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Distribution of hyperglycaemia and related cardiovascular disease risk factors in low-income countries: a cross-sectional population-based survey in rural Uganda

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Background Data on non-communicable disease (NCD) burden are often limited in developing countries in Africa but crucial for planning and implementation of prevention and control strategies. We assessed the prevalence of related cardiovascular disease risk factors (hyperglycaemia, high blood pressure and obesity) in a longstanding population cohort in rural Uganda.

Methods Trained field staff conducted a cross-sectional population-based survey of cardiovascular disease risk indicators using a questionnaire and simple measurements of body mass index (BMI), waist and hip circumference, waist/hip ratio (WHR), blood pressure and random plasma glucose. All members of the population cohort aged $\geqslant$13 years were eligible to participate in the survey.

Results Of the 4801 males and 5372 females who were eligible, 2719 (56.6%) males and 3959 (73.7%) females participated in the survey. Male and female participants had a mean standard deviation (SD) age of 31.8 (18.4) years and 33.7 (17.6) years, respectively. The observed prevalences of probable diabetes (glucose >11.0 mmol/l) and probable hyperglycaemia (7.0–11.0 mmol/l) were 0.4 and 2.9%, respectively. Less than 1% of males and 4% of females were obese (BMI $\geqslant$30 kg/m^2), with 3.6% of males and 14.5% of females being overweight (BMI 25.0–29.9 kg/m^2). However, in women, the prevalence of abdominal obesity was high (71.3% as measured by WHR and 31.2% as measured by waist circumference). The proportions of male and female current regular smokers were low (13.7 and 0.9%, respectively). The commonest cardiovascular disease risk factor was high blood pressure, with an observed prevalence of 22.5% in both sexes.

Conclusions Population-based data on the burden of related cardiovascular disease risk factors can aid in the planning and implementation of an effective response to the double burden of communicable

diseases and NCDs in this rural population of a low-income country undergoing epidemiological transition.

Keywords Cardiovascular disease, prevalence, Africa

Introduction

Diabetes is an important cause of morbidity and mortality worldwide,[1] and with hypertension and obesity it is an important risk factor for cardiovascular disease,[2] a leading global cause of death.[3] Type 2 diabetes, hypertension and obesity share several characteristics: (i) their common risk factors (unhealthy diets, physical inactivity and harmful alcohol use) and other exacerbating factors (e.g. tobacco use) are potentially amenable to behavioural modification;[4] (ii) they can be detected using simple tests and managed in primary-care settings in low-income countries;[5] (iii) the benefits of prevention and care extend beyond cardiovascular disease to related conditions of public health importance;[6] (iv) they are the focus of efforts to ensure greater prioritization of non-communicable diseases (NCDs) on the global research agenda,[7] the research agenda of development agencies[8] and in the health and development policies of low-income countries.[9]

With globalization, chronic NCDs are becoming more common in developing countries,[10] with the greatest regional increase in NCD deaths over the next decade predicted in Africa.[9] Emerging country-level evidence, e.g. from South Africa,[11] suggests that chronic NCDs are contributing to epidemiological transition (concomitant high burdens of both communicable diseases and NCDs) in many low-income countries.[12] Recent estimates indicate the global burden of chronic NCDs: 285 million people with diabetes in 2010,[1] 972 million with hypertension in 2000[13] and 400 million adults with obesity in 2005.[3] About 65–70% of those with diabetes or hypertension live in the developing world.[1,13]

NCDs such as diabetes are poorly understood and under-prioritized in developing countries.[14] Information on diabetes prevalence is often limited in low-income countries, particularly in sub-Saharan Africa and in rural populations.[15] For example, the 2010 International Diabetes Federation Atlas found that only four African countries (Uganda not included) possessed data, mostly >10 years old.[1] Since data have to be extrapolated from distant and probably dissimilar countries and populations, further epidemiological investigation in the region is urgently needed.[15] Good-quality data on disease burden are crucial to aid planning and implementation of prevention and control strategies for diabetes and other chronic NCDs.[16] Detailed epidemiological studies help in understanding NCD pathogenesis and in rational clinical management. A large population-based cohort in rural southwest Uganda, initially established in 1989 for human immunodeficiency virus (HIV) surveillance,[17,18] provided the opportunity to assess community prevalence in adults of hyperglycaemia, high blood pressure and obesity, selected for survey on account of their shared characteristics and their importance as cardiovascular disease risk factors.

Methods

Setting

Uganda has been recovering since 1986 from previous civil, political and economic turmoil. The estimated 30 million population are mostly engaged in subsistence agriculture. Annual Gross National Income is $300 per capita and mean life expectancy at birth is 50 years.[19] It is one of the countries in Africa where the HIV epidemic was first reported and that was initially most badly affected by HIV.

The study cohort comprises approximately 20 000 residents of 25 neighbouring villages in south-western Uganda, not far from Lake Victoria. The vast majority of dwellings are distributed throughout the countryside rather than clustered in villages, which mainly represent administrative areas demarcated on maps rather than population centres. The study population are mostly subsistence farmers, whose staple diet consists of matooke (cooking bananas) with groundnuts. There are no tarmac roads and access may be difficult during the rains. People live in semi-permanent structures built from locally available materials. The community is stable and homogeneous, with most people from the Baganda tribe, and 15% of Rwandese origin, who are well assimilated. Religious affiliation is mostly Christian, with a significant Muslim minority (28%). Levels of literacy are low and the main income-earning activities are growing bananas, coffee and beans, and trading fish.[20]

Annual general population cohort survey

Full details of the cohort and annual HIV serosurvey have been published elsewhere.[17,18] In brief, an annual household survey has been conducted since 1989, with all study-village residents eligible for inclusion. Average annual serosurvey participation is ~60–65%, although a much higher percentage has ever participated. Community-sensitization activities precede each survey round, including local council briefings and village meetings. All households are visited by, in turn, the mapping, census and survey teams. Consenting residents are interviewed at home in the local language by trained survey staff and provide a blood sample for HIV testing.

Measurement of indicators of cardiovascular disease risk

As part of the 20th annual HIV serosurvey (December 2008–November 2009), field staff assessed consenting adults (defined for the HIV serosurvey as aged ⩾13 years) for indicators of cardiovascular disease risk using a questionnaire and simple measurements. Study participants with an abnormal finding were advised to attend their nearest local health facility or the study clinic for further management. Questionnaire information included socio-demographic factors (including education level) and economic status. Socio-economic status (SES) was measured using an asset index, created by combining data on 22 household possessions using principal component analysis. Participants were asked if they were currently, or ever used to be, a regular cigarette smoker (including both manufactured and local cigarettes), if they had diabetes or hypertension and if they were already attending a clinic for either condition.

Anthropometric measurements were taken on standing participants wearing light clothes and without shoes. Weight was measured to the nearest 0.1 kg, using a spring balance, and height to the nearest 0.5 cm, using a stadiometer. Waist and hip circumferences were measured to the nearest 0.1 cm using standard techniques.[21] A single measurement of blood pressure was taken on the left arm of seated subjects after resting for 15 min, using a machine with an inflatable 15-cm cuff and automatic digital read-out to within 1 mmHg (WelchAllyn OSZ 5 easy) (note: WelchAllyn confirm that the 'OSZ 5 easy' is the same device as Microlife BP 3BTO-A, originally manufactured by Microlife).[22] Body mass index (BMI) was calculated as an indicator of obesity (BMI ⩾30 kg/m^2) and overweight (BMI = 25.0–29.9 kg/m^2).[23] Waist/hip ratio (WHR) and waist circumference (WC) were used as indicators of abdominal obesity (defined respectively as WHR >0.95 for men and >0.80 for women[24] and WC >94 cm for men and >80 cm for women).[25] High blood pressure (possible hypertension) was defined as systolic blood pressure ⩾140 mmHg or diastolic blood pressure ⩾90 mmHg.[26]

During venepuncture for HIV serotesting, a 4-ml blood sample was taken from participants into a tube containing oxalate and sodium fluoride for a random plasma glucose measurement, and transported to the laboratory at the nearby rural field station for centrifugation and storage of 1-ml plasma aliquots at 2–8°C. Samples were transported the following day using a cool box with ice packs to Entebbe, where plasma glucose was measured at the research unit main laboratory using the enzymatic reference method with hexokinase (Roche COBAS Integra 400 analyser with Glucose HK Gen.3 reagent). Daily calibration of the glucose assay was performed with normal and elevated control solutions provided by the manufacturer. The laboratory also participates in the external quality assurance programme of National Health Laboratory Services of South Africa, which involves monthly checks and feedback on glucose and other analytes. The results of random plasma glucose tests were interpreted as effectively post-prandial: <7 mmol/l was normal, 7.0–11.0 mmol/l indicated probable hyperglycaemia and >11.0 mmol/l indicated probable diabetes.[27] For participants who declined HIV testing, HIV serostatus was obtained from the last available serosurvey result.

Statistics

Data were double-entered and verified in Access. Stata 10 (Stata Corporation, College Station, USA) was used for analyses. Characteristics of persons with plasma glucose ⩾7 mmol/l (i.e. probable hyperglycaemia or diabetes) and those with normal plasma glucose were compared using chi-squared tests for categorical variables, and *t*-tests for continuous data.

As a sensitivity analysis, we compared our estimate of diabetes prevalence based on random plasma glucose results with the estimate obtained when participants who reported having diabetes, but had normal glucose results, were included as probable diabetes. In addition, the overall age-standardized prevalence of probable diabetes and possible diabetes was calculated by combining observed prevalence with age-stratified population estimates from the study population in the 2008 census round.

Lastly, we investigated factors associated with the observed prevalence of probable hyperglycaemia/diabetes (i.e. plasma glucose ⩾7 mmol/l) using random effects logistic regression to account for correlation within households. Because the prevalence of random plasma glucose >11 mmol/l was so low, we combined the groups with probable diabetes and probable hyperglycaemia as our outcome of interest. Exposures of interest included socio-demographic variables and clinical factors. Our hypothesis was that known cardiovascular disease risk factors, such as obesity and abdominal fat mass, would be associated with the prevalence of elevated plasma glucose in our study population. Analyses were stratified by sex because it was thought that some associations might differ between males and females. All factors whose univariate association with the outcome reached significance at $P < 0.20$ were considered for inclusion in a multivariable analysis. Ordered categorical variables for which the likelihood ratio test for departure from linearity was not significant at $P < 0.05$ were fit as linear terms. High blood pressure was considered to be a possible consequence of, rather than a risk factor for, plasma glucose ⩾7 mmol/l, so was not included in the final multivariable model. Instead, the association between high blood pressure and the prevalence of glucose ⩾7 mmol/l was assessed after adjusting for independent predictors of elevated glucose. The final multivariable model was reached by excluding factors one at a time until all remaining factors were significant at the $P < 0.10$ level.

Ethics

The study was approved by the Science and Ethics Committee of the Uganda Virus Research Institute and by the Uganda National Council for Science and Technology.

Results

Characteristics of cohort participants

At census, there were 4801 males and 5372 females aged ⩾13 years resident in the study area and eligible as survey participants. Of those, 2719 (56.6%) males and 3959 (73.7%) females responded to the survey questionnaire (Figure 1).

Participation was lower in younger age groups, for both sexes, and among women ⩾60 years. The mean standard deviation (SD) age of responders was 31.8 (18.4) years for males and 33.7 (17.6) years for females (Table 1). There was strong evidence of higher SES among non-responders, with 25% of non-responders in the highest SES quintile compared with 22.6% of responders ($P = 0.001$). There was no evidence of a difference in HIV serostatus between responders and non-responders, with 6.0 vs 6.2% being HIV seropositive, respectively ($P = 0.78$).

Prevalence of hyperglycaemia, high blood pressure and obesity

The observed prevalence of probable diabetes was 0.4% in both males and females, and of probable hyperglycaemia was 3% in males and 2.8% in females (Table 1). Age-standardized prevalences of probable diabetes and probable hyperglycaemia were 0.4% [95% confidence interval (CI) 0.3–0.5] and 2.8% (95% CI 2.5–3.1), respectively. The observed prevalence of high blood pressure was 22.5% in males and 22.6% in females. Less than 1% of males and 4% of females were obese (BMI ⩾30 kg/m^2), and 3.6% of males and 14.5% of females were overweight (BMI 25–29.9 kg/m^2). The prevalence of under-nutrition (BMI < 18.5 kg/m^2) was 29.8% in males and 16.5% in females. Using standard cut-offs, the proportions of participants with abdominal obesity among males and females were 3.8 and 71.3% (WHR) and 1.0 and 31.2% (WC), respectively.

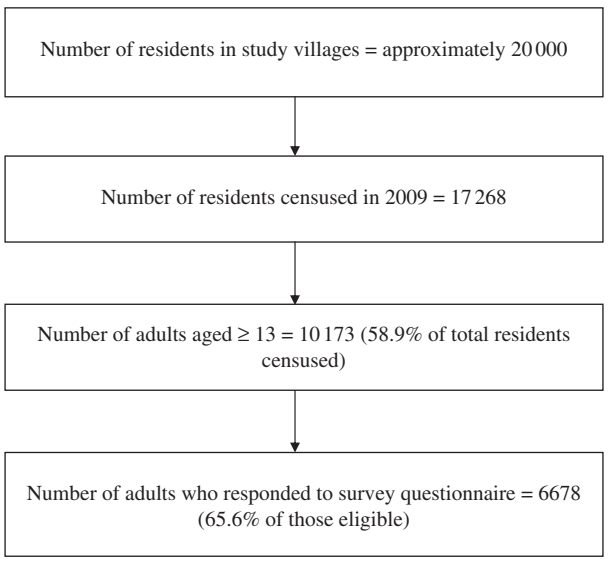

Figure 1 Numbers of residents of study villages, adults censused and survey participants

Most people with probable diabetes or hyperglycaemia were not aware of it: 74% of persons with plasma glucose >11 mmol/l and 98% of those with plasma glucose ⩾7 mmol/l did not report having diabetes. There was no difference between males and females in the proportion being aware of the condition. Among the 17 persons who reported having diabetes, plasma glucose was >11 mmol/l in six persons (35.3%) and ⩾7 mmol/l in four (23.5%). Only six persons reported they were attending a clinic for diabetes. If persons with reported diabetes are included in the group with probable diabetes, the age-standardized prevalence was 0.6% (95% CI 0.4–0.7).

There was strong evidence that participants with plasma glucose ⩾7 mmol/l (probable hyperglycaemia or diabetes) were older than those with normal plasma glucose, in both males and females (Table 2). There was no evidence of a difference in mean BMI between males with probable hyperglycaemia/diabetes and those with normal plasma glucose. In contrast, there was strong evidence that mean BMI was higher in females with probable hyperglycaemia/diabetes than in those with normal plasma glucose. In both males and females, there was strong evidence that mean WC was higher in persons with probable hyperglycaemia/diabetes than in those with normal plasma glucose. In both sexes, there was strong evidence that mean systolic and diastolic blood pressure increased with increasing glucose category.

Plasma glucose results were unavailable for 265 (9.7%) male and 427 (10.8%) female survey participants, because of either refusal to give a blood sample or an insufficient sample. There was strong evidence that participants with missing glucose results were older than those with glucose results (mean difference = 3.3 years, 95% CI 1.8–4.7, $P < 0.001$), and more likely to be HIV positive (19.1 vs 4.6%, $P < 0.001$). In addition, there was weak evidence that males with missing glucose results had a higher mean WC than males with glucose results (mean difference = 0.89 cm, 95% CI –0.15 to 1.92, $P = 0.09$).

The proportions of males and females who reported being a current regular smoker were 13.7% (95% CI 12.5–15.1) and 0.9% (95% CI 0.6–1.2), respectively,

Table 1 Description of study participants

	Males ($n = 2719$)	Females ($n = 3959$)
Socio-demographic/economic factors		
Age (years)		
<20	1037 (38.1%)	1123 (28.4%)
20–29	471 (17.3%)	838 (21.2%)
30–39	407 (15.0%)	700 (17.7%)
40–49	320 (11.8%)	530 (13.4%)
50–59	201 (7.4%)	347 (8.8%)
⩾60	283 (10.4%)	421 (10.6%)
Mean (SD) age (years)	31.8 (18.4)	33.7 (17.6)
Currently married	1052 (38.7%)	1806 (45.6%)
Education level		
Less than primary	167 (6.1%)	493 (12.5%)
Incomplete primary	1398 (51.5%)	1663 (42.0%)
Primary	501 (18.4%)	851 (21.5%)
Junior/secondary	556 (20.5%)	818 (20.7%)
Above secondary	95 (3.5%)	131 (3.3%)
Current regular smoker	373 (13.7%)	34 (0.9%)
Ever regular smoker	547 (20.2%)	50 (1.3%)
SES score tertile[a]		
Low	806 (30.1%)	993 (25.5%)
Middle	929 (34.7%)	1449 (37.3%)
High	939 (35.1%)	1448 (37.2%)
Clinical indicators		
BMI (kg/m^2)[a]		
<18.5	768 (29.8%)	625 (16.5%)
18.5–24.9	1706 (66.2%)	2461 (65.0%)
25.0–29.9	92 (3.6%)	549 (14.5%)
⩾30	13 (0.5%)	149 (3.9%)
Mean (SD) BMI (kg/m^2)	20.1 (2.9)	22.0 (4.0)
WHR ⩾0.95 (males)/⩾0.80 (females)[a]	102 (3.8%)	2620 (71.3%)
Mean (SD) WHR	0.85 (0.05)	0.83 (0.06)
WC ⩾94 cm (males)/⩾80 cm (females)[a]	26 (1.0%)	1148 (31.2%)
Mean (SD) WC (cm)	72.6 (8.0)	76.0 (10.0)
Blood pressure ⩾140/90[a]	602 (22.5%)	887 (22.6%)
Mean (SD) systolic blood pressure	125.8 (18.0)	126.0 (19.0)
Mean (SD) diastolic blood pressure	77.5 (11.7)	78.4 (10.9)
Reported hypertension	50 (1.8%)	216 (5.5%)
Random plasma glucose (mmol/l)[a]		
<7	2370 (96.6%)	3421 (96.9%)
7–11	74 (3.0%)	98 (2.8%)
>11	10 (0.4%)	13 (0.4%)
Mean (SD) plasma glucose	4.8 (1.6)	4.8 (1.3)
Reported diabetes	9 (0.3%)	10 (0.3%)
HIV serostatus		
Positive	128 (4.8%)	269 (6.9%)

[a]Missing data for ⩾1% of participants: SES index (45 males and 69 females); BMI (140 males and 175 females); WHR (43 males and 286 females); WC (41 males and 285 females); blood pressure (43 males and 26 females); plasma glucose results (265 males and 427 females).

with slightly higher proportions who reported ever smoking regularly.

Factors associated with plasma glucose ⩾7 mmol/l

Among males, factors associated with the prevalence of probable hyperglycaemia/diabetes in the univariate analysis included increasing age, current marriage, level of education (prevalence highest among those with less than primary education), current smoking, WHR ⩾0.95, increasing WHR, WC ⩾94 cm, and high blood pressure (Table 3). In the multivariable analysis, increasing age was the only factor that remained independently associated with the prevalence of probable hyperglycaemia/diabetes. After adjusting for age, there was no evidence of an independent association with measures of obesity, BMI, WHR or WC, either when included in the model as a categorical factor or as a continuous measurement. However, after adjusting for age, some evidence of an association between the prevalence of probable hyperglycaemia/diabetes and high blood pressure still remained.

Among females, factors associated with the prevalence of probable hyperglycaemia/diabetes in the univariate analysis included increasing age, decreasing education level, lower SES, increasing BMI, WHR ⩾0.80, increasing WHR, WC ⩾80 cm and high blood pressure. In the multivariable analysis, factors independently associated with the prevalence of probable hyperglycaemia/diabetes were increasing age, decreasing education level and WC ⩾80 cm. There was no evidence of an independent association with other measures of adiposity, BMI or WHR, either when included in the model as a categorical factor, or as a continuous measurement. However, although WC was the adiposity measure with the strongest association with probable hyperglycaemia/diabetes, there was some evidence of an association with BMI, and with WHR, after adjusting for age and education alone [adjusted odds ratio (OR) = 1.98, 95% CI 0.97–4.02, for BMI ⩾25 vs BMI <18.5; adjusted

Table 2 Observed characteristics of participants by plasma glucose level and sex[a]

	Normal (glucose <7 mmol/l)[b] *n* (col %)	**Possible diabetes (glucose 7–11 mmol/l)** *n* (col %)	**Probable diabetes (glucose >11 mmol/l)** *n* (col %)
Males			
n	2370	74	10
Mean (SD) age (years)	31.1 (18.1)	43.8 (20.2)	56.6 (15.3)
Reported diabetes			
No	2099 (88.6)	60 (81.1)	6 (60.0)
Yes	3 (0.1)	2 (2.7)	2 (20.0)
Don't know	267 (11.3)	12 (16.2)	2 (20.0)
SES score tertile			
Low	692 (29.7)	27 (37.0)	2 (20.0)
Middle	797 (34.2)	25 (34.2)	7 (70.0)
High	840 (36.1)	21 (28.8)	1 (10.0)
BMI (kg/m^2)			
<18.5	683 (30.3)	18 (25.0)	3 (30.0)
18.5–24.9	1478 (65.7)	48 (66.7)	7 (70.0)
25.0–29.9	79 (3.5)	5 (6.9)	0 (–)
⩾30	11 (0.5)	1 (1.4)	0 (–)
Mean (SD) BMI (kg/m^2)	20.1 (2.9)	20.3 (3.2)	20.7 (2.7)
WHR ⩾0.95			
No	2251 (96.4)	68 (91.9)	9 (90.0)
Yes	84 (3.6)	6 (8.1)	1 (10.0)
WHR tertile			
Low	786 (33.7)	20 (27.0)	0 (–)
Middle	788 (33.7)	23 (30.1)	4 (40.0)
High	761 (32.6)	31 (41.9)	6 (60.0)
Mean (SD) WHR	0.85 (0.05)	0.86 (0.07)	0.90 (0.04)
WC ⩾94 cm			
No	2318 (99.2)	71 (95.9)	10 (100)
Yes	18 (0.8)	3 (4.1)	0 (-)
Mean (SD) WC (cm)	72.5 (8.0)	75.5 (10.6)	80.8 (7.2)
Mean (SD) systolic blood pressure	125.4 (17.5)	135.2 (25.0)	148.1 (26.4)
Mean (SD) diastolic blood pressure	77.4 (11.5)	83.1 (18.1)	89.8 (13.8)
Females			
n	3421	98	13
Mean (SD) age (years)	32.9 (17.4)	46.9 (17.9)	48.0 (14.1)
Reported diabetes			
No	2949 (86.3)	72 (73.5)	4 (30.8)
Yes	4 (0.1)	2 (2.0)	4 (30.8)
Don't know	466 (13.6)	24 (24.5)	5 (38.5)
SES score tertile			
Low	836 (24.9)	30 (30.9)	5 (38.5)
Middle	1246 (37.1)	39 (40.2)	7 (53.8)
High	1280 (38.1)	28 (28.9)	1 (7.7)

(continued)

Table 2 Continued

	Normal (glucose <7 mmol/l)[b] *n* (col %)	Possible diabetes (glucose 7–11 mmol/l) *n* (col %)	Probable diabetes (glucose >11 mmol/l) *n* (col %)
BMI (kg/m^2)			
<18.5	554 (16.9)	12 (13.0)	1 (10.0)
18.5–24.9	2128 (64.8)	55 (59.8)	3 (30.0)
25.0–29.9	467 (14.2)	19 (20.7)	4 (40.0)
⩾30	134 (4.1)	6 (6.5)	2 (20.0)
Mean (SD) BMI (kg/m^2)	22.0 (4.0)	23.2 (4.8)	25.1 (6.1)
WHR ⩾0.80			
No	929 (29.3)	18 (19.6)	2 (15.4)
Yes	2245 (70.7)	74 (80.4)	11 (84.6)
WHR tertile			
Low	1081 (34.1)	24 (26.1)	3 (23.1)
Middle	1057 (33.3)	25 (27.2)	5 (38.5)
High	1036 (32.6)	43 (46.7)	5 (38.5)
Mean (SD) WHR	0.83 (0.06)	0.85 (0.06)	0.85 (0.06)
WC ⩾80 cm			
No	2220 (69.9)	45 (48.9)	3 (23.1)
Yes	955 (30.1)	47 (51.1)	10 (76.9)
Mean (SD) WC (cm)	75.7 (9.8)	82.1 (12.3)	87.2 (13.7)
Mean (SD) systolic blood pressure	125.7 (18.5)	134.8 (21.7)	139.2 (27.6)
Mean (SD) diastolic blood pressure	78.3 (10.7)	81.4 (11.5)	82.8 (12.9)

[a]Characteristics of participants with normal glucose and those with glucose ⩾7 mmol/l were compared using chi-square tests for categorical data and *t*-tests for continuous data. Comparisons are described in the text.
[b]Random plasma glucose results interpreted as effectively post-prandial, therefore <7 mmol/l is classified as 'normal', 7–11 mmol/l indicates possible diabetes and >11 mmol/l indicates probable diabetes.

OR = 1.70, 95% CI 1.02–2.85, for WHR ⩾0.80]. Lastly, after adjusting for age, education and WC ⩾80 cm, some evidence of an association between the prevalence of probable hyperglycaemia/diabetes and high blood pressure still remained.

Discussion

In this low-income rural community in southwest Uganda, age-standardized prevalences of probable diabetes and probable hyperglycaemia were 0.4 and 2.8%, respectively, and were similar in males and females. Less than 1% of males and 4% of females were obese (BMI ⩾30 kg/m^2), with 3.6% of males and 14.5% of females overweight (BMI 25–29.9 kg/m^2). The proportions of male and of female current regular smokers were low (13.7 and 0.9%, respectively). The commonest cardiovascular disease risk factor was high blood pressure, found in ~23% of both males and females. The burden of chronic NCDs in this relatively young rural population represents a challenge in providing an effective health-care response.

Our prevalence of probable diabetes (0.4%) is similar to that reported in a largely rural population in The Gambia (0.3%),[28] but much lower than that reported in rural settings in Tanzania (1.1–1.7%),[29] Kenya (2.2%)[30] and South Africa (3.9%).[31] Studies have generally found higher diabetes prevalence in urban than rural settings, e.g. 8% in Kampala, Uganda,[32] and 6.4% in a combined group of urban and rural Ghanaians.[33] Although sites may use different ways of measuring and defining diabetes, such findings highlight the heterogeneity of diabetes distribution among communities in Africa[30] and the need for comprehensive epidemiological mapping.[15] We found a strong association between age and probable hyperglycaemia/diabetes in both males and females, consistent with other studies.[28–30] However, the association between obesity as measured by BMI and elevated glucose was less clear, particularly among men. Among women, after adjusting for age, abdominal obesity was the strongest independent predictor of

Table 3 Factors associated with elevated plasma glucose (⩾7 mmol/l) among males and females ⩾13 years old

	Males ($n=2454$)			Females ($n=3532$)		
	Number with glucose ⩾7 (mmol/l)/total (%)	Unadjusted OR (95% CI)	Adjusted OR[a] (95% CI)	Number with glucose ⩾7 (mmol/l)/total (%)	Unadjusted OR (95% CI)	Adjusted OR[a] (95% CI)
Socio-demographic/economic factors						
Age (years)						
<20	12/950 (1.3)	1	1	7/1041 (0.7)	1	1
20–29	8/430 (1.9)	1.50 (0.60–3.75)	1.50 (0.60–3.75)	12/758 (1.6)	2.39 (0.93–6.17)	1.95 (0.72–5.28)
30–39	12/365 (3.3)	2.70 (1.18–6.19)	2.70 (1.18–6.19)	23/595 (3.9)	6.06 (2.55–14.38)	4.38 (1.78–10.77)
40–49	18/276 (6.5)	5.71 (2.62–12.43)	5.71 (2.62–14.43)	20/470 (4.3)	6.71 (2.78–16.19)	4.50 (1.81–11.22)
50–59	15/178 (8.4)	7.68 (3.35–17.64)	7.68 (3.35–17.64)	15/303 (5.0)	7.87 (3.13–19.83)	5.19 (1.98–13.63)
⩾60	19/255 (7.5)	6.59 (3.04–14.28)	6.59 (3.04–14.28)	34/365 (9.3)	16.18 (6.80–38.52)	11.24 (4.44–28.44)
Currently married						
Yes	47/934 (5.0)	1	1	53/1597 (3.3)	1	1
No	37/1519 (2.4)	0.46 (0.29–0.73)	0.97 (0.58–1.61)	58/1934 (3.0)	0.90 (0.61–1.32)	1.01 (0.66–1.55)
Education level						
Secondary/above	17/578 (2.9)	1	1	10/849 (1.2)	1	1
Primary	21/456 (4.6)	1.60 (0.81–3.16)	1.73 (0.87–3.44)	24/770 (3.1)	2.71 (1.28–5.74)	2.69 (1.21–6.01)
Some primary	35/1270 (2.8)	0.92 (0.50–1.70)	0.97 (0.52–1.79)	53/1486 (3.6)	3.13 (1.57–6.22)	2.33 (1.10–4.94)
Less than primary	11/148 (7.4)	2.80 (1.21–6.47)	1.46 (0.62–3.45)	24/424 (5.7)	5.13 (2.39–10.99)	2.20 (0.93–5.18)
Current regular smoker						
No	66/2124 (3.1)	1	1	110/3500 (3.1)	1	1
Yes	18/328 (5.5)	1.85 (1.05–3.25)	1.10 (0.61–1.97)	1/32 (3.1)	1.00 (0.13–7.64)	0.61 (0.07–4.97)
SES score tertile						
Low	29/721 (4.0)	1	1	35/871 (4.0)	1	1
Middle	32/829 (3.9)	0.95 (0.55–1.63)	1.17 (0.68–2.04)	46/1292 (3.6)	0.88 (0.55–1.39)	0.93 (0.56–1.53)
High	22/862 (2.6)	0.62 (0.34–1.11)	0.81 (0.44–1.47)	29/1309 (2.2)	0.53 (0.32–0.89)	0.69 (0.38–1.24)
Clinical factors						
BMI (kg/m^2)						
<18.5	21/704 (3.0)	1	1	13/567 (2.3)	1	1
18.5–24.9	55/1533 (3.6)	1.21 (0.72–2.05)	1.03 (0.60–1.76)	58/2186 (2.7)	1.16 (0.63–2.16)	0.93 (0.47–1.83)
⩾25	6/96 (6.3)	2.24 (0.84–5.96)	1.52 (0.56–4.12)	31/632 (4.9)	2.23 (1.14–4.38)	1.20 (0.51–2.82)
WHR ⩾0.95 (males)/⩾0.80 (females)						
No	77/2328 (3.3)	1	1	20/949 (2.1)	1	1
Yes	7/91 (7.7)	2.48 (1.06–5.80)	1.57 (0.65–3.79)	85/2330 (3.6)	1.77 (1.07–2.91)	1.36 (0.79–2.34)
WHR tertile						
Low	20/806 (2.5)	1	1	27/1108 (2.4)	1	1
Middle	27/815 (3.3)	1.36 (0.74–2.48)	1.22 (0.66–2.26)	30/1087 (2.8)	1.14 (0.67–1.94)	1.03 (0.58–1.81)
High	37/798 (4.6)	1.95 (1.10–3.47)	1.25 (0.68–2.29)	48/1084 (4.4)	1.88 (1.15–3.06)	1.20 (0.69–2.07)
WC ⩾94 cm (males)/⩾80 cm (females)						
No	81/2399 (3.4)	1	1	48/2268 (2.1)	1	1
Yes	3/21 (14.3)	5.14 (1.30–20.31)	2.86 (0.71–11.46)	57/1012 (5.6)	2.83 (1.87–4.28)	2.04 (1.33–3.13)
Systolic BP ⩾140 mmHg or diastolic BP ⩾90 mmHg						
No	50/1872 (2.7)	1	1	63/2729 (2.3)	1	1
Yes	34/546 (6.2)	2.51 (1.56–4.04)	1.62 (0.98–2.70)	47/782 (6.0)	2.76 (1.84–4.13)	1.52 (0.97–2.39)
HIV serostatus						
Negative	79/2351 (3.4)	1	1	105/3329 (3.2)	1	1
Positive	5/87 (5.7)	1.79 (0.67–4.77)	1.55 (0.58–4.16)	6/186 (3.2)	1.02 (0.43–2.38)	1.25 (0.52–3.01)

[a]Adjusted for all independent predictors in final multivariate model (i.e. for males, age category; for females, age category, education and WC ⩾80 cm). ORs displayed for age group as a categorical factor, but included in final multivariate model as a linear term.

probable hyperglycaemia/diabetes. A similar (although not statistically significant) trend was seen in men. Abdominal obesity, as indicated by a high WC, was also found to be independently associated with diabetes in a study in Guinea.[34] The established BMI cut-offs for overweight and obesity may not be good indicators of cardiovascular disease risk in our study population. A study in North America found that WC was more sensitive than BMI in predicting cardiovascular disease risk in different ethnic groups.[35]

The observed prevalence of high blood pressure in our study (22.5%) was lower than the prevalence of hypertension reported in rural Rukungiri, Uganda (30.5%),[36] but compatible with similar studies elsewhere in Africa.[37] Overestimation of hypertension as high blood pressure is likely due to the stress of survey participation and the reliance on a single measurement of blood pressure, which may be overestimated by as much as 50% compared with measurements made on three visits.[38] However, we may have underestimated prevalence of hypertension by not including the few participants with reported hypertension who had normal blood pressure. A systematic review of hypertension in Africa found that prevalence varied extensively between and within studies, but was generally higher in urban than rural settings, increased with age[37] and was as high as that in most industrialized countries.[39] The low proportion of current regular smokers in our study (13.7% of males and 0.9% of females) reflects the low national smoking prevalence among 15- to 49-year-olds in Uganda (18% in males and 0.9% in females in 2006).[40]

Obesity and overweight were more common among females (4 and 14.5%, respectively) than males (0.5 and 3.6%, respectively). The combined prevalence of obesity and overweight among females in our study was similar to that nationally in Uganda (4.1 and 16.5%, respectively)[40] and compatible with that found in rural settings elsewhere in Africa.[41] Although only 18.5% of women in our study had BMI $\geqslant 25\,kg/m^2$, the prevalence of abdominal obesity as measured by WHR and WC was much higher (71.3 and 31.2%, respectively). Although the predictive value of WC for diabetes and hypertension is well established in some industrialized countries, e.g. the USA,[42] validation is necessary elsewhere. Rapidly increasing urbanization is associated with trends towards unhealthy diets and sedentary lifestyles. The effects of changes of globalization on lifestyle may be appearing slowly in this rural community—the high prevalence of under-nutrition (BMI $< 18.5\,kg/m^2$) in males (29.8%) and females (16.5%) reflects the low-income status of the vast majority of the population. However under-nutrition and obesity may exist side by side within the same country, the same community and even the same household.[3]

Diagnosis of diabetes in an individual depends on at least an initial and a confirmatory recommended standard test,[43] based on measuring plasma glucose fasting or 2 h after an oral glucose load.[27] Since either approach is of limited feasibility in a large population-based survey in a rural setting in a low-income country, we measured random plasma glucose as a practical approach to estimating population-level hyperglycaemia. Estimation of glycated haemoglobin A_{1c} as an alternative diagnostic method is not currently recommended by the World Health Organization (WHO) or the International Diabetes Foundation because of insufficient validation in people of different ages and ethnicity, inadequate standardization of laboratory tests, and cost.[27] In North America, random plasma glucose testing has been shown to discriminate well between those with and without diabetes, and with and without hyperglycaemia, when compared with the results of an oral glucose tolerance test.[44] Furthermore, random plasma glucose is a better discriminator for diabetes and glucose intolerance than using age, BMI and race[45] and as good as using metabolic syndrome even when it includes fasting glucose.[46] The performance of random plasma glucose testing in rural Africa cannot be assumed to be similar to that in North America, and even if it does the positive predictive values will be lower, reflecting lower prevalence in rural Africa. However, it is reassuring that the WHO-recommended cut-points[43] used in our study were found in North America to be highly specific (94 to >97%), although with much lower sensitivity (<20%).

An additional limitation in plasma glucose testing arises from the delay for practical reasons of up to 24 h between taking the blood sample and measuring the plasma glucose concentration. Whole blood for glucose measurement was collected into sodium fluoride tubes, which are designed to inhibit further glucose metabolism in the sample. The sample was separated, providing a stable plasma sample, within half a day. However, it is known that prior to separation, even with sodium fluoride tubes, inhibition of further glucose metabolism is not immediate, and that over the first hour the glucose concentration continues to fall, becoming stable at ~4 h for the next 24–48 h.[47] It is likely therefore that on average glucose values were ~0.5 mmol/l lower than they would have been had the measurement been made, or the sample separated, immediately after collection.[47]

Given the above factors the prevalence estimates reported here, particularly for probable diabetes, are likely to be an underestimation of the true prevalence. It is likely that standard testing would confirm that those classified by random plasma glucose as having probable diabetes mostly do have diabetes, and as having probable hyperglycaemia mostly do have diabetes, impaired glucose tolerance or impaired fasting glycaemia. Given the dearth of population-based data on hyperglycaemia in Africa, our data provide new and important information.

Although diabetes, hypertension and obesity are key cardiovascular disease risk factors,[48] there have been few large population-based studies of these conditions in developing countries in Africa, and most have been in urban settings.[49] Our study is unusual in providing prevalence estimates of key cardiovascular disease risk factors based on a large general population cohort in a rural community in a low-income country in Africa. A limitation of our study is incomplete (65.6%) participation among all those identified as eligible in the census. Males were less likely than females to take part in the survey, probably because they are more likely to be away from the household when the survey team arrives. Maintaining a high participation rate is a challenge in a long established community-based annual HIV serosurvey. Some participants may decline participation because they have previously had a blood test for HIV, know their result and decide against a repeat test. Although there was no evidence of a difference in HIV serostatus between survey participants and those who declined, survey participants with missing glucose results (i.e. answered the questionnaire but declined a blood test) were more likely to be HIV positive. Furthermore, participants with missing plasma glucose results were older and had a higher WC, and therefore are at higher risk of diabetes, resulting in possible underestimation of diabetes prevalence. Lastly, we did not classify participants with reported diabetes who had normal plasma glucose results in the group with probable diabetes, which could lead to an underestimation of diabetes prevalence.

Despite these limitations, our findings help to fill the enormous gap between the sparse population-based data available and the comprehensive data needed for a good understanding of NCD distribution in Africa. Such data on disease burden are crucial to aid planning and implementation of NCD prevention and control strategies. This study provides baseline findings of the prevalence of diabetes, hypertension and obesity in a rural community in a developing country in Africa at a time of socio-economic development and globalization, when these problems are increasing in cities and likely to extend to rural areas. The chronic NCD burden is also likely to increase further as more HIV-infected people in Africa receive antiretroviral treatment (ART), leading to reduced HIV-related mortality and to possible metabolic side effects resulting from lifelong ART. Responding to the global challenge of chronic NCDs globally, including in Africa, requires substantial investment[50] and concerted action through new alliances, such as The Global Alliance for Chronic Diseases.[51]

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KEY MESSAGES

- Existing research infrastructure for HIV surveys in Africa can provide a platform for assessing the prevalence of other conditions, e.g. cardiovascular disease risk factors.
- The commonest cardiovascular disease risk factor was high blood pressure.
- Most people with probable diabetes or hyperglycaemia were not aware of it.
- Data on NCD burden are often limited in developing countries in Africa, but are crucial for planning and implementation of prevention and control strategies.

References

[1] International Diabetes Federation. *Diabetes Atlas*. 4th edn. Brussels: International Diabetes Federation, 2010.

[2] 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.

[3] World Health Organization. Obesity and overweight. Fact sheet no. 311. http://www.who.int/mediacentre/factsheets/fs311/en/index.html (accessed 15 January 2010).

[4] Magnusson R. Developing a global framework to address non-communicable diseases. *Diabetes Voice* 2008;**53:**9–12.

[5] Beaglehole R, Epping-Jordan J, Patel V *et al*. Improving the prevention and management of chronic disease in low-income and middle-income countries: a priority for primary care. *Lancet* 2008;**372:**940–49.

[6] Jeon CY, Murray MB. Diabetes Mellitus Increases the Risk of Active Tuberculosis: A Systematic Review of 13 Observational Studies. *PLoS Med* 2008;**5:**e152. doi:10.1371/journal.pmed.0050152.

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

[8] United Kingdom Department for International Development (DFID). *Research Strategy 2008–2013*. London: DFID, 2008.

[9] World Health Organization. *2008-2013 Action Plan for the Global Strategy for the Prevention and Control of Noncommunicable Diseases*. Geneva: World Health Organization, 2008.

[10] Nabel EG, Stevens S, Smith R. Combating chronic disease in developing countries. *Lancet* 2009;**373:**2004–6.

[11] 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.

[12] World Health Organization. *The World Health Report 2004: Changing History*. Geneva: World Health Organization, 2004.

[13] Editorial. Hypertension: uncontrolled and conquering the world. *Lancet* 2007;**370:**539.

[14] Anonymous. Diabetes – a global threat. (Editorial). *Lancet* 2009;**373:**17.

[15] International Diabetes Federation. Diabetes atlas. http://www.diabetesatlas.org/content/africa (10 January 2010, date last accessed).

[16] Beaglehole R, Ebrahim S, Reddy S, Voute J, Leeder S. Prevention of chronic diseases: a call to action. *Lancet* 2007;**370:**2152–57.

[17] Nunn AJ, Mulder DW, Kamali A, Ruberantwari A, Kengeya-Kayondo JF, Whitworth J. Mortality associated with HIV-1 infection over five years in a rural Ugandan population: cohort study. *BMJ* 1997;**315:**767–71.

[18] Kengeya-Kayondo JF, Kamali A, Nunn AJ, Ruberantwari A, Wagner H-U, Mulder DW. Incidence of HIV-1 infection in adults and socio-demographic characteristics of seroconverters in a rural population in Uganda: 1990-1994. *Int J Epidemiol* 1996;**25:**1077–82.

[19] UNICEF. *The State of the World's Children*. New York: UNICEF, 2008.

[20] Nakibinge S, Maher D, Katende J, Kamali A, Grosskurth H, Seeley J. Community engagement in health research: two decades of experience from a research project on HIV in rural Uganda. *Tropical Medicine and International Health* 2009;**14:**190–95.

[21] Tolonen H, Kuulasmaa K, Laatikainen T, Wolf H. and the European Health Risk Monitoring Project. *Recommendations for Indicators, International Collaboration, Protocol and Manual of Operations for Chronic Disease Risk Factor Surveys*. Helsinki: European Health Risk Monitoring, 2002.

[22] Cuckson AC, Reinders A, Shabeeh H, Shennan AH. Validation of the Microlife BP 3BTO-A oscillometric blood pressure monitoring device according to a modified British Hypertension Society protocol. *Devices and Technology* 2002;**7:**319–24.

[23] World Health Organization. WHO Expert Committee. *Physical Status: The Use and Interpretation of Anthropometry*. WHO Technical Report Series No. 854. Geneva: WHO, 1995.

[24] U.S. Department of Agriculture, U.S. Department of Health and Human Services. *Dietary Guidelines for Americans*. 3rd edn. Washington, DC: Government Printing Office, 1990.

[25] International Diabetes Federation (IDF). *Worldwide Definition of the Metabolic Syndrome*. Brussels: International Diabetes Federation, 2006.

[26] World Health Organization (WHO). International Society of Hypertension (ISH) Writing Group. WHO/ISH statement on management of hypertension. *J Hyperten* 2003; **21:**1983–92.

[27] World Health Organization (WHO) and International Diabetes Foundation (IDF). *Definition and Diagnosis of Diabetes Mellitus and Intermediate Hyperglycemia: Report of a WHO/IDF Consultation*. Geneva: WHO, 2006.

[28] van der Sande MAB, Bailey R, Faal H *et al*. Nationwide prevalence study of hypertension and related noncommunicable diseases in The Gambia. *Tropical Medicine and International Health* 1997;**2:**1039–48.

[29] Aspray TJ, Mugusi F, Rashid S *et al*. Essential Non-Communicable Disease Health Intervention Project: Rural and urban differences in diabetes prevalence in Tanzania: the role of obesity, physical inactivity and urban living. *Trans R Soc Trop Med Hyg* 2000;**94:**637–44.

[30] Christensen DL, Friis H, Mwaniki DL *et al*. Prevalence of glucose intolerance and associated risk factors in rural and urban populations of different ethnic groups in Kenya. *Diabetes Res Clin Pract* 2009;**84:**303–10.

[31] Motala AA, Esterhuizen T, Gouws E *et al*. Diabetes and other disorders of glycemia in a rural South African community: prevalence and associated risk factors. *Diabetes Care* 2008;**31:**1783–88.

[32] 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.

[33] Amoah AG, Owusu SK, Adjei S. Diabetes in Ghana: a community based prevalence study in Greater Accra. *Diabetes Res Clin Pract* 2002;**56:**197–205.

[34] Balde N-M, Diallo I, Balde M-D *et al*. Diabetes and inpaired fasting glucose in rural and urban populations in Futa Jallon (Guinea): prevalence and associated risk factors. *Diabetes Metab* 2007;**33:**114–20.

[35] Zhu S, Heymsfield S, Toyoshima H, Wang Z, Pietrobelli A, Heshka S. Race-ethnicity-specific waist circumference cutoffs for identifying cardiovascular disease risk factors. *Am J Clin Nutr* 2005;**81:**409–15.

[36] Wamala JF, Karyabakabo Z, Ndungutse D, Guwatudde D. Prevalence factors associated with hypertension in Rukungiri District, Uganda – a community-based study. *Afr Health Sci* 2009;**9:**153–60.

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

[38] Bovet P, Gervasoni J-P, Ross AG *et al*. Assessing the prevalence of hypertension in populations: are we doing it right? *J Hyperten* 2003;**21:**509–17.

[39] Kearney PM, Whelton M, Reynolds K, Muntner P, Whelton PK, He J. Global burden of hypertension: analysis of worldwide data. *Lancet* 2005;**365:**217–23.

[40] Uganda Bureau of Statistics. *Uganda Demographic and Health Survey 2006*. Calverton, MD: UBOS and Macro International Inc, 2007.

[41] Ziraba AK, Fotso JC, Ochako R. Overweight and obesity in urban Africa: a problem of the rich or the poor? *BMC Public Health* 2009;**9:**465.

[42] Janssen I, Katzmarzyk PT, Ross R. Body mass index, waist circumference, and health risk. Evidence in support of current National Institutes of Health guidelines. *Arch Intern Med* 2002;**162:**2074–79.

[43] World Health Organization (WHO). *Definition, Diagnosis and Classification of Diabetes Mellitus and Its Complications: Report of a WHO Consultation. Part 1. Diagnosis and Classification of Diabetes Mellitus*. Geneva: WHO, 1999.

[44] Ziemer DC, Kolm P, Foster JK *et al*. Random plasma glucose in serendipitous screening for glucose intolerance: screening for impaired glucose tolerance study 2. *J Gen Intern Med* 2008;**23:**528–35.

[45] Ziemer DC, Kolm P, Weintraub WS *et al*. Age, BMI, and race are less important than random plasma glucose in identifying risk of glucose intolerance: the Screening for Impaired Glucose Tolerance Study (SIGT 5). *Diabetes Care* 2008;**31:**884–86.

[46] El Bassuoni EA, Ziemer DC, Kolm P *et al*. The "metabolic syndrome" is less useful than random plasma glucose to screen for glucose intolerance. *Prim Care Diabetes* 2008;**2:** 147–53.

[47] Chan AYW, Swaminathan A, Cockram CS. Effectiveness of sodium fluoride as a preservative of glucose in blood. *Clin Chem* 1989;**35:**315–17.

[48] Steyn K, Sliwa K, Hawken S *et al*. INTERHEART Investigators in Africa. Risk factors associated with myocardial infarction in Africa: the INTERHEART Africa study. *Circulation* 2005;**112:**3536–40.

[49] Abubakari AR, Lauder W, Jones MC, Kirk A, Agyemang C, Bhopal RS. Prevalence and time trends in diabetes and physical inactivity among adult West African populations: the epidemic has arrived. *Public Health* 2009;**123:**602–14.

[50] Nugent RA, Yach D, Feigl AB. Non-communicable diseases and the Paris Declaration. *Lancet* 2009;**374:** 784–85.

[51] Anonymous. The global alliance for chronic diseases. *Lancet* 2009;**373:**2084.

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Commentary: Cardiovascular risk factors—the next epidemic in Uganda: findings from the population-based HIV/AIDS rural surveillance cohort

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Data from successive World Heath Reports provide convincing evidence that chronic non-communicable diseases (NCDs) have become the leading cause of premature deaths in low- and middle-income countries, except in sub-saharan Africa (SSA), which is still struggling predominantly with HIV/AIDS.[1,2] However, information on NCDs from SSA is scarce and most available reports are from urban areas. In this issue of *IJE*, Maher and colleagues[3] report their findings indicative of a detectable burden of high blood glucose and a significant prevalence of high blood pressure in a population-based HIV/AIDS surveillance cohort in rural Uganda.

Prevalence estimates rely heavily on sampling strategy and diagnostic criteria, including measurement accuracy. The findings of Maher and colleagues are based on the 20th annual follow-up data collected from an HIV/AIDS surveillance cohort originally established in 1989 in 25 villages in south-western rural Uganda. Of the 20 000 residents, all persons aged $\geqslant$13 years ($n = 8760$) were invited to participate in the NCD survey, primarily focused on diabetes. A total of 2719 (56.6%) males and 3959 (73.7%) females consented to participate. A random plasma glucose level >11.0 mmol/l was defined as 'probable diabetes', and between 7.0 and 11.0 mmol/l as 'probable hyperglycemia'. Individuals with a single reading of systolic BP of 140 mmHg or diastolic BP of $\geqslant$90 mmHg in the sitting positing measured with a digital (WelchAlleyn OSZ 5) device were classified as having 'probable high blood pressure'.

The overall prevalence of probable diabetes in the study participants was 0.4%, and 3% had probable hyperglycaemia. About 10% of participants did not provide blood samples for glucose determination. The HIV sero-prevalence was significantly greater