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Prevalence and correlates of diabetes mellitus in Uganda: a population-based national survey

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Abstract

OBJECTIVE We analysed fasting blood glucose (FBG) and other data collected as part of a population-based nationwide non-communicable disease risk factor survey, to estimate the prevalence of impaired fasting glycaemia (IFG) and diabetes mellitus and to identify associated factors in Uganda.

METHODS The nationwide cross-sectional survey was conducted between April and July 2014. Participants were adults aged 18–69 years. A multistage stratified sample design was used to produce a national representative sample. Fasting capillary glucose was measured to estimate glycaemia. Data were managed with WHO e-STEPs software and Epi Info. Stata® survey procedures were used to account for the sampling design, and sampling weights were used to account for differential probability of selection between strata.

RESULTS Of the 3689 participants, 1467 (39.8%) were males, and 2713 (73.5%) resided in the rural areas. The mean age was 35.1 years (standard deviation = 12.6) for males and 35.8 years (13.2) for females. The overall prevalence of IFG was 2.0% (95% confidence interval (CI) = 1.5–2.5%), whereas that of diabetes mellitus was 1.4% (95% CI 0.9–1.9%). The prevalence of IFG was 2.1% (95% CI 1.3–2.9%) among males and 1.9% (95% CI 1.3–2.6%) among females, whereas that of diabetes mellitus was 1.6% (95% CI 0.8–2.6%) and 1.1% (95% CI 0.6–1.7%), respectively. The prevalence of IFG was 2.6% (95% CI 1.4–3.8%) among urban and 1.9% (95% CI 1.3–2.4%) among rural residents, whereas that of diabetes mellitus was 2.7% (95% CI 1.4–4.1) and 1.0% (95% 0.5–1.6%), respectively. The majority of participants identified with hyperglycaemia (90.5% IFG and 48.9% diabetes) were not aware of their hyperglycaemic status. Factors associated with IFG were region of residence, body mass index and total cholesterol; factors associated with diabetes mellitus were age, sex, household floor finish and abdominal obesity.

CONCLUSION The prevalence of IFG and of diabetes mellitus is low in the Ugandan population, providing an opportunity for the prevention of diabetes. The majority of persons with hyperglycaemia were not aware of their hyperglycaemic status, which implies a likelihood of presenting late with complications.

keywords diabetes mellitus, non-communicable diseases, chronic disease epidemiology, Uganda

Introduction

Globally, the prevalence of diabetes mellitus alongside other non-communicable diseases (NCD), mainly cardiovascular diseases, cancers and chronic respiratory diseases, has increased [1]. In 2013, the world prevalence of diabetes among adults (aged 20–79 years) was estimated at 8.3%, affecting 382 million adults, and projected to rise beyond 592 million in fewer than 25 years [2]. In Uganda, diabetes and the other NCD were rare in the early 1900 [3], but recent data suggest that they have become significant public health problems, although the information has been generated from a few locale-specific surveys [4–10] that have included a wide age range of participants with differing methodologies and therefore do not sufficiently clarify the prevalence of diabetes in the country. Prevalence estimates for diabetes have varied from 0.4% in cross-sectional surveys around the shores of Lake Victoria [4] to 8.1% in a town close to the capital city of Kampala [9] and 9.0% in foothills of Ruwenzori Mountains in Western Uganda [10]. Type 2 diabetes is the most common form of diabetes reported, accounting for more than 90% of cases. Due to multiple barriers in accessing diagnosis and treatment, patients with diabetes were often unaware and undiagnosed and those on treatment were poorly managed [7, 8, 11, 12]. Therefore, there was need for detailed national population-based data on the prevalence and correlates of diabetes in Uganda, to inform baseline data for surveillance, policies and interventions. Thus, a nationwide population-based cross-sectional NCD risk factor survey was conducted in the months of April through June 2014. We present its findings on the prevalence and correlates of impaired fasting glycaemia (IFG) and diabetes mellitus.

Methods

The study followed the World Health Organization (WHO) STEPwise approach to surveillance (STEPS), which provides a standardised method for analysing and disseminating data on risk factors for non-communicable diseases (NCD) [13]. Detailed description of methods used to conduct the national NCD risk factor survey has been reported elsewhere [14]. Briefly, the study used a multistage stratified sample design to produce a national representative sample. The sample size was estimated using a standard formula on the basis of 50% prevalence of risk factors as no representative figures were available for the Ugandan population and multiple factors with variable prevalence were under investigation: 1.5% design effect, 95% confidence interval and margin of error of 0.05% with an expected response rate of 80% and 3 age–sex category estimates in the 18–69 year age range. A total of 350 enumeration areas (EA) selected from 2014 Uganda Population and Housing Census Mapping Frame with a target of 14 households from each EA gave a sample size of 4900. In Uganda, EA are administrative areas with boundaries mapped and delineated by the Cartographic Section of the Uganda Bureau of Statistics (UBOS) [15]. At the first stage – the EA (the Primary Sampling Unit), the sample was drawn with probability proportional to size (PPS). At the second stage – the household (the secondary sampling unit), which was the ultimate sampling unit – the sample was drawn using simple random sampling without replacement (SRS). At household level, only one eligible participant was selected using Kish sampling, a built-in method in the personal digital assistants (PDAs, HP iPAQ) used in data collection. To be eligible, an individual had to be residing or intending to reside in the household for at least 6 months, be of 18–69 years of age and be of sound mind. Households with no eligible participant were not replaced and are reflected as non-participants in the survey. The sampling and the enrolment procedure of participants are displayed in Figure 1.

St. Francis Nsambya Hospital Ethics Committee approved the study. All participants gave written informed consent.

Listing and mapping took place in January and February 2014, data collectors were trained in March, and data were collected from April to July 2014.

Data were collected in a systematic, structured manner using PDAs. The first part of the survey (Step 1) comprised the collection of socio-demographic and behavioural information. This included the Global Physical Activity Questionnaire (GPAQ) developed by WHO for physical activity surveillance across countries [16]. Housing conditions were used as a proxy for socio-economic status. Participants were asked about the finish of the floor of their dwelling with an answer in two main domains: earth and cow dung floors *vs.* cement or tiled floors. Living in a house with an earth and cow dung floor was a robust proxy of low socio-economic status in previous surveys in Uganda [17]. The second part of the survey (Step 2) comprised collection of physical measurements: height, weight, blood pressure and waist and hip circumferences. Body weight (to the nearest 0.1 kg) was measured using a calibrated digital weighing scale (SECA® 877), while the subject was barefoot and wearing light clothing. Standing height was measured using a portable stadiometer (SECA® 877) to the nearest 0.5 cm with the subject standing barefoot, back square against the stadiometer and eyes looking straight ahead. Waist and hip circumferences (to the nearest 0.5 cm) were measured using a non-stretchable standard tape measure and measurement taken midway between the lowest rib and the iliac crest with the subject standing at the end of gentle expiration and hip measurement at the level of the greater trochanters. Blood pressure was measured as previously described [14]. The third part of the survey (Step 3) comprised of the measurement of biochemical parameters in the fasting state to assess blood levels of total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C) and fasting blood glucose (FBG) using a finger-prick blood sample. Participants were informed that they would participate in the survey for 2 days: day 1 for Step 1 and Step 2 and day 2 for Step 3. For Step 3, all participants were requested to fast from food and drinks for at least 8 h overnight, and not to

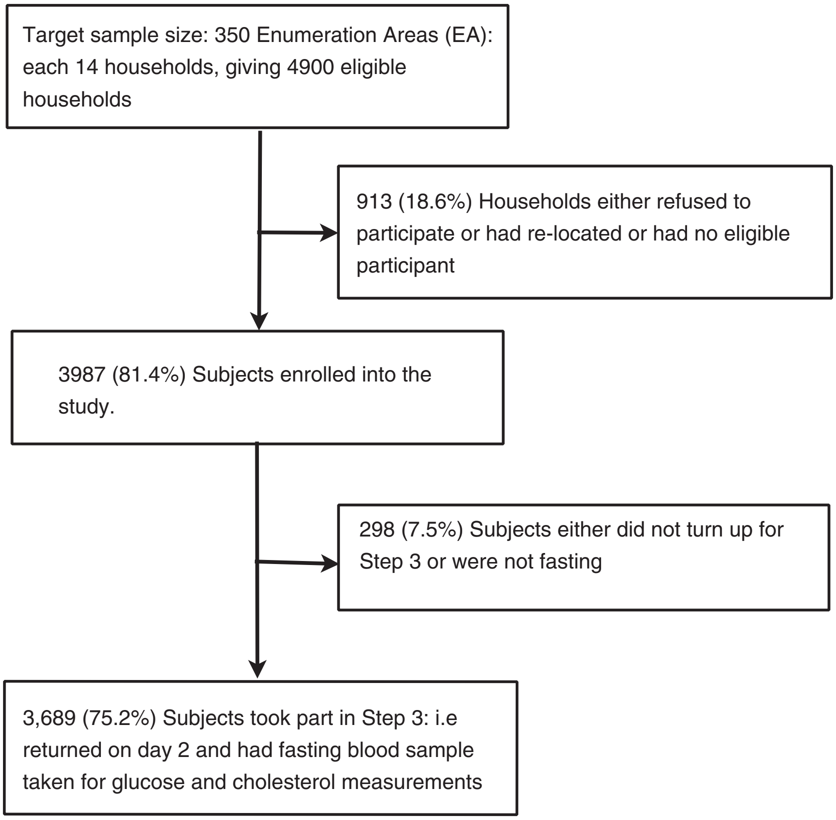

Figure 1 Flow diagram of the study selection of households and reasons for non-participation.

indulge in exercise or smoking in the morning prior to data collection. Plain water could be consumed ad lib.

Steps 1 and 2 were carried out in the participant's home. For Step 3, participants converged at an agreed place in the EA starting from 7.00 am. Most of the participants had a very short distance to walk, and if substantial distance was envisaged, they came on a motorcycle (*Boda-Boda*) or were collected by the survey team vehicle. A blood sample from a finger prick was taken for the measurement of TC, HDL-C and FBG and analysis carried out using the CardioChek® PA meter (Miller Medical Supplies). The finger was first cleaned with cotton using plain water and then dried with dry cotton. A single-use safety lancet (Unistik® 3, Comfort; Owen Mumford) was then used to prick the finger. Only those participants that reported compliance with the procedures for Step 3 (overnight 8-h fast, no exercise and no smoking in the morning of the study) were eligible for finger-prick blood sample collection.

Definitions

Impaired fasting glycaemia (IFG) was defined as fasting capillary whole blood concentration ≥6.1 mmol/l but less than 7.0 mmol/l. Diabetes mellitus was defined as fasting capillary whole blood glucose concentration ≥7.0 mmol/l or currently on medication for diabetes mellitus [18–20]. Hypertension was defined as systolic blood pressure level ≥140 mmHg and/or diastolic blood pressure level ≥90 mmHg and/or taking medications for high blood pressure [21]. Body mass index (BMI) was computed by dividing the weight (kg) by the height in metres squared (m^2) and used to develop categories of underweight, normal weight, overweight and obesity [22]. Abdominal obesity was defined as a waist circumference ≥102 cm in males and ≥88 cm in females [22]. Intensity of physical activity was expressed in metabolic equivalent task (MET) and derived from the reported questionnaire using the WHO GPAQ analysis tool [16]. Dyslipidaemia was conservatively defined as total cholesterol ≥5.0 mmol/l and/or HDL-C < 1.0 mmol/l in men and <1.3 mmol/l in women [20, 23]. Ethnicity was defined by the major ethnic tribes of Uganda according to the Uganda Bureau of Statistics [24]. We merged the ethnic tribes into three main groups (Baganda–Basoga, Banyakitara and Lugbara–Acholi–Sabiny) based on similarity of their spoken language, and a fourth group (Other Ethnic Groups) comprising the rest of the tribes.

Statistical analysis

Data management was conducted using WHO e-STEPs software and Epi Info, version 3.5.1 (Centres for Disease Control and Prevention, Atlanta, GA, USA) and Stata version 12 (StataCorp, College Station, TX, USA). Characteristics of persons with IFG or diabetes mellitus and those with normal fasting glucose were compared using chi-squared tests for categorical variables, and t-tests for continuous data. We used the Stata survey procedures to account for the sampling design and sampling weights to account for differential probability of selection between strata. We investigated factors associated with glycaemia [normoglycaemia (FBG < 6.1 mmol/l), IFG (FBG = 6.1–7.0 mmol/l) and diabetes mellitus (FBG >7.0 mmol/l or taking diabetic medicines)] using weighted multinomial logistic regression to estimate odds ratios (OR) and 95% confidence intervals (CI). Sampling selection weights were used. The independent variables of interest included socio-demographic, clinical and behavioural characteristics that we presumed would be associated with the prevalence of elevated blood glucose in the study population (Table 1). All factors of interest were included in the multivariable analysis. In the final model, a stepwise backward elimination was used to remove variables not significantly associated with hyperglycaemia (IFG and/or diabetes mellitus). Variables were removed one at a time, starting with those with largest *P*-value. A 5% level of statistical significance ($\alpha = 0.05$) was used to retain variables significantly associated with hyperglycaemia.

Results

Enrolment and characteristics of participants

A total of 3987 eligible adults participated in the national NCD risk factor survey. Of these, 3689 took part in Step 3 that included FBG measurements; 298 subjects (137 males, 161 females) did not participate; either they were found not fasting on the morning of the study, or they were not found at home despite repeated visits by the data collection team, or declined to participate (Figure 1). The proportion of the subjects who did not participate was similar across the age groups: 7.6%, 7.3% and 7.8%, respectively, for the age groups 18–29, 30–49 and 50–69 years.

Of the 3689 participants in Step 3, 1168 (31.7%) were resident in the central region, 883 (23.9%) in the eastern region, 730 (19.8%) in the northern region and 908 (24.6%) in the western region. A total of 2713 (73.5%) participants resided in rural areas. The average age of male participants was 35.1 years, with a standard deviation (SD) of 12.6, while that of female participants was 35.8 years (SD = 13.2). Table 1 summarises the socio-demographic and clinical characteristics of the participants.

Prevalence of hyperglycaemia

The overall prevalence of IFG was 2.0% (95% CI 1.5–2.5%), whereas that of diabetes mellitus was 1.4% (95% CI 0.9–1.9%). The prevalence of IFG in the urban areas was 2.6% (95% CI 1.4–3.8%), while the prevalence was 1.9% (95% CI 1.3–2.4%) in the rural areas. The prevalence of diabetes mellitus in the urban areas was 2.7% (95% CI 1.4–4.1%), while the prevalence was 1.0% (95% CI 0.5–1.6%) in the rural areas.

The prevalence of IFG and diabetes mellitus was lowest in participants residing in the eastern region of Uganda at 0.8% (95% CI 0.2–1.3%) and 0.8% (95% CI 0.1–1.5%), respectively. The prevalence of IFG was highest in the western region at 3.3% (2.0–4.6%), whereas the prevalence of diabetes mellitus was highest in the central region at 1.6% (0.5–2.8%).

The prevalence of IFG was higher at the extremes of BMI categories: 3.9% (95% CI 1.2–6.7) in the underweight category (BMI below 18.5 kg/m^2) and 2.6% (95% CI 0.5–4.8%) in the obesity category (BMI above 30.0 kg/m^2). We observed a similar trend for diabetes mellitus, with a prevalence of 1.9% (95% CI 0.1–3.7%) among participants who were underweight and 4.0% (95% CI 0.3–7.7%) among participants who were obese. The prevalence of IFG was similar in participants with and without abdominal obesity: 2.1% (95% CI 1.5–2.7%) and 2.1% (95% CI 0.9–3.4%), respectively. The prevalence of diabetes increased with abdominal obesity: 1.0% (95% CI 0.5–1.5%) and 4.3% (95% CI 1.6–6.9%) without and with abdominal obesity, respectively. The prevalence of diabetes mellitus increased with age, from 0.2% (0.0–0.5) to 2.1% (1.1–3.1) and to 2.3% (0.9–3.8) in the 18–29, 30–49 and 50–69 years age groups, respectively. Details of prevalence distribution for IFG and diabetes mellitus by the participant characteristics are presented in Table 2.

Factors associated with IFG and diabetes mellitus

Factors independently associated with impaired fasting glycaemia (IFG) were region of residence, BMI and total cholesterol (Table 3). Participants residing in the eastern region were less likely to have IFG with an adjusted odds ratio (AOD) of 0.35 (95% CI 0.14–0.86). Participants with BMI of 18.5–24.9 kg/m^2 category (normal weight for height) were less likely to have IFG, with an AOD of

Table 1 Characteristics of participants

	Males		Females		Both sexes	
	n	Weighted %	*n*	Weighted %	*n*	Weighted %
Socio-demographic/Economic Factors						
Age (years)						
18–29	601	42.0	893	42.2	1494	42.1
30–49	622	41.7	936	40.8	1558	41.2
50–69	244	16.3	393	17.0	637	16.7
Marital status						
Never married	354	25.1	218	11.5	572	17.2
Currently married	983	67.7	1481	68.5	2464	68.2
Separated/divorced/ widowed	130	7.1	519	19.9	649	14.6
Education						
No formal education	113	7.6	499	22.9	612	16.6
Primary education	597	42.6	918	41.4	1515	41.9
Secondary education	548	37.9	662	30.2	1210	33.4
University/Postgraduate education	197	12.0	139	5.5	336	8.2
Region of Residence						
Central region	483	28.0	685	27.1	1168	27.5
Eastern region	376	24.4	507	22.0	883	23.0
Northern region	255	19.5	475	22.1	730	21.0
Western region	353	28.0	555	28.8	908	28.5
Ethnicity						
Baganda–Basoga	400	24.6	411	22.8	1092	23.5
Banyakitara	355	26.2	258	27.2	963	26.8
Lugbara–Acholi–Sabiny	358	26.4	142	26.7	985	26.6
Other Ethnic Groups	353	22.8	176	23.3	945	23.1
Urbanicity						
Urban	396	18.2	580	19.3	976	18.9
Rural	1071	81.8	1642	80.7	2713	81.1
Type floor of dwelling						
Earth and cow dung	934	67.7	1460	69.4	2394	68.7
Cement/tiles	533	32.3	760	30.6	1293	31.3
Clinical indicators						
Body mass index BMI (kg/m^2)†						
<18.5	158	11.3	157	7.7	315	9.3
18.5–24.9	1095	77.1	1254	65.2	2349	70.4
25.0–29.9	148	9.2	394	19.3	542	14.9
>30.0	35	2.4	177	7.8	212	5.4
Waist circumference†						
Male <102 cm; female <88 cm	1417	98.9	1594	80.4	3011	88.5
Male ≥102 cm; female ≥88 cm	17	1.1	379	19.6	396	11.5
Blood Pressure						
BP <140/90 mmHg	1089	75.4	1683	75.9	2772	75.7
BP ≥140/90 mmHg/Medications for BP	378	24.6	539	24.1	917	24.3
Dyslipidaemia						
Total cholesterol <5.0 mmol/l	1407	96.2	2049	93.6	3456	94.6
Total cholesterol ≥5.0 mmol/l	60	3.8	173	6.4	233	5.4
HDL-C < 1.0 mmol/l males HDL-C < 1.3 mmol/l females	814	56.0	1495	68.8	2309	63.5
HDL-C ≥ 1.0 mmol/l males HDL-C ≥ 1.3 mmol/l females	653	44.0	727	31.2	1380	36.5

Table 1 (*Continued*)

	Males		Females		Both sexes	
	n	Weighted %	*n*	Weighted %	*n*	Weighted %
Physical activity†						
Physical activity <600 METS/Week	254	17.5	475	22.3	729	20.3
Physical activity ≥600 METS/Week	1184	82.5	1671	77.7	2855	79.7

n, number in the group; %, column weighted percentage of the group; BMI, body mass index; BP, blood pressure; HDL-C, high-density cholesterol; METS, metabolic equivalent task.
†Missing data for ≥1% of participants: BMI (31 males; 240 females), waist circumference (33 males, 249 males), physical activity (29 males, 76 females).

0.34 (95% CI 0.14–0.82), while participants with total cholesterol ≥5 mmol/l were more likely to have IFG, with an AOD of 2.38 (95% CI 1.05–5.41).

Factors independently associated with diabetes mellitus were age, sex, household floor finish and waist circumference. Participants aged 30–49 years and 50–69 years were more likely to have diabetes mellitus, with AOD of 6.30 (95% CI 1.93–20.54) and AOD of 5.73 (95% CI 1.51–21.76), respectively. Females were less likely to have diabetes, with an AOD of 0.27 (95% CI 0.13–0.58). Participants living in houses with cement or tiled floors were more likely to have diabetes than participants living in households with earth and cow dung floors, with an AOD of 2.51(95% CI 1.13–5.60). Finally, participants with abdominal obesity were more likely to have diabetes mellitus, with an AOD of 10.35 (95% CI 3.34–32.04).

Other factors we investigated for association with either IFG or diabetes mellitus, but found no association included urban–rural residence, ethnicity, blood pressure status, HDL-C, intensity of physical activity and marital status.

Discussion

This is the first study to report results from a comprehensive general population-based survey on the prevalence estimates and correlates of impaired fasting glycaemia (IFG) and diabetes mellitus among persons aged 18–69 years in the Ugandan population. The findings of this study provide baseline information against which interventions for the prevention and control of diabetes in Ugandan population may be measured. The overall prevalence estimates for IFG and diabetes were low: 2.0% [95% CI 1.5–2.5%] and 1.4% [95% CI 0.9–1.9%], respectively. Among males, IFG prevalence was 2.1% and diabetes prevalence 1.6%. In females, IFG prevalence was 1.9% and diabetes prevalence 1.1%. These estimates are in agreement with previously reported prevalence estimates of IFG and diabetes in smaller studies in rural populations of Uganda [4–6]. Two studies, however, Mondo *et al.* in 2013 [10] and Lasky *et al.* in 2002 [9] reported higher diabetes prevalence estimates of 9.0% and 8.1%, respectively. These differences may be a result of the heterogeneity of diabetes across the communities [25] or from differences in health determinants across the populations [26], but also because the different studies may have used different ways of measuring and defining diabetes.

Regionally, the observed prevalence in this study is among the lowest in sub-Saharan Africa [25, 26], only similar to that reported in predominantly rural populations [27–29]. Other studies from the region have generally reported higher prevalence estimates in the general population. Hilawe *et al.* in a systematic review and meta-analysis of sub-Saharan Africa published in 2013 reported regional estimates of 4.5% for IFG and 5.7% for diabetes mellitus [26]. Dirk *et al.* in 2009 reported a prevalence of 4.2% in different ethnic groups of Kenya [30], while Motala *et al.* in 2008 reported a diabetes prevalence of 3.9% in South Africa [31] and Msyamboza *et al.* in 2014 reported a diabetes prevalence of 5.9% in Malawi [32]. Sobngwi *et al.* in 2002 reported a prevalence of 2.9% in rural women and 4.7% rural men, and 4.7% in urban women and 6.2% in urban men in Cameroon [33], while Kufe *et al.* in 2015 from the same country, but in an urban population, reported a prevalence of 5.7% IFG and 3.3% diabetes [34]. Amoah in 2002 reported a prevalence of 6.4% in the population of Greater Accra in Ghana [35]. Factors stemming from previous social strife and relating to poor socio-economic performance of the Ugandan population may underlie the low prevalence of IFG and diabetes observed in this study. Indeed, households with cement or tiled floors were associated with diabetes. Cement or tiled flooring is a proxy of a higher income than earth and cow dung flooring [17] giving credence to poor socio-economic

Table 2 Prevalence and distribution of hyperglycaemic status of participants

Characteristic	*n*	Hyperglycaemic status <6.1 mmol/l (% [95% CI])	6.1–7.0 mmol/l (% [95% CI])	≥7.0 mmol/l (% [95% CI])	*P*-value§
All participants	3689	96.6 [95.9–97.3]	2.0 [1.5–2.5]	1.4 [0.9–1.9]	
Age					
18–29	1494	97.4 [96.5–98.3]	2.3 [1.4–3.2]	0.2 [0.0–0.5]	0.001
30–49	1558	96.3 [95.1–97.5]	1.6 [1.0–2.3]	2.1 [1.1–3.1]	
50–69	637	95.5 [93.6–97.4]	2.1 [0.9–3.4]	2.3 [0.9–3.8]	
Gender					
Male	1467	96.2 [95.0–97.4]	2.1 [1.3–2.9]	1.6 [0.8–2.6]	0.421
Female	2222	97.0 [96.1–97.8]	1.9 [1.3–2.6]	1.1 [0.6–1.7]	
Marital status					
Never married	572	98.1 [96.7–99.4]	1.6 [0.4–2.9]	0.3 [-0.1–0.7]	0.009
Currently married	2464	96.7 [95.9–97.5]	2.1 [1.5–2.7]	1.2 [0.7–1.7]	
Separated/divorced/widowed	649	94.5 [91.9–97.1]	2.1 [0.9–3.2]	3.4 [1.1–5.8]	
Education					
No formal education	612	96.9 [95.4–98.4]	2.0 [0.9–3.2]	1.1 [0.2–2.0]	0.469
Primary education	1515	96.1 [94.8–97.3]	2.1 [1.3–2.9]	1.8 [0.9–2.8]	
Secondary education	1210	97.8 [96.9–98.7]	1.5 [0.8–2.2]	0.7 [0.1–1.3]	
University/Postgraduate education	336	94.2 [91.0–97.4]	3.7 [1.0–6.4]	2.1 [0.3 -3.9]	
Region of residence					
Central region	1168	95.9 [94.4–97.4]	2.4 [1.4–3.4]	1.6 [0.5–2.8]	0.010
Eastern region	883	98.4 [97.6–99.3]	0.8 [0.2–1.3]	0.8 [0.1–1.5]	
Northern region	730	97.5 [96.2–98.8]	1.1 [0.4–1.7]	1.4 [0.4–2.5]	
Western region	908	95.2 [93.6–96.8]	3.3 [2.0–4.6]	1.5 [0.6–2.4]	
Ethnicity					
Baganda–Basoga	1092	95.9 [94.2–97.6]	2.0 [1.0–3.0]	2.1 [0.7–3.5]	0.538
Banyakitara	963	96.2 [94.6–97.7]	2.6 [1.4–3.7]	1.2 [0.3–2.1]	
Lugbara–Acholi–Sabiny	985	97.1 [95.9–98.4]	1.6 [0.8–2.3]	1.3 [0.3–2.2]	
Other Ethnic Groups	945	97.3 [96.1–98.5]	1.9 [0.8–2.9]	0.8 [0.2–1.5]	
Urbanicity					
Urban	976	94.6 [92.9–96.4]	2.6 [1.4–3.8]	2.7 [1.4–4.1]	0.000
Rural	2713	97.1 [96.3–97.9]	1.9 [1.3–2.4]	1.0 [0.5–1.6]	
Type floor of Dwelling					
Earth and cow dung	1394	97.3 [96.6–98.1]	1.8 [1.2–2.3]	0.9 [0.4–1.4]	0.001
Cement/tiles	1293	95.1 [93.5–96.6]	2.6 [1.6–3.6]	2.4 [1.1–3.6]	
Clinical indicators					
Body mass index BMI (kg/m^2)†					
<18.5	315	94.2 [90.9–97.4]	3.9 [1.2–6.7]	1.9 [0.1–3.7]	0.030
18.5–24.9	2349	97.0 [96.2–97.9]	1.8 [1.2–2.4]	1.2 [0.6–1.8]	
25.0–29.9	542	96.9 [95.3–98.5]	2.1 [0.8–3.4]	1.0 [0.1–1.9]	
>30.0	212	93.4 [89.1–97.6]	2.6 [0.5–4.8]	4.0 [0.3–7.7]	
Waist circumference†					
Male <102 cm; female <88 cm	3011	96.9 [96.2–97.7]	2.1 [1.5–2.7]	1.0 [0.5–1.5]	0.000
Male ≥102 cm; female ≥88 cm	396	93.6 [90.6–96.5]	2.1 [0.9–3.4]	4.3 [1.6–6.9]	
Blood pressure					
BP <140/90 mmHg	2772	97.3 [96.6–98.1]	1.8 [1.2–2.3]	0.9 [0.4–1.4]	0.000
BP ≥140/90 mmHg/Medications for BP	917	94.4 [92.8–96.2]	2.7 [1.5–3.9]	2.8 [1.5–4.1]	
Dyslipidaemia					
Total cholesterol <5.0 mmol/l	3456	96.9 [96.2–96.2]	1.9 [1.4–2.4]	1.2 [0.7–1.6]	0.000
Total cholesterol ≥5.0 mmol/l	233	991.5 [87.2–95.7]	3.5 [1.1–5.9]	5.0 [1.4–8.6]	

Table 2 (*Continued*)

Characteristic	*n*	Hyperglycaemic status <6.1 mmol/l (% [95% CI])	6.1–7.0 mmol/l (% [95% CI])	≥7.0 mmol/l (% [95% CI])	*P*-value§
HDL-C < 1.0 mmol/l males HDL-C < 1.3 mmol/l females	2309	97.2 [96.5–98.0]	1.8 [1.2–2.4]	1.0 [0.5–1.4]	0.246
HDL-C ≥ 1.0 mmol/l males HDL-C ≥ 1.3 mmol/l females	1380	95.6 [94.2–97.0]	2.3 [1.4–3.2]	2.0 [0.9–3.1]	
Physical activity†					
Physical activity <600 METS/Week	729	96.0 [94.4–97.6]	2.1 [1.1–3.2]	1.9 [0.6–3.1]	0.397
Physical activity ≥600 METS/Week	2855	96.8 [96.0–97.6]	2.0 [1.4–2.6]	1.2 [0.6–1.7]	

N, number in the group; %, weighted row percentages; CI, confidence interval; BMI, body mass index; BP, blood pressure; HDL-C, high-density cholesterol; METS, metabolic equivalent task.
†Missing data for ≥1% of participants: BMI (31 males; 240 females), waist circumference (33 males, 249 males), physical activity (29 males, 76 females).
§*P*-value for bivariable comparison only, not adjusted for other variables.

status underlying the observed prevalence of IFG and diabetes. Residing in the eastern region of Uganda was least likely associated with IFG. The eastern region of Uganda has a high percentage of people living below the poverty line [36].

IFG is a risk state prior to diabetes and its significance is underscored in diabetes prevention strategies that identify and focus on individuals at the pre-diabetes state. Factors associated with IFG are therefore important in the prevention and control strategies for diabetes. In this study, IFG was significantly associated with raised total cholesterol with an AOD of 2.38 (95% CI: 1.05–5.41) but least likely observed in persons with normal body weight, with an AOD of 0.34 (95% CI: 0.14–0.82). The association of hyperglycaemia and dyslipidaemia is important information in prevention programmes targeting metabolic syndrome [37]. In both IFG and diabetes, the association with obesity as measured by BMI was less clear. Instead, waist circumference as a measure of adiposity (abdominal obesity) was a strong independent predictor of diabetes. Abdominal obesity has previously been found to be associated with diabetes in Uganda [4].

There was a strong association between advancing age and hyperglycaemia, consistent with other studies [4, 27, 28, 30]. Female sex was less likely associated with diabetes with an AOD of 0.29, in contrast to the findings of a systematic and meta-analysis review in sub-Saharan Africa where the male and female sex had similar diabetes prevalence estimates [26].

As observed for IFG, intensity of physical activity had no significant association with diabetes, when included in the model neither as a categorical factor nor as a continuous measurement. The lack of association, otherwise expected with physical activity and hyperglycaemia, may be a reflection of a methodological challenge in the WHO-STEPs tool for evaluation of intensity of physical activity.

The majority of persons (90.5% IFG and 48.9% diabetes) with hyperglycaemia were unaware of their hyperglycaemic status. Similar observations were made in neighbouring Tanzania [38, 39]. This may be a result of poor access to health facilities [40, 41], implying that patients with diabetes are most likely to present late, some with long-term complications of diabetes [42].

Study limitations

The diagnosis of diabetes in an individual depends on at least an initial and a confirmatory recommended standard test, if the individual is not overwhelmingly symptomatic [18], based on measuring venous fasting plasma glucose or 2 h after an oral glucose load [37]. As either approach is of limited feasibility in a national population-based survey in a low-income country, we measured fasting capillary glucose as a practical approach to estimating population-level hyperglycaemia. While the use of fasting capillary blood glucose in epidemiological studies has been reported to correlate well with venous plasma glucose [18, 43, 44], the limitation in this study was the inability to ensure that the participant adhered to the fasting state. Estimation of glycated haemoglobin (A1c), as an alternative diagnostic method, could have

Table 3 Association of participant characteristics with categories of fasting glycaemia

	Adjusted odds ratios (AOD) [95% CI]†		
Characteristic	<6.1 mmol/l	6.1–7.0 mmol/l	≥7.0 mmol/l or medications for diabetes
Age			
18–29	1	1	1
30–49	1	0.59 [0.33–1.06]	6.30** [1.93–20.54]
50–69	1	0.79 [0.36–1.75]	5.73* [1.51–21.76]
Gender			
Male	1	1	1
Female	1	1.03 [0.56–1.90]	0.27** [0.13–0.58]
Marital status			
Never married	1	1	1
Currently married	1	1.82 [0.78–4.26]	1.91 [0.27–13.50]
Separated/divorced/widowed	1	1.66 [0.58–4.76]	4.52 [0.45–45.87]
Education			
No formal education	1	1	1
Primary education	1	1.01[0.52–2.00]	1.69[0.59–4.79]
Secondary education	1	0.60[0.27–1.36]	0.51[0.11–2.33]
University/Postgraduate education	1	1.27[0.41–3.98]	0.79[0.17–3.67]
Region of Residence			
Central region	1	1	1
Eastern region	1	0.35* [0.14–0.86]	0.79 [0.21–2.97]
Northern region	1	0.41 [0.15–1.10]	2.11 [0.70–6.43]
Western region	1	1.72[0.84–3.52]	1.59 [0.53–4.82]
Ethnicity			
Baganda–Basoga	1	1	1
Banyakitara	1	0.67 [0.22–1.97]	0.34 [0.08–1.39]
Lugbara–Acholi–Sabiny	1	1.56 [0.57–4.27]	0.52 [0.08–3.44]
Other Ethnic Groups	1	1.07 [0.43–2.66]	0.38 [0.12–1.20]
Urbanicity			
Urban	1	1	1
Rural	1	1.01 [0.53–1.91]	0.55 [0.23–1.33]
Type floor of dwelling			
Earth and cow dung	1	1	1
Cement/tiles	1	1.33 [0.66–2.69]	2.51* [1.13–5.60]
Clinical indicators			
Body mass index BMI (kg/m^2)‡			
<18.5	1	1	1
18.5–24.9	1	0.34* [0.14–0.82]	0.83 [0.27–2.55]
25.0 -29.9	1	0.34 [0.10–1.12]	0.26 [0.06–1.17]
>30.0	1	0.42 [0.11–1.53]	0.36 [0.05–2.67]
Waist circumference‡			
Male <102 cm; female <88 cm	1	1	1
Male ≥102 cm; female ≥88 cm	1	0.89 [0.36–2.20]	10.35*** [3.34–32.04]
Blood pressure			
BP <140/90 mmHg	1	1	1
BP ≥140/90 mmHg/Medications for BP	1	1.68 [0.96–2.94]	1.61 [0.74–3.50]
Dyslipidaemia			
Total cholesterol <5.0 mmol/l	1	1	1
Total cholesterol ≥5.0 mmol/l	1	2.38* [1.05–5.41]	2.27 [0.62–8.26]
HDL-C < 1.0 mmol/l males HDL-C < 1.3 mmol/l females	1	1	1
HDL-C ≥ 1.0 mmol/l males HDL-C ≥ 1.3 mmol/l females	1	1.37 [0.76–2.46]	1.89 [0.84–4.23]

Table 3 (*Continued*)

Characteristic	Adjusted odds ratios (AOD) [95% CI]† <6.1 mmol/l	6.1–7.0 mmol/l	≥7.0 mmol/l or medications for diabetes
Physical activity‡			
Physical activity <600 METS/Week	1	1	1
Physical activity ≥600 METS/Week	1	1.16 [0.60–2.25]	0.58 [0.25–1.33]

CI, confidence interval; BMI, body mass index; BP, blood pressure; HDL-C, high-density cholesterol; METS, metabolic equivalent task.
†Adjusted for age category, gender, region of residence, floor finishing of dwelling, body mass index, waist circumference and total cholesterol. *$P < 0.05$; **$P < 0.01$ ***$P <$ 001.
‡Missing data for ≥1% of participants: BMI (31 males; 240 females), waist circumference (33 males, 249 males), physical activity (29 males, 76 females).

been used, but this is not currently recommended by the WHO or International Diabetes Federation (IDF) because of insufficient validation in people of different ages and ethnicity, inadequate standardisation of laboratory tests and cost [37]. A further limitation of this study was the incomplete (75.3%) participation among those identified as eligible in the sample selection. Furthermore, missing information in the survey population may limit generalisability of the study results. Participants on antidiabetic medication were considered to be diabetic; however, some may have been prescribed antidiabetic medication at a pre-diabetes stage, which might have resulted in some misclassification of IFG and diabetes.

Despite these limitations, taking into consideration feasibility, reproducibility, acceptability and local context, our study provides the first comprehensive national population data on IFG and diabetes in the Ugandan population. The study seeks to enhance public awareness on the seriousness of diabetes and its complications and the need for prevention strategies.

Conclusion

The prevalence of IFG and of diabetes mellitus is low in the Ugandan population, providing an opportunity for the prevention of diabetes. The majority of persons with hyperglycaemia were not aware of their hyperglycaemic status, implying a likelihood of presenting late with complications.

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