

Prevalence and awareness of diabetes in Guinea: findings from a WHO STEPS

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Aims: The aim of the present study was to determine the prevalence of diabetes, and to assess its awareness and related risk factors among adult Guineans.

Methods: A population-based cross-sectional survey was conducted on 1 100 adults (46.6% women) aged 35–64 years from Lower Guinea, during September to December 2009, using the WHO STEPwise approach of surveillance of chronic disease risk factors. Data were collected in three steps: demographic and behavioural risk factors, blood pressure and anthropometric measurements, and fasting blood cholesterol and glucose testing. A multi-stage cluster sample design was applied to generate nationwide representative data.

Results: The mean age of all participants was 47.3 years (SD 8.8), similarly in Conakry, rural Lower Guinea and urban Lower Guinea. The prevalence of diabetes was 5.7% (95% CI 4.0–8.1). Among participants with diabetes, only 44.0% were aware of their status. In multivariable logistic regression analysis, determinants of diabetes prevalence were urban residency, male sex, age group 45–64 years, increased waist circumference, hypertension and hypercholesterolemia. Male sex, rural residency, age group 45–54 years, no formal education, waist circumference, hypertension and hypercholesterolemia were independent predictors of screen-detected diabetes.

Conclusion: The present study found a high prevalence and low awareness of diabetes, suggesting the need for appropriate actions to strengthen primary healthcare approaches towards non-communicable diseases in Guinea.

Keywords: Diabetes, epidemiology, Guinea

Introduction

Diabetes mellitus and other non-communicable diseases (NCDs) including cardiovascular diseases, cancers and chronic respiratory diseases are growing public health issues worldwide.¹ Countries in sub-Saharan Africa (SSA) are now confronted with a burden of both communicable and non-communicable diseases.^{2–4} Thus, diabetes and other NCDs are increasing causes of premature deaths in Africa.^{5,6} However, reliable population-based data on the magnitude of these conditions are still lacking in significant parts of SSA.⁷ Furthermore, due to limited access to diagnosis and treatment, and lack of and misdistribution of the health workforce, people with prevalent NCDs such as diabetes in SSA are often unaware of their condition. Similarly, the few people under treatment are poorly managed and, as a result, experience poor outcomes and high complication rates.^{6,8,9} Common risk factors for diabetes in SSA include increasing age, urbanisation, physical inactivity, hypertension and obesity.^{5,10,11}

Most available prevalence figures for diabetes in Africa originate from unstandardised estimates, making comparisons between countries and regions very difficult. In the case of Guinea, the few data available to date suggest that diabetes is an important public health issue, with a prevalence of 6.5% among people aged ≥ 35 years.¹² The prevalence of undiagnosed diabetes is very high, ranging from 56% in urban areas to 100% in rural areas in the Futa Jallon region of Guinea.⁶ The availability of the World Health Organization's STEPwise approach to surveillance (STEPS) tools offers the opportunity of collecting standardised and comparable data on NCD risk factors across countries.¹³ Accordingly, the present study aimed to assess the prevalence, awareness,

treatment and control of diabetes, as well as related risk factors in Guinea, using data from a representative STEPS survey.

Methods

Study design and sample size

This study was a subnational population-based cross-sectional household survey designed according to a WHO STEPwise approach for chronic disease risk factors surveillance.¹³ A pilot study was conducted in Conakry, the most densely populated and accessible geographical area of the study region. This pilot study served to confirm the feasibility of the WHO STEPS in Conakry and in the Lower Guinea region and to adapt the protocol for the main study accordingly. The WHO STEPS comprises three steps: a structured questionnaire to assess the self-reported behavioural/lifestyle risk factors (step 1); measurement of blood pressure and anthropometric parameters (step 2); and biochemical analysis of blood samples (step 3). In 1996, Guinea had a population of just above 7 million, distributed across four natural regions (Lower Guinea, Upper Guinea, Middle Guinea or Futa Jallon, and Forest Region).¹⁴ For logistic reasons, the study was restricted to the Lower Guinea region, which includes Conakry. Conakry is the political and economic capital, with the largest urbanised population, accounting for 15% of the total population of the country.¹⁴ The Lower Guinea region is a coastal region with fishing and agriculture being the main income-generating activities. The sample size was calculated using the standard formula. It was assumed that the non-response rate would be high due to selective dropout from blood sample collection and/or low adherence to fasting requirements for blood glucose testing. A multistage stratified

cluster random sampling technique was used to recruit participants. Based on the proposed methodology of the STEPS approach, a sample size of 1 200 was estimated for each of these two strata (Conakry and Lower Guinea). The final population sample selected for the present study was 2 491 individuals.

Sampling of survey sites, households and eligible participants

The clusters were used as survey sites. Administratively, Guinea is divided into eight regions, three of which form Lower Guinea. Each region is further sub-divided into districts and the National Statistic Direction clusters each district into sectors. A cluster was defined as a neighbourhood in an urban and a locality in a rural area. The number of households per cluster ranged from 145 to 218 in rural and 218 to 327 in urban areas.

The number of clusters required from each district was randomly selected from the list of National Statistic Direction. We pre-specified the number of households to be selected per cluster to 40. Therefore, to reach the required sample size, the total number of clusters selected was 63 clusters (2 491/40). In each cluster, 40 households were randomly selected using a systematic sampling method. At household level, only one eligible participant was automatically randomly selected using the Kish sampling method, and a built-in personal digital assistant (PDA, HP iPAQ [Hewlett Packard, Palo Alto, CA, USA]).

Recruitment of participants and data collection

Eligible participants were between 15 and 64 years old, and recruitment was conducted over two consecutive days for each participant. On day one the questionnaire was administered and anthropometric measurements performed, while blood pressure measurements and laboratory tests were performed on day two. Formal written consent was obtained from each selected participant. Participants with abnormal physical or laboratory examination as defined below were counselled and referred to their nearest health facility for further examination and follow-up. Physical measurements and laboratory tests were performed by nurses and clinical officers who conducted the interviews. A total of five survey teams, each with five members, were deployed to collect data over a period of 20 days between September and December 2009.

Demographic and lifestyle data collection

Demographic and lifestyle data were collected using the WHO STEPS questionnaire. The questionnaire was programmed on PDA to collect the core (age, sex and education level), expanded (rural/urban setting, occupation, average household income) and optional (marital status, medical and health history) variables.

The medical and health history component included questions on medications, existing diabetes mellitus and hypertension. The French questionnaire was translated into the main local languages (Sussu, Fulani, Maninka and Nguerze) for those participants who do not understand French.

Biochemical measurements

On the first day of the survey, participants were asked to observe an overnight fast, except water as beverage after supper/dinner until the next visit of the survey team in the morning of the following day (day 2). Participants were then asked to converge at the agreed gathering places in their community where finger-prick blood samples were taken. Fasting blood glucose and total cholesterol were measured using Accutrend® Plus devices

(Roche, Mannheim, Germany). The machines were calibrated every day using the glucose and cholesterol control strips as per the manufacturer's instructions.

Variables, measures and definitions

The socio-demographic variables included were age group, sex, and level of education (none, primary/secondary school and higher). Locality was classified as Conakry, Urban and Rural areas of Lower Guinea. Body mass index (BMI) was calculated as weight in kilograms (kg) divided by height in square metres (m²). Overweight was defined as BMI 25–29.9 kg/m² and obesity as BMI ≥ 30 kg/m². Waist circumference was measured using a flexible tape. Hypertension was defined as a systolic (SBP) ≥ 140 mmHg and/or a diastolic blood pressure (DBP) ≥ 90 mmHg or current treatment with antihypertensive agents.¹⁵

Pre-diabetes was defined as impaired fasting glucose (IFG) ≥ 6.1 mmol/L (110 mg/dl) and < 7.0 mmol/L (126 mg/dl). Diabetes was defined as fasting capillary blood glucose ≥ 7.0 mmol/L (≥ 126 mg/dl) or currently on medication for diabetes mellitus (documented in the health booklet).¹⁶ Participants with diabetes were considered to be aware of their status if they answered 'yes' to the question 'Have you ever been told by a doctor or health professional that you had diabetes?'. As HbA1c was not performed in this study, glycaemia was considered controlled if fasting capillary glucose ≤ 7.0 mmol/L (126 mg/dl) for participants who were aware of their diabetes status. Hypercholesterolemia was defined as total cholesterol ≥ 200 mg/L (≥5.2 mmol/L) or previous diagnosis and on drug treatment.¹⁷

Data management and statistical analysis strategy

Data were collected electronically using PDAs programmed with WHO e-STEPS software. Data on the PDAs were downloaded onto a computer with WHO NCD STEPS software installed. Data were weighted by calculating sample weights for all records using the probability of selection at each stage of sampling. Thus, for each participant his/her weight was calculated by multiplying the probability of the cluster's selection by the probability of household selection, the probability of participant selection within the household and age–sex population distribution in Guinea. The participant's weight was equal to the inverse of this product. For this paper, participants between the ages of 35 years and 64 years were included because of the high risk of type 2 diabetes in this age group.^{6,9} Thus, a total of 1 100 people out of 2 491 were analysed.

The prevalence of diabetes and pre-diabetes was calculated as the total number of people with diabetes or pre-diabetes respectively, divided by the total study sample, presented as a percentage. Results are summarised as count and percentages for categorical variables and mean and standard deviation (SD) for quantitative variables, separately for men and women. Age-sex standardised prevalence was calculated using the latest Guinea national population's age structure in 1996 as the standard population, and direct standardisation methods.¹⁴ Ninety-five per cent confidence intervals were calculated for prevalence. Comparison of groups was done using chi-square tests for categorical variables, and Student's t-test and analysis of variance (ANOVA) for quantitative variables.

Logistic regression analyses with weighted data were used to investigate potential determinants of diabetes or undiagnosed diabetes. We conducted stratified analysis by sex and all variables found to be associated with diabetes ($p < 0.10$) in bivariate analyses were entered into a multivariable logistic regression

model. Multivariate logistic regression modelling, using forward selection methods, was performed to examine factors associated with diabetes, or undiagnosed diabetes independently. Candidate predictors were age groups (35–44, 45–54 and 55–64 years), sex, education (no formal education, primary and higher school), setting (urban for localities of Conakry and urban Lower Guinea, rural for rural Lower Guinea), BMI (< 25, 25–29.9 and ≥ 30 kg/m²), waist circumference (< 94 cm (men)/< 80 cm (women) and ≥ 94 cm (men)/ ≥ 80 cm (women)), hypertension and hypercholesterolemia status. Interaction terms with sex or setting were tested and lack of multicollinearity between the independent variables of the model was verified. Further, a fully adjusted model was established. This model is based on the earlier Hosmer–Lemeshow test. A *p*-value < 0.05 indicated statistically significant results. Data analysis was conducted using SAS (version 9.3; SAS Institute, Cary, NC, USA).

Ethics statement

The study was approved by the National Ethical Committee of Guinea. Participants detected with disease and abnormal findings were referred for treatment to an appropriate health facility. Informed consent was obtained from all individuals selected for the study. All data were analysed anonymously, according to the Declaration of Helsinki.¹⁸

Results

The overall profile of the 1 100 participants (512 women; 46.6%) included is provided in Table 1. The majority (60.9%) of participants were urban dwellers (Conakry and urban Lower Guinea residents). The mean age of participants was 47.3 years (SD 8.8), similarly in Conakry, rural Lower Guinea and urban Lower Guinea. Participants from rural areas in Lower Guinea frequently had no formal education and had a lower prevalence of hypercholesterolemia than par-

Table 1: General characteristics of the study population overall and by locality among adults in Guinea

Characteristic		Total (%)	Conakry (%)	Urban Lower Guinea (%)	Rural Lower Guinea (%)	<i>p</i> -value	Total age–sex standardised (%) ^a
<i>n</i>		1 100	449	221	430		
Sex	Female	512 (46.5%)	221 (49.2%)	112 (50.7%)	179 (41.6%)	0.03	(52.5%)
	Male	588 (53.5%)	228 (50.8%)	109 (49.3%)	251 (58.4%)		(47.5%)
Age	35–44	451 (41.0%)	186 (41.4%)	85 (38.5%)	180 (41.9%)	0.88	(47.7%)
	45–54	373 (33.9%)	155 (34.5%)	76 (34.4%)	142 (33.0%)		(31.8%)
	55–64	276 (25.1%)	108 (25.1%)	60 (27.2%)	108 (25.1%)		(20.5%)
Mean age, years (±SD)		47.3 (±8.8)	47.2 (±8.7)	47.8 (±8.6)	47.0 (±9.1)	0.53	45.9 (±8.6)
Education	No formal education	671 (61.0%)	200 (44.5%)	108 (48.9%)	363 (84.4%)	< 0.001	(67.5%)
	Primary and high	429 (39.0%)	249 (55.5%)	113 (51.1%)	67 (15.6%)		(32.5%)
Hypertension	Yes	553 (50.3%)	218 (48.6%)	127 (57.5%)	208 (48.4%)	0.04	(50.3%)
	No	547 (49.7%)	231 (51.4%)	94 (42.5%)	222 (51.6%)		(49.7%)
Mean systolic blood pressure (±SD)		142.3 (±26.8)	139.5 (±25.8)	147.3 (±28.7)	142.6 (±26.5)	0.002	142.1 (±26.2)
Mean diastolic blood pressure (±SD)		85.2 (±13.9)	85.3 (±14.5)	88.5 (±14.5)	83.3 (±12.7)	< 0.001	85.2 (±13.8)
Hypercholesterolemia ^b	< 200 mg/L	956 (88.8%)	366 (83.9%)	181 (82.3%)	409 (97.1%)	< 0.001	(90.7%)
	≥ 200 mg/L	121 (11.2%)	70 (16.1%)	39 (17.7%)	12 (2.9%)		(9.3%)
Mean cholesterol, mg/L (±SD)		168.8 (±23.5)	174.8 (±26.1)	174.7 (±25.3)	159.7 (±15.3)	< 0.001	166.7 (±22.5)
BMI (kg/m ²) ^c	<25	732 (68.1%)	269 (61.5%)	118 (53.9%)	345 (82.3%)	< 0.001	(69.3%)
	25–29.9	221 (20.6%)	93 (21.3%)	66 (30.1%)	62 (14.8%)		(21.2%)
	≥ 30	122 (11.3%)	75 (17.2%)	35 (16.0%)	12 (2.9%)		(9.5%)
Mean body mass index, kg/m ² (±SD)		23.8 (±5.6)	24.9 (±6.4)	25.3 (±5.7)	21.8 (±3.7)	< 0.001	23.6 (±5.3)
Waist circumference (cm)	≥ 80 (women) or ≥ 94 (men)	446 (40.5%)	218 (48.6%)	116 (52.5%)	112 (26.0%)	< 0.001	(40.7%)
	< 80 (women) or < 94 (men)	654 (59.5%)	231 (51.4%)	105 (47.5%)	318 (74.0%)		(59.3%)
Mean waist circumference (±SD)		85.4 (±13.0)	87.8 (±13.7)	88.1 (±15.1)	81.4 (±9.7)	< 0.001	84.8 (±12.5)
Mean glycaemia, mg/dl (±SD)		79.8 (±30.6)	80.2 (±30.55)	79.5 (±30.2)	79.4 (±30.9)	0.96	77.9 (±28.2)

^aAge and sex standardised according to the 1996 Guinean national population distribution; SD = standard deviation; BMI = body mass index.

^bHypercholesterolemia was missing from 23 subjects.

^cBMI was missing from 25 subjects; data are presented as the mean (standard deviation, SD) or number (percentage).

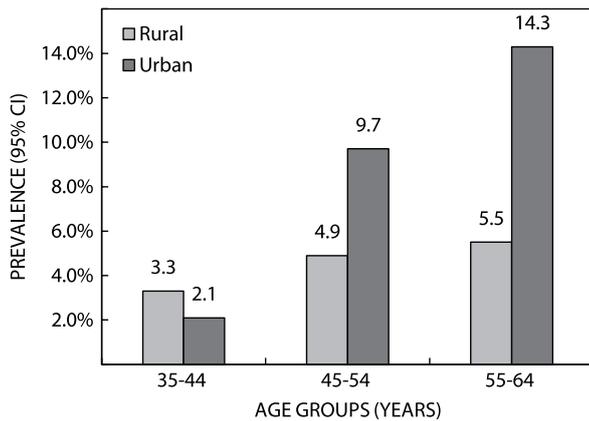


Figure 1: Prevalence of diabetes in the adult population in Guinea by age group (35–44, 45–54, 55–64) and by area (rural and urban). Data presented are percentage of patients with diabetes within each group.

participants in Conakry and urban Lower Guinea (all $p < 0.0001$). Women were significantly heavier, less educated, and had a higher prevalence of hypercholesterolemia than men ($p < 0.0001$).

The age–sex standardised prevalence of diabetes was 5.7% (95% CI 4.0–8.1) overall, 6.4% (4.2–9.7) in women and 4.9% (3.2–7.4) in men, $p < 0.0001$. The standardised prevalence of diabetes increased significantly with age in both rural and urban areas, $p < 0.0001$ (Figure 1). Overall, this prevalence was lowest in the age group 35–44 years (2.8%: 1.1–6.6) and highest in the age group 55–64 years (9.9%: 6.1–15.5). The prevalence of diabetes was higher among urban participants (7.4%: 5.3–10.2) than rural participants (4.2%: 1.9–9.1), $p < 0.0001$. The prevalence of diabetes across other major subgroups was 4.7% (non-obese) and 16.1% (obese, $p < 0.0001$); 2.3% (no hypertension) and 9.1% (hypertension, $p < 0.0001$); and 5.1% (no hypercholesterolemia) vs. 12.8% (hypercholesterolemia, $p < 0.0001$).

Age–sex standardised prevalence of awareness, treatment and control of diabetes

Table 2 shows that age–sex standardized prevalence of awareness among diabetic participants was significantly higher in Conakry (60.4%) and urban Lower Guinea (57.3%) than rural Lower Guinea (11.3%), $p < 0.0001$. Among all participants with diabetes, 58.8% (39.7–75.5) were undiagnosed before the survey. The prevalence of screen-detected diabetes across other major subgroups was 59.2% (men) and 58.4% (women, $p = 0.2$); 82.6% (35–44 years), 65.9% (45–54 years) and 34.7% (54–64 years, $p < 0.0001$); 71.3% (no formal education), 32.8% (primary and high school, $p < 0.0001$); 58.2% (non-obese) and 60.4% (obese, $p = 0.001$); 70.6% (no hypertension) and 55.7% (hypertension, $p < 0.0001$); and 63.7% (no hypercholesterolemia) vs. 39.2% (hypercholesterolemia, $p < 0.0001$).

The age–sex standardised treatment rate for diabetes was 53.6% among aware diabetic subjects (Table 2). Among diabetes subjects on treatment, insulin alone (25.2%), oral glucose control agents alone (23.5%) and the combination of both (4.9%) were the main treatment regimens. Furthermore 27.3% of diabetic participants on treatment were also using herbal/traditional medicines. Among all of the diabetic subjects, the prevalence of current use of herbal/traditional medicines was 28.1%.

Of the diabetic participants receiving treatments, blood sugar was at target control levels in 66.3% (Table 2). The age–sex standardised prevalence of controlled glycaemia among diabetics was 57.5% (insulin alone), 75.4% (oral glucose control agents alone) and 61.4% (oral glucose control agents + insulin, $p < 0.0001$).

Table 3 shows the characteristics associated with diabetes in a logistic regression. In multivariable models without interaction terms, diabetes was significantly associated with male sex (odds ratio: 1.40 [95% confidence interval: 1.36–1.44]), urban setting (1.30 [1.26–1.34]), age 45–54 (2.00 [1.93–2.06]), age 55–64 (2.37 [2.29–2.46]), no formal education (1.15 [1.11–1.18]), waist

Table 2: Prevalence, undiagnosed diabetes status, awareness, treatment and control of diabetes and pre-diabetes by locality

Condition	Overall n (%)	Overall standardized % (95% CI)	Standardized % (95% CI)			p-value
			Conakry	Urban Lower Guinea	Rural Lower Guinea	
<i>n</i>	<i>n</i> = 1 100		<i>n</i> = 449	<i>n</i> = 221	<i>n</i> = 430	
Pre-diabetes	10 (0.9%)	0.9 (0.4–2.0)	1.3 (0.5–3.4)	0.6 (0.1–4.2)	0.7 (0.2–3.1)	< 0.001
Diabetes						
FBG > 7.0 mmol/L or treatment	75 (6.8%)	5.7 (4.0–8.1)	7.3 (4.9–10.9)	7.5 (4.4–12.4)	4.2 (2.5–6.9)	< 0.001
Screened-detected diabetes among diabetics	42 (56.0%)	58.8 (43.8–72.2)	39.6 (22.2–60.1)	42.7 (19.8–69.3)	88.7 (69.2–96.5)	
Awareness among diabetics	33 (44.0%)	41.2 (27.8–56.2)	60.4 (39.9–77.8)	57.3 (30.7–80.2)	11.3 (3.5–30.8)	< 0.001
Treatment among aware diabetics	21 (63.6%)	53.6 (30.9–74.9)	55.0 (25.9–81.1)	46.8 (16.6–79.5)	58.1 (10.9–94.0)	< 0.001
Control among treated diabetics ^a	9 (45.0%)	66.3 (37.1–86.7)	94.4 (73.4–99.0)	8.1 (0.8–48.7)	–	< 0.001

Notes: FBG, fasting blood glucose; CI, confidence interval.

Age and sex standardized according to the 1996 Guinean national population distribution.

All tests were two-sided and a p-value of < 0.05 was considered statistically significant.

^aFBG was missing from 1 subject.

Table 3: Crude and adjusted odds ratios for associated risk factors of diabetes among adults in Guinea

Variable	Crude OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Sex		< 0.0001		< 0.0001
Female	1.00 (reference)		1.00 (reference)	
Male	0.75 (0.73–0.77)		1.40 (1.36–1.44)	
Setting		< 0.0001		< 0.0001
Rural	1.00 (reference)		1.00 (reference)	
Urban	1.82 (1.77–1.87)		1.30 (1.26–1.34)	
Age groups		< 0.0001		< 0.0001
35–44	1.00 (reference)		1.00 (reference)	
45–54	2.83 (2.74–2.92)		2.00 (1.93–2.06)	
55–64	3.84 (3.72–3.97)		2.37 (2.29–2.46)	
Education level		0.45		< 0.0001
Primary and high school	1.00 (reference)		1.00 (reference)	
No formal education	0.99 (0.96–1.02)		1.15 (1.11–1.18)	
BMI (kg/m ²)		< 0.0001		
< 25	1.00 (reference)			
25–29.99	1.83 (1.78–1.89)			
≥ 30	4.63 (4.49–4.77)			
Waist circumference		< 0.0001		< 0.0001
< 80 cm (women) or < 94 cm (men)	1.00 (reference)		1.00 (reference)	
≥ 80 cm (women) or ≥ 94 cm (men)	3.25 (3.17–3.33)		2.78 (2.70–2.88)	
Hypertensive		< 0.0001		< 0.0001
No	1.00 (reference)		1.00 (reference)	
Yes	4.15 (4.03–4.28)		2.94 (2.85–3.03)	
Hypercholesterolemia		< 0.0001		< 0.0001
< 200 mg/L	1.00 (reference)		1.00 (reference)	
≥ 200 mg/L	2.72 (2.63–3.80)		1.48 (1.43–1.54)	

Notes: BMI = body mass index; CI, = confidence interval. Associations were studied using stepwise logistic regression and expressed as odds ratios (ORs) with 95% confidence intervals (CIs).

circumference (2.78 [2.70–2.88]), hypertension (2.94 [2.85–3.03]) and hypercholesterolemia (1.48 [1.43–1.54]). The interactions between sex and setting, age, education level, waist circumference, hypertension and hypercholesterolemia were significant (all $p < 0.0001$). The interactions between setting and age, education level, waist circumference, hypertension and hypercholesterolemia were significant (all $p \leq 0.01$). After stratifying the data by sex, age 45–54 (1.48 [1.42–1.54]), age 55–64 (1.54 [1.47–1.61]), waist circumference (4.69 [4.43–4.97]), and hypertension (5.46 [5.21–5.73]) were significantly and positively associated with diabetes among females (Table 4); while urban setting (0.90 [0.86–0.94]), hypercholesterolemia (0.85 [0.81–0.90]) and no formal education (0.74 [0.71–0.77]) were inversely associated with diabetes risk. Urban setting (1.96 [1.87–2.05]), age 45–54 (4.36 [4.08–4.66]), age 55–64 (6.16 [5.76–6.58]), no formal education (1.89 [1.81–1.97]), waist circumference (1.90 [1.81–1.99]), hypertension (1.49 [1.43–1.56]) and

Table 4: Adjusted odds ratios for associated risk factors of diabetes by sex and setting in Guinea

Variables	Female		Male		
	Adjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value	
Urban setting	0.90 (0.86–0.94)	< 0.0001	1.96 (1.87–2.05)	< 0.0001	
Age groups					
45–54	1.48 (1.42–1.54)	< 0.0001	4.36 (4.08–4.66)	< 0.0001	
55–64	1.54 (1.47–1.61)		6.16 (5.76–6.58)		
No formal education	0.74 (0.71–0.77)	< 0.0001	1.89 (1.81–1.97)	< 0.0001	
Waist					
≥ 80 (women) or ≥ 94 (men)	4.69 (4.43–4.97)	< 0.0001	1.90 (1.81–1.99)	< 0.0001	
Hypertensive	Yes	5.46 (5.21–5.73)	< 0.0001	1.49 (1.43–1.56)	< 0.0001
Hypercholesterolemia	Yes	0.85 (0.81–0.90)	< 0.0001	3.09 (2.95–3.25)	< 0.0001
			Urban	Rural	
			Adjusted OR (95% CI)	p-value	
Male			1.64 (1.57–1.71)	< 0.0001	
			1.32 (1.26–1.39)	< 0.0001	
Age groups					
45–54	3.25 (3.09–3.41)	< 0.0001	1.51 (1.43–1.58)	< 0.0001	
55–64	4.66 (4.42–4.91)		1.16 (1.11–1.23)		
No formal education	0.96 (0.93–0.99)	0.02	1.83 (1.71–1.96)	< 0.0001	
Waist					
≥ 80 (women) or ≥ 94 (men)	2.44 (2.34–2.55)	< 0.0001	3.92 (3.74–4.12)	< 0.0001	
Hypertensive	Yes	3.69 (3.53–3.85)	< 0.0001	2.15 (2.06–2.25)	< 0.0001
Hypercholesterolemia	Yes	1.42 (1.37–1.48)	< 0.0001	1.57 (1.42–1.74)	< 0.0001

Note: CI = confidence interval.

hypercholesterolemia (3.09 [2.95–3.25]) were positively associated with diabetes among males.

In the urban setting, diabetes was positively associated with male sex (1.64 [1.57–1.71]), age 45–54 (3.25 [3.09–3.41]), age 55–64 (4.66 [4.42–4.91]), waist circumference (2.44 [2.34–2.55]), hypertension (3.69 [3.53–3.85]) and hypercholesterolemia (1.42 [1.37–1.48]) (Table 4); while no formal education (0.96 [0.93–0.99]), was inversely associated with diabetes risk. In the rural population, diabetes was positively associated with male sex (1.32 [1.26–1.39]), age 45–54 (1.51 [1.43–1.58]), age 55–64 (1.16 [1.11–1.23]), no formal education (1.83 [1.71–1.96]), waist circumference (3.92 [3.74–4.12]), hypertension (2.15 [2.06–2.25]) and hypercholesterolemia (1.57 [1.42–1.74]).

In the subsample short of participants without diabetes known before study, male sex (odds ratio 2.03 [95% CI 1.95–2.11]), rural resi-

dency (1.57 [1.52–1.63]), age group 45–54 years (1.82 [1.75–1.89]), no formal education (2.29 [2.19–2.39]), waist circumference (4.81 [4.61–5.02]), hypertension (2.55 [2.45–2.64]) and hypercholesterolemia (1.39 [1.32–1.47]) were significant predictors of screen-detected diabetes; while age group 55–64 years (0.93 [0.89–0.98]) was inversely associated with screen-detected diabetes risk.

Discussion

This study, the largest and the most representative in the country since the Futa Jallon study, has confirmed the high prevalence of diabetes among Guinean populations, and highlighted the critical need for action in prevention and early detection of the disease.¹² Indeed, while almost 7 in 100 adults in the study had prevalent diabetes, over half of those with the disease were discovered only during the survey. There was further evidence that the drivers of diabetes in this population were largely those already reported in other African populations and in particular advanced age, waist circumference and adiposity, while low education and rural residency emerged as drivers of low awareness of existing diabetes. The age–sex standardised prevalence of diabetes was high in this Guinean study, particularly among urban dwellers and the age group 55–64 years. Our overall prevalence is consistent with findings from the Futa Jallon study in Guinea.¹² Our findings are, however, likely more representative of the Guinean population, considering that the study was also conducted in Conakry where all major ethnic groups of the country are represented. Data available from STEPS surveys conducted in other Western African countries have revealed various prevalences of diabetes mellitus: Togo 2.6%; Benin 3.0%; Ghana 4.5%; Mauritania 6.2%; Liberia 19.2%; and Niger 22.5%.¹⁹ The results of some studies reveal considerable between-country variation in the prevalence of diabetes mellitus among adults.^{6,20} As expected, our data reported that urban settings have a higher prevalence of diabetes than rural. Finding from various studies have shown a positive rural–urban gradient in prevalence of diabetes.^{6,11} Some studies showed that urbanisation and economic development are increasing the prevalence of diabetes by about 40%.^{6,21} Among participants identified as having diabetes, the prevalence of screen-detected cases of diabetes was 58.8%, and particularly high in rural areas. A similar finding was reported in previous studies in Guinea and North West Ethiopia.^{12,22} All of the prevalence surveys in Africa that recorded proportions of previously undiagnosed diabetes among participants who attended screening programmes found very high levels ($\geq 40\%$).⁹ The high rates of screen-detected diabetes suggest that existing screening practices in the region are not effective.⁹ A systematic search for diabetes in the follow-up reports of hypertensive subjects could explain why these subjects with hypertension were more aware of their diabetes. The low treatment and control rates in our study reflect the interplay between many individual/household and health-system level factors, many of which were not directly captured in the current study. These include among others poor access to health facilities, availability and affordability of drugs, poor dietary habits and poverty.^{6,8,9,11} In this study, 57.5% taking insulin had controlled glycaemia. This observation most likely reflects the phenomenon of reverse causality, i.e. more intensive treatment being required with the presence of elevated glycaemia. Some other studies have reported the same.^{8,23} However, this result should be considered with caution as we used only a punctual fasting blood glucose less than 126 mg/dl as glycaemia control criterion. Indeed, diabetes control should be assessed by glycated haemoglobin, which was not available in the conditions of the study. The associations of screened detected diabetes with low education in our sample likely reflect the low

health literacy among people with limited formal education, but also possibly the effects of low socio-economic status, considering that low education is a good surrogate of low socio-economic position, a major determinant of the access to health care.²⁴

In the current study, male, urban setting, increasing age, waist circumference, hypertension and hypercholesterolemia were the major variables steady associated with diabetes, which is consistent with other reports.^{12,25–27} Other findings from this study show that diabetes is associated with major modifiable cardiovascular risk factors including hypertension, waist circumference and hypercholesterolemia, reflecting the constellation of cardiometabolic risk factors. Indeed, metabolic syndrome has been reported at a high frequency among Guinean people with type 2 diabetes, of which hypertension and obesity were principal components.²⁸ This constellation of risk factors likely indicates the importance of an absolute risk approach to cardiometabolic risk reduction in this population, as opposed to strategies based on single risk factors.

Among the limitations of the present study is its cross-sectional design. We cannot therefore demonstrate causality of the association with the factors evident in the present study. Also, we did not analyse the nutritional status or physical activity in this study, which are well-known risk factors for diabetes and dysglycaemia. The second limitation is related to the fact that diagnosis of diabetes was based on a fasting glucose test only. Without oral glucose tolerance test results, the estimated prevalence of 6.6% could be lower than the real prevalence, considering that early-stage diabetes among Africans tends to be reflected more on post-load and not fasting glucose. Indeed, in a report from South Africa, the prevalence of diabetes was 36% lower (2.5% vs. 3.9%) when only fasting plasma glucose results were used than when an oral glucose tolerance test was used.²⁵ Glycated haemoglobin (HbA1c) is the gold-standard marker to assess the control of diabetes. The FBG used in this study is a limitation in this respect and was only intended to show a general trend. We did not include individuals older than 64 years, an age group in which the prevalence of diabetes is likely to be particularly high.²⁹ Despite these limitations, this study provides important data regarding the prevalence and the factors associated with diabetes, and information on diabetes care in Guinea.

Conclusion

This study has confirmed the high prevalence of diabetes and assessed the related risk factors in the region of Lower Guinea including Conakry. Because of this high prevalence, which mostly comprised prevalent undiagnosed diabetes that tends to be more predominant in some segments of the population, there is a substantial margin to consider targeted screening a strategy to improve diabetes detection in this population. Such strategies should ultimately include actions to prevent the development of the disease among those with identified risk factors of diabetes.

Conflict of interest statement – The authors declare that they have no conflict of interest with this submission.

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References

1. Guariguata L, Whiting DR, Hambleton I, Beagley J, Linnenkamp U, Shaw JE. Global estimates of diabetes prevalence for 2013 and projections for 2035. *Diabetes Res Clin Pract.* 2014;103:137–49. doi:10.1016/j.diabres.2013.11.002.
2. Maher D, Sekajugo J. Health transition in Africa: practical policy proposals for primary care. *Bull World Health Organ.* 2010;88: 943–8. doi:10.1590/S0042-96862010001200016.
3. Mathers CD, Loncar D. Projections of global mortality and burden of disease from 2000 to 2030. *PLoS Med.* 2002;2006(3):e442. doi:10.1371/journal.pmed.0030442.
4. Kengne AP, Mayosi BM. Readiness of the primary care system for non-communicable diseases in sub-Saharan Africa. *Lancet Glob Health.* 2014;2:e247–8. doi:10.1016/S2214-109X(14)70212-8.
5. Assah FK, Mbanya J-C. Diabetes in sub-Saharan Africa—overview of a looming health challenge. *Eur Endocrinol.* 2009;5:13–7. <https://doi.org/10.17925/EE.2009.05.00.13>
6. Mbanya JCN, Motala AA, Sobngwi E, Assah FK, Enoru ST. Diabetes in sub-Saharan Africa. *The Lancet.* 2010;375:2254–66. doi:10.1016/S0140-6736(10)60550-8.
7. Rathmann W, Giani G. Global Prevalence of diabetes: estimates for the year 2000 and projections for 2030. *Diabetes Care.* 2004;27:2568–9. doi:10.2337/diacare.27.10.2568.
8. Camara A, Baldé NM, Sobngwi-Tambekou J, Kengne AP, Diallo MM, Tchatchoua APK, et al. Poor glycemic control in type 2 diabetes in the South of the Sahara: The issue of limited access to an HbA1c test. *Diabetes Res Clin Pract.* 2015;108: 187–92. doi:10.1016/j.diabres.2014.08.025.
9. Hall V, Thomsen RW, Henriksen O, Lohse N. Diabetes in Sub Saharan Africa 1999-2011: epidemiology and public health implications. *Syst Rev BMC Public Health.* 2011;11:564. <https://doi.org/10.1186/1471-2458-11-564>
10. Mbanya JC, Assah FK, Saji J, Atanga EN. Obesity and Type 2 Diabetes in Sub-Sahara Africa. *Curr Diab Rep.* 2014 Jul;1(14):1–8.
11. Levitt NS. Diabetes in Africa: epidemiology, management and healthcare challenges. *Heart.* 2008;94:1376–82. doi:10.1136/hrt.2008.147306.
12. Baldé N-M, Diallo I, Baldé M-D, Barry I-S, Kaba L, Diallo M-M, et al. Diabetes and impaired fasting glucose in rural and urban populations in Futa Jallon (Guinea): prevalence and associated risk factors. *Diabetes Metab.* 2007;33:114–20. doi:10.1016/j.diabet.2006.10.001.
13. Armstrong T, Bonita R. Capacity building for an integrated noncommunicable disease risk factor surveillance system in developing countries. *Ethn Dis.* 2003;13(2 Suppl 2):S13–8.
14. Bah MC. Recensement Général de la Population et de l'Habitat de 1996. Conakry: Ministère du Plan—Direction Nationale de la Statistique; 2000.
15. Organization WH. Group IS of HW, others. 2003 World Health Organization (WHO)/International Society of Hypertension (ISH) statement on management of hypertension. *J Hypertens.* 2003;21(11):1983–92.
16. World Health Organization. Definition and diagnosis of diabetes mellitus and intermediate hyperglycaemia: Report of a WHO/IDF consultation. 2006; Available from: https://apps.who.int/iris/handle/10665/43588/1/9241594934_eng.pdf
17. Executive Summary of the Third Report of the National Cholesterol Education Program (NCEP). Expert Panel on detection, evaluation, and treatment of high blood cholesterol in adults (Adult Treatment Panel III). *JAMA.* 2001;285:2486–97.
18. Wishart D. Convention cities: Helsinki. *Can Med Assoc J.* 1983;129:491–6.
19. World Health Organization. WHO/STEPS Country Reports. WHO. 2014. <https://www.who.int/chp/steps/reports/en/>
20. Hilawe EH, Yatsuya H, Kawaguchi L, et al. Differences by sex in the prevalence of diabetes mellitus, impaired fasting glycaemia and impaired glucose tolerance in sub-Saharan Africa: a systematic review and meta-analysis. *Bull World Health Organ.* 2013;91:671–82D. doi:10.2471/BLT.12.113415.
21. Ramachandran A, Mary S, Yamuna A, et al. High prevalence of diabetes and cardiovascular risk factors associated with urbanization in India. *Diabetes Care.* 2008;31:893–8. doi:10.2337/dc07-1207.
22. Abebe SM, Berhane Y, Worku A, Assefa A. Diabetes mellitus in North West Ethiopia: a community based study. *BMC Public Health.* 2014;14:97. <https://doi.org/10.1186/1471-2458-14-97>
23. Valle T, Koivisto VA, Reunanen A, et al. Glycemic control in patients with diabetes in Finland. *Diabetes Care.* 1999;22:575–9. doi:10.2337/diacare.22.4.575.
24. Danquah I, Bedu-Addo G, Terpe K-J, Micah F, Amoako YA, Awuku YA, et al. Diabetes mellitus type 2 in urban Ghana: characteristics and associated factors. *BMC Public Health.* 2012;12:210. <https://doi.org/10.1186/1471-2458-12-210>
25. 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;31:1783–1788. doi:10.2337/dc08-0212.
26. Ning G, Bloomgarden Z. Diabetes in China: prevalence, diagnosis, and control. *J Diabetes.* 2013;5:372–372. <https://doi.org/10.1111/jdb.2013.5.issue-4>
27. Islam FMA, Chakrabarti R, Islam MT. et al. Prediabetes, diagnosed and undiagnosed diabetes, their risk factors and association with knowledge of diabetes in rural Bangladesh: the Bangladesh population-based diabetes and eye study. *J Diabetes.* 2015;n/a– n/a.
28. Diallo A-M, Diallo M-M, Baldé N-M, et al. Prévalence et association des différents critères du syndrome métabolique dans une population de diabétiques de type 2, en Guinée. *Médecine Mal Métabol.* 2012;6:542–545. doi:10.1016/S1957-2557(12)70482-0.
29. Qiao Q, Hu G, Tuomilehto J, et al. Age- and sex-specific prevalence of diabetes and impaired glucose regulation in 11 Asian cohorts. *Diabetes Care.* 2003;26:1770–80. doi:10.2337/diacare.26.6.1770.

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