE, Stampfer MJ *et al*. Diet, lifestyle, and the risk of type 2 diabetes mellitus in women. *N Engl J Med* 2001;**345:**790–97.

[17] Mozaffarian D, Kamineni A, Carnethon M, Djoussé L, Mukamal KJ, Siscovick DS. Lifestyle risk factors and new-onset diabetes mellitus in older adults: the cardiovascular health study. *Arch Intern Med* 2009; in press.

[18] Stampfer MJ, Hu FB, Manson JE, Rimm EB, Willett WC. Primary prevention of coronary heart disease in women through diet and lifestyle. *N Engl J Med* 2000;**343:**16–22.

[19] Yusuf S, Hawken S, Ounpuu S *et al*. Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study. *Lancet* 2004;**364:**937–52.

[20] Mayosi BM, Flisher AJ, Lalloo UG, Sitas F, Tollman SM, Bradshaw D. The burden of non-communicable diseases in South Africa. *Lancet* 2009;**374:**934–47.

[21] Njelekela M, Negishi H, Nara Y *et al*. Cardiovascular risk factors in Tanzania: a revisit. *Acta Trop* 2001;**79:** 231–39.

[22] Rosengren A, Hawken S, Ounpuu S *et al*. Association of psychosocial risk factors with risk of acute myocardial infarction in 11119 cases and 13648 controls from 52 countries (the INTERHEART study): case-control study. *Lancet* 2004;**364:**953–62.

[23] Marijon E, Ou P, Celermajer DS *et al*. Prevalence of rheumatic heart disease detected by echocardiographic screening. *N Engl J Med* 2007;**357:**470–76.

[24] Ntsekhe M, Hakim J. Impact of human immunodeficiency virus infection on cardiovascular disease in Africa. *Circulation* 2005;**112:**3602–7.

[25] Tibazarwa KB, Volmink JA, Mayosi BM. Incidence of acute rheumatic fever in the world: a systematic review of population-based studies. *Heart* 2008;**94:** 1534–40.

[26] Magula NP, Mayosi BM. Cardiac involvement in HIV-infected people living in Africa: a review. *Cardiovasc J S Afr* 2003;**14:**231–37.

[27] Nkomo VT. Epidemiology and prevention of valvular heart diseases and infective endocarditis in Africa. *Heart* 2007;**93:**1510–19.

[28] McLaren MJ, Hawkins DM, Koornhof HJ *et al*. Epidemiology of rheumatic heart disease in black shcool-children of Soweto, Johannesburg. *Br Med J* 1975;**3:** 474–78.

[29] Ogunbi O, Fadahunsi HO, Ahmed I *et al*. An epidemiological study of rheumatic fever and rheumatic heart disease in Lagos. *J Epidemiol Commun Health* 1978;**32:** 68–71.

[30] Ibrahim-Khalil S, Elhag M, Ali E *et al*. An epidemiological survey of rheumatic fever and rheumatic heart disease in Sahafa Town, Sudan. *J Epidemiol Commun Health* 1992;**46:**477–79.

[31] Oli K, Tekle-Haimanot R, Forsgren L, Ekstedt J. Rheumatic heart disease prevalence among schoolchildren of an Ethiopian rural town. *Cardiology* 1992;**80:** 152–55.

[32] Anabwani GM, Amoa AB, Muita AK. Epidemiology of rheumatic heart disease among primary school children in western Kenya. *Int J Cardiol* 1989;**23:**249–52.

[33] Mensah GA. Epidemiology of stroke and high blood pressure in Africa. *Heart* 2008;**94:**697–705.

[34] Kengne AP, Anderson CS. The neglected burden of stroke in Sub-Saharan Africa. *Int J Stroke* 2006;**1:**180–90.

[35] Walker R, Whiting D, Unwin N *et al*. Stroke incidence in rural and urban Tanzania: a prospective, community-based study. *Lancet Neurol* 2010;**9:**786–92.

[36] Addo J, Smeeth L, Leon DA. Hypertension in sub-Saharan Africa: a systematic review. *Hypertension* 2007;**50:**1012–18.

[37] Monyeki K, Kemper H. The risk factors for elevated blood pressure and how to address cardiovascular risk factors: a review in paediatric populations. *J Hum Hypertens* 2008;**22:**450–59.

[38] Opie LH. Heart disease in Africa. *Lancet* 2006;**368:**449–50.

[39] Opie LH, Seedat YK. Hypertension in sub-Saharan African populations. *Circulation* 2005;**112:**3562–68.

[40] MacMahon S, Alderman MH, Lindholm LH, Liu L, Sanchez RA, Seedat YK. Blood-pressure-related disease is a global health priority. *Lancet* 2008;**371:**1480–82.

[41] Cappuccio FP, Kerry SM, Adeyemo A *et al*. Body size and blood pressure: an analysis of Africans and the African diaspora. *Epidemiology* 2008;**19:**38–46.

[42] Nesamvuni A, Labadarios D, Steyn N *et al*. The anthropometric status of children aged 1-9 years in South Africa: the national food consumption survey, 1999. *South African J Clin Nutr* 2000;**13:**99.

[43] World Health Organization. *STEPS Country Report*. http://www.who.int/chp.steps/reports/en. (15 June 2010, date last accessed).

[44] *International Diabetes Federation IDF- Diabetes Atlas regional overview (Africa)*. 2009. http://www.diabetesatlas.org/content/regional-overview (20 April 2009, date last accessed).

[45] Motala AA, Omar MA, Pirie FJ. Diabetes in Africa. Epidemiology of type 1 and type 2 diabetes in Africa. *J Cardiovascular Risk* 2003;**10:**77–83.

[46] Sobngwi E, Mauvais-Jarvis F, Vexiau P, Mbanya JC, Gautier JF. Diabetes in Africans. Part 1: epidemiology and clinical specificities. *Diabetes Metab* 2001;**27:**628–34.

[47] Lasky D, Becerra E, Boto W, Otim M, Ntambi J. Obesity and gender differences in the risk of type 2 diabetes mellitus in Uganda. *Nutrition* 2002;**18:**417–21.

[48] Levitt NS, Katzenellenbogen JM, Bradshaw D, Hoffman MN, Bonnici F. The prevalence and identification of risk factors for NIDDM in urban Africans in Cape Town, South Africa. *Diabetes care* 1993;**16:**1–7.

[49] Motala AA, Esterhuizen T, Gouws E, Pirie FJ, Omar MA. Diabetes and other disorders of glycemia in a rural South African community: prevalence and associated risk factors. *Diabetes care* 2008;**31:**1783–88.

[50] McLarty DG, Swai AB, Kitange HM *et al*. Prevalence of diabetes and impaired glucose tolerance in rural Tanzania. *Lancet* 1989;**1:**871–75.

[51] Neuhann HF, Warter-Neuhann C, Lyaruu I, Msuya L. Diabetes care in Kilimanjaro region: clinical presentation and problems of patients of the diabetes clinic at the regional referral hospital-an inventory before structured intervention. *Diabet Med* 2002;**19:**509–13.

[52] Lester FT. Clinical status of Ethiopian diabetic patients after 20 years of diabetes. *Diabet Med* 1991;**8:** 272–76.

[53] Agaba EI, Agaba PA, Puepet FH. Prevalence of microalbuminuria in newly diagnosed type 2 diabetic patients in Jos Nigeria. *Afr J Med Med Sci* 2004;**33:**19–22.

[54] Lester FT. Clinical features, complications and mortality in type 2 (non-insulin dependent) diabetic patients in Addis Abeba, Ethiopia, 1976–1990. *Ethiopian Med J* 1993;**31:**109–26.

[55] Ahmed A, Hussein A, Ahmed N. Diabetic autonomic neuropathy. *Saudi Med J* 2000;**21:**1034–37.

[56] Rotchford AP, Rotchford KM. Diabetes in rural South Africa–an assessment of care and complications. *S Afr Med J* 2002;**92:**536–41.

[57] Seyum B, Mebrahtu G, Usman A *et al*. Profile of patients with diabetes in Eritrea: results of first phase registry analyses. *Acta Diabetol* 2010;**47:**23–27.

[58] Harris MI. Undiagnosed NIDDM: clinical and public health issues. *Diabetes Care* 1993;**16:**642–52.

[59] Ntyintyane LM, Panz VR, Raal FJ, Gill GV. Metabolic syndrome, undiagnosed diabetes mellitus and insulin resistance are highly prevalent in urbanised South African blacks with coronary artery disease. *Cardiovasc J S Afr* 2006;**17:**50–55.

[60] Mbanya JC, Sobngwi E. Diabetes in Africa. Diabetes microvascular and macrovascular disease in Africa. *J Cardiovas Risk* 2003;**10:**97–102.

[61] Dehayem YM, Kengne AP, Choukem SP, Simo NL, Awah KP, Mbanya JC. The spectrum of coma among people with diabetes in Cameroon: an appraisal of the implications and challenges at the Yaounde Central Hospital. *Ann Trop Med Parasitol* 2008;**102:**73–78.

[62] Aspray TJ, Mugusi F, Rashid S *et al*. Rural and urban differences in diabetes prevalence in Tanzania: the role of obesity, physical inactivity and urban living. *Transact Royal Soc Trop Med Hygiene* 2000; **94:**637–44.

[63] Ogbera AO, Fasanmade O, Ohwovoriole AE, Adediran O. An assessment of the disease burden of foot ulcers in patients with diabetes mellitus attending a teaching hospital in Lagos, Nigeria. *The international journal of lower extremity wounds* 2006;**5:**244–9.

[64] Health of Populations in Transition Research Group—Cameroon. *Cameroon Burden of Diabetes (CamBoD) Project: Baseline Survey Report*. Geneva, Switzerland: World Health Organization, 2004. http://www.who.int/chp/steps/STEPS_Cameroon.pdf. (26 May 2009, date last accessed).

[65] Sitas F, Parkin DM, Chirenje M, Stein L, Abratt R, Wabinga H. Part II: cancer in indigenous Africans—causes and control. *Lancet Oncol* 2008;**9:**786–95.

[66] Bray F, Moller B. Predicting the future burden of cancer. *Nat Rev Cancer* 2006;**6:**63–74.

[67] Curado M, Edwards B, Shin H *et al*. *Cancer Incidence in Five Continents. Volume IX*. Lyon: International Agency for Research on Cancer, 2008.

[68] Barton MB, Frommer M, Shafiq J. Role of radiotherapy in cancer control in low-income and middle-income countries. *Lancet Oncol* 2006;**7:**584–95.

[69] Danaei G, Vander Hoorn S, Lopez AD, Murray CJ, Ezzati M. Causes of cancer in the world: comparative risk assessment of nine behavioural and environmental risk factors. *Lancet* 2005;**366:**1784–93.

[70] Blokhuis MM, Goldberg PA, Pietersen GE *et al*. The extracolonic cancer spectrum in females with the common 'South African' hMLH1 c.C1528T mutation. *Fam Cancer* 2008;**7:**191–98.

[71] Huo D, Adebamowo CA, Ogundiran TO *et al*. Parity and breastfeeding are protective against breast cancer in Nigerian women. *Br J Cancer* 2008;**98:**992–96.

[72] Hainaut P, Boyle P. Curbing the liver cancer epidemic in Africa. *Lancet* 2008;**371:**367–68.

[73] Rainey JJ, Mwanda WO, Wairiumu P, Moormann AM, Wilson ML, Rochford R. Spatial distribution of Burkitt's lymphoma in Kenya and association with malaria risk. *Trop Med Int Health* 2007;**12:**936–43.

[74] Daar AS, Singer PA, Persad DL *et al*. Grand challenges in chronic non-communicable diseases. *Nature* 2007;**450:**494–96.

[75] Holmes MD, Dalal S, Volmink J *et al*. Non-communicable diseases in sub-Saharan Africa: the case for cohort studies. *PLoS Med* 2010;**7:**e1000244.

[76] Volmink J, Dare L. Addressing inequalities in research capacity in Africa. *BMJ* 2005;**331:**705–06.

[77] Boyle P, Levin B. *World Cancer Report 2008*. Geneva: World Health Organization, 2008.

[78] Mackay J, Mensah G, Mendis S, Greenlund K. World Health Organization. Department of Management of Noncommunicable Diseases. *The Atlas of Heart Disease and Stroke*. Geneva: World Health Organization, 2004.

[79] World Health Organization. *WHO Statistical Information System*. http://www.who.int/whosis/en/. (13 April 2009, date last accessed).

[80] Demographic and Health Surveys. http://www.measuredhs.com/start.cfm. (19 May 2009, date last accessed).

[81] Pampel F. Tobacco use in sub-Sahara Africa: estimates from the demographic health surveys. *Soc Sci Med* 2008; **66:**1772–83.

[82] *INDEPTH Network*. http://www.indepth-network.org/. (13 May 2009, date last accessed).

[83] Barnighausen T, Welz T, Hosegood V *et al*. Hiding in the shadows of the HIV epidemic: obesity and hypertension in a rural population with very high HIV prevalence in South Africa. *J Hum Hypertens* 2008;**22:**236–39.

[84] Tollman SM, Kahn K, Sartorius B, Collinson MA, Clark SJ, Garenne ML. Implications of mortality transition for primary health care in rural South Africa: a population-based surveillance study. *Lancet* 2008;**372:**893–901.

[85] Stewart S, Wilkinson D, Becker A *et al*. Mapping the emergence of heart disease in a black, urban population in Africa: the Heart of Soweto Study. *Int J Cardiol* 2006; **108:**101–8.

[86] World Health Organization. *STEPwise approach to surveillance*. http://www.who.int/chp.steps/en. (8 March 2010, date last accessed).

[87] Dalal S, Holmes MD, Ramesar RS. Advancing public health genomics in Africa through prospective cohort studies. *J Epidemiol Community Health* 2010;**64:**585–86.

[88] Cappuccio FP, Kerry SM, Micah FB, Plange-Rhule J, Eastwood JB. A community programme to reduce salt intake and blood pressure in Ghana [ISRCTN88789643]. *BMC Pub Health* 2006;**6:**13.

[89] Obi SN, Ozumba BC. Cervical cancer: socioeconomic implications of management in a developing nation. *J Obstet Gynaecol* 2008;**28:**526–28.

[90] Sankaranarayanan R, Nene BM, Shastri SS *et al*. HPV screening for cervical cancer in rural India. *N Engl J Med* 2009;**360:**1385–94.

[91] Biddlecom A, Bankole A, Patterson K. Vaccine for cervical cancer: reaching adolescents in sub-Saharan Africa. *Lancet* 2006;**367:**1299–300.

[92] Addo J, Smeeth L, Leon DA. Smoking patterns in Ghanaian civil servants: changes over three decades. *Int J Environ Res Public Health* 2009;**6:**200–8.

[93] Idowu B, Adagunodo R, Adedoyin R. Information technology infusion model for health sector in a developing country: Nigeria as a case. *Technol Health Care* 2006;**14:**69–77.

[94] Kumar V, Pentland A. DiaBetNet: Learning and Predicting Blood Glucose Results to Optimize Glycemic Control. 4th Annual Diabetes Technology Meeting; 2002; Atlanta GA, 2002.

[95] Mocumbi AO, Ferreira MB, Sidi D, Yacoub MH. A population study of endomyocardial fibrosis in a rural area of Mozambique. *N Engl J Med* 2008;**359:**43–49.

[96] Marijon E, Tivane A, Voicu S *et al*. Prevalence of congenital heart disease in schoolchildren of sub-Saharan Africa, Mozambique. *Int J Cardiol* 2006; **113:**440–41.

[97] Oli K, Porteous J. Prevalence of rheumatic heart disease among school children in Addis Ababa. *East Afr Med J* 1999;**76:**601–5.

[98] Longo-Mbenza B, Bayekula M, Ngiyulu R *et al*. Survey of rheumatic heart disease in school children of Kinshasa town. *Int J Cardiol* 1998;**63:**287–94.

[99] Khalil SI, Ibrahim-Khalil M, el Hag M, el Shafie S, Mahgoub F, Ali EN. Coronary events in Khartoum, Sudan. *J Clin Epidemiol* 1996;**49:**1013–16.

[100] Anabwani GM, Bonhoeffer P. Prevalence of heart disease in school children in rural Kenya using colour-flow echocardiography. *East Afr Med J* 1996;**73:**215–17.

[101] Seedat YK, Mayet FG, Gouws E. Risk factors for coronary heart disease in the white community of Durban. *S Afr Med J* 1994;**84:**257–62.

[102] Seedat YK, Mayet FG, Khan S, Somers SR, Joubert G. Risk factors for coronary heart disease in the Indians of Durban. *S Afr Med J* 1990;**78:**447–54.

[103] Rossouw JE, Weich HF, Steyn K, Kotze JP, Kotze TJ. The prevalence of ischaemic heart disease in three rural South African communities. *J Chronic Dis* 1984;**37:** 97–106.

[104] McLaren MJ, Lachman AS, Barlow JB. Prevalence of congenital heart disease in black schoolchildren of Soweto, Johannesburg. *Br Heart J* 1979;**41:**554–58.

[105] Ikeme AC, Pole DJ, Pobee JO, Larbi E, Blankson J, Williams H. Cardiovascular status and blood pressure in a population sample in Ghana—the Mamprobi survey. *Trop Geogr Med* 1978;**30:**313–29.

[106] Yazov L, Petros WG, Stump E. Epidemiological studies on rheumatic heart disease and streptococcal carriers among school-children in Addis-Ababa, Ethiopia. Preliminary communication. *Z Rheumatol* 1978;**37:**304–8.

[107] Danesi M, Okubadejo N, Ojini F. Prevalence of stroke in an urban, mixed-income community in Lagos, Nigeria. *Neuroepidemiology* 2007;**28:**216–23.

[108] Connor MD, Thorogood M, Casserly B, Dobson C, Warlow CP. Prevalence of stroke survivors in rural South Africa: results from the Southern Africa Stroke Prevention Initiative (SASPI) Agincourt field site. *Stroke* 2004;**35:**627–32.

[109] Walker RW, McLarty DG, Kitange HM *et al*. Stroke mortality in urban and rural Tanzania. Adult Morbidity and Mortality Project. *Lancet* 2000;**355:**1684–87.

[110] Nyenwe EA, Odia OJ, Ihekwaba AE, Ojule A, Babatunde S. Type 2 diabetes in adult Nigerians: a study of its prevalence and risk factors in Port Harcourt, Nigeria. *Diabetes Res Clin Pract* 2003;**62:**177–85.

[111] Levitt NS, Steyn K, Lambert EV *et al*. Modifiable risk factors for type 2 diabetes mellitus in a peri-urban community in South Africa. *Diabet Med* 1999;**16:**946–50.

[112] Ceesay MM, Morgan MW, Kamanda MO, Willoughby VR, Lisk DR. Prevalence of diabetes in rural and urban populations in southern Sierra Leone: a preliminary survey. *Trop Med Int Health* 1997;**2:**272–77.

[113] Mbanya JC, Ngogang J, Salah JN, Minkoulou E, Balkau B. Prevalence of NIDDM and impaired glucose tolerance in a rural and an urban population in Cameroon. *Diabetologia* 1997;**40:**824–29.

[114] Teuscher T, Baillod P, Rosman JB, Teuscher A. Absence of diabetes in a rural West African population with a high carbohydrate/cassava diet. *Lancet* 1987;**1:**65–68.

[115] Ahren B, Corrigan CB. Prevalence of diabetes mellitus in north-western Tanzania. *Diabetologia* 1984;**26:**333–36.

[116] Libhaber CD, Norton GR, Majane OH *et al*. Contribution of central and general adiposity to abnormal left ventricular diastolic function in a community sample with a high prevalence of obesity. *Am J Cardiol* 2009; **104:**1527–33.

[117] Addo J, Smeeth L, Leon DA. Obesity in urban civil servants in Ghana: association with pre-adult wealth and adult socio-economic status. *Public Health* 2009;**123:** 365–70.

[118] Addo J, Smeeth L, Leon DA. Prevalence, detection, management, and control of hypertension in Ghanaian civil servants. *Ethn Dis* 2008;**18:**505–11.

[119] Vorster HH, Kruger A, Venter CS, Margetts BM, Macintyre UE. Cardiovascular disease risk factors and socio-economic position of Africans in transition: the THUSA study. *Cardiovasc J Afr* 2007;**18:**282–89.

[120] Thorogood M, Connor M, Tollman S, Lewando Hundt G, Fowkes G, Marsh J. A cross-sectional study of vascular risk factors in a rural South African population: data from the Southern African Stroke Prevention Initiative (SASPI). *BMC Public Health* 2007;**7:**326.

[121] Cappuccio FP, Micah FB, Emmett L *et al*. Prevalence, detection, management, and control of hypertension in Ashanti, West Africa. *Hypertension* 2004;**43:**1017–22.

[122] Puoane T, Steyn K, Bradshaw D *et al*. Obesity in South Africa: the South African demographic and health survey. *Obes Res* 2002;**10:**1038–48.

[123] Vorster HH, Jerling JC, Steyn K *et al*. Plasma fibrinogen of black South Africans: the BRISK study. *Public Health Nutr* 1998;**1:**169–76.

[124] Okesina AB, Oparinde DP, Akindoyin KA, Erasmus RT. Prevalence of some risk factors of coronary heart disease in a rural Nigerian population. *East Afr Med J* 1999;**76:** 212–16.

[125] Huston SL, Bunker CH, Ukoli FA, Rautaharju PM, Kuller LH. Electrocardiographic left ventricular hypertrophy by five criteria among civil servants in Benin City, Nigeria: prevalence and correlates. *Int J Cardiol* 1999;**70:** 1–14.

[126] Betre M, Kebede D, Kassaye M. Modifiable risk factors for coronary heart disease among young people in Addis Ababa. *East Afr Med J* 1997;**74:**376–81.

[127] Mollentze WF, Moore AJ, Steyn AF *et al*. Coronary heart disease risk factors in a rural and urban Orange Free State black population. *S Afr Med J* 1995;**85:**90–96.

[128] Grinbaum A, Rosenthal T, Peleg E, Segal P. Ischaemic heart disease risk factors in young black Africans from urban Zaire. *J Hum Hypertens* 1993;**7:**555–57.

[129] Kitange HM, Swai AB, Masuki G, Kilima PM, Alberti KG, McLarty DG. Coronary heart disease risk factors in sub-Saharan Africa: studies in Tanzanian adolescents. *J Epidemiol Community Health* 1993;**47:**303–7.

[130] Swai AB, McLarty DG, Kitange HM *et al*. Low prevalence of risk factors for coronary heart disease in rural Tanzania. *Int J Epidemiol* 1993;**22:**651–59.

[131] Ramaiya KL, Swai AB, McLarty DG, Bhopal RS, Alberti KG. Prevalences of diabetes and cardiovascular disease risk factors in Hindu Indian subcommunities in Tanzania. *BMJ* 1991;**303:**271–76.

[132] Steyn K, Jooste PL, Bourne L *et al*. Risk factors for coronary heart disease in the black population of the

Cape Peninsula. The BRISK study. *S Afr Med J* 1991;**79:** 480–85.

[133] Steenkamp HJ, Jooste PL, Chalton DO, Rossouw JE, Benade AJ, Steyn M. Hypertension in a rural South African white population and the effect of antihypertensive treatment on the risk of coronary heart disease. *S Afr Med J* 1990;**78:**89–93.

[134] Steenkamp HJ, Jooste PL, Rossouw JE, Benade AJ, Swanepoel AS. Hypercholesterolaemia in a rural white population and its relationship with other coronary risk factors. *S Afr Med J* 1990;**78:**85–88.

[135] Steyn K, Rossouw JE, Joubert G. The coexistence of major coronary heart disease risk factors in the coloured population of the Cape Peninsula (CRISIC study). *S Afr Med J* 1990;**78:**61–63.

[136] Steenkamp E, Jooste PL, Christopher KJ. The prevalence of smoking and its relationship to other coronary risk factors in a rural white community. *S Afr Med J* 1988; **73:**402–5.

[137] Wyndham CH, Greenacre MJ, Wiles FJ. Effects of personal, environmental and occupational factors on ischaemic heart disease in white miners in South Africa. *Int J Epidemiol* 1986;**15:**507–12.

[138] Steyn K, Jooste PL, Langenhoven ML *et al*. Coronary risk factors in the coloured population of the Cape Peninsula. *S Afr Med J* 1985;**67:**619–25.

[139] Osuntokun BO, Bademosi O, Akinkugbe OO, Oyediran AB, Carlisle R. Incidence of stroke in an African City: results from the Stroke Registry at Ibadan, Nigeria, 1973–1975. *Stroke* 1979;**10:**205–7.

[140] Ikeme AC, Bennett FJ, Somers K. A survey for cardiovascular disease in middle-aged Ugandans. *Bull World Health Organ* 1973;**48:**751–53.

[141] Jackson WP, Goldberg MD, Major V, Campbell GD. Vascular and other diabetes-related disorders among Natal Indian diabetics and non-diabetics. *S Afr Med J* 1970;**44:**279–85.

[142] Kamara NT, Asiimwe S. Dyslipidaemia and hypertension among adults with diabetes in rural Uganda. *Trop Dict* 2010;**40:**41–42.

[143] Okafor CI, Fasanmade OA, Oke DA. Pattern of dyslipidaemia among Nigerians with type 2 diabetes mellitus. *Niger J Clin Pract* 2008;**11:**25–31.

[144] Lutale JJ, Thordarson H, Abbas ZG, Vetvik K. Microalbuminuria among Type 1 and Type 2 diabetic patients of African origin in Dar Es Salaam, Tanzania. *BMC Nephrol* 2007;**8:**2.

[145] Choukem SP, Kengne AP, Dehayem YM, Simo NL, Mbanya JC. Hypertension in people with diabetes in sub-Saharan Africa: revealing the hidden face of the iceberg. *Diabetes Res Clin Pr* 2007;**77:**293–99.

[146] Kalk WJ, Joffe BI. Differences in coronary heart disease prevalence and risk factors in African and White patients with type 2 diabetes. *Diabetes Res Clin Pr* 2007;**77:** 107–12.

[147] Siraj ES, Seyoum B, Saenz C, Abdulkadir J. Lipid and lipoprotein profiles in Ethiopian patients with diabetes mellitus. *Metabolism* 2006;**55:**706–10.

[148] Otieno CF, Vaghela V, Mwendwa FW, Kayima JK, Ogola EN. Cardiovascular risk factors in patients with type 2 diabetes mellitus in Kenya: levels of control attained at the Outpatient Diabetic Clinic of Kenyatta National Hospital, Nairobi. *East Afr Med J* 2005; **82(12 Suppl.):**S184–90.

[149] Mwendwa FM, Otieno CF, Kayima JK, Amayo EO, Otieno PO. Risk factor profile and the occurrence of microvascular complications in short-term type 2 diabetes mellitus at Kenyatta National Hospital, Nairobi. *East Afr Med J* 2005;**82(12 Suppl.):**S163–72.

[150] Isezuo SA, Ezunu E. Demographic and clinical correlates of metabolic syndrome in Native African type-2 diabetic patients. *J Natl Med Assoc* 2005;**97:**557–63.

[151] Fadupin GT, Joseph EU, Keshinro OO. Prevalence of obesity among type 2 diabetics in Nigeria a case study of patients in Ibadan, Oyo State, Nigeria. *Afr J Med Med Sci* 2004;**33:**381–84.

[152] Makuyana D, Gomo Z, Munyombwe T, Matenga JA, Hakim JG. Metabolic syndrome disorders in urban black Zimbabweans with type 2 Diabetes mellitus. *Cent Afr J Med* 2004;**50:**24–29.

[153] Seyoum B, Mengistu Z, Berhanu P *et al*. Retinopathy in patients of Tikur Anbessa Hospital diabetic clinic. *Ethiopian Med J* 2001;**39:**123–31.

[154] Alebiosu CO, Odusan BO. Metabolic syndrome in subjects with type-2 diabetes mellitus. *J Natl Med Assoc* 2004; **96:**817–21.

[155] Seyoum B, Abdulkadir J, Berhanu P *et al*. Analysis of serum lipids and lipoproteins in Ethiopian diabetic patients. *Ethiopian Med J* 2003;**41:**1–8.

[156] Alebiosu CO, Odusan O, Jaiyesimi A. Morbidity in relation to stage of diabetic nephropathy in type-2 diabetic patients. *J Natl Med Assoc* 2003;**95:**1042–47.

[157] Wanjohi FW, Otieno FC, Ogola EN, Amayo EO. Nephropathy in patients with recently diagnosed type 2 diabetes mellitus in black Africans. *East Afr Med J* 2002; **79:**399–404.

[158] Ikem RT, Akinola NO, Balogun MO, Ohwovoriole AE, Akinsola A. What does the presence of hypertension portend in the Nigerian with non insulin dependent diabetes mellitus. *West Afr J Med* 2001;**20:**127–30.

[159] Rahlenbeck SI, Gebre-Yohannes A. Prevalence and epidemiology of micro- and macroalbuminuria in Ethiopian diabetic patients. *J Diabetes Complicat* 1997;**11:**343–49.

[160] Mugusi F, Ramaiya KL, Chale S, Swai AB, McLarty DG, Alberti KG. Blood pressure changes in diabetes in urban Tanzania. *Acta Diabetol* 1995;**32:**28–31.

[161] Ahmed Me-B, Elmahadi EM. Pattern of blood pressure in African diabetics: report from Sudan. *J Hum Hypertens* 1995;**9:**899–901.

[162] Elmahdi EM, Kaballo AM, Mukhtar EA. Features of non-insulin-dependent diabetes mellitus (NIDDM) in the Sudan. *Diabetes Res Clin Pr* 1991;**11:**59–63.

[163] Rolfe M. The neurology of diabetes mellitus in Central Africa. *Diabet Med* 1988;**5:**399–401.

[164] Rolfe M. Diabetic renal disease in central Africa. *Diabet Med* 1988;**57:**630–33.

[165] Akintewe TA, Adetuyibi A. Obesity and hypertension in diabetic Nigerians. *Trop Geogr Med* 1986;**38:**146–49.

[166] Lester FT. Long-standing diabetes mellitus in Ethiopia: a survey of 105 patients. *Diabetologia* 1983;**25:**222–25.