Open Science Journal of Clinical Medicine
2015; 3(4): 145-152
Published online August 20, 2015 (http://www.openscienceonline.com/journal/osjcm)

High Glucose Abnormalities and Its Risk Factors in Adult Patients Attending Outpatient Clinics in Banjul, the Gambia

Bernard C. Nkum[1], Frank B. Micah[1, *], Theophilus C. Ankrah[1], Ousman Nyan[2, 3], A. E. Ohwovoriole[4]

[1]Department of Medicine, School of Medical Sciences, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana
[2]Department of Medicine, Edward Francis Small Teaching Hospital, Banjul, The Gambia
[3]Medical Research Council Laboratories, Fajara, The Gambia
[4]Department of Medicine, College of Medicine of the University of Lagos, Lagos, Nigeria

Email address

fbmicah@hotmail.com (F. B. Micah)

To cite this article

Bernard C. Nkum, Frank B. Micah, Theophilus C. Ankrah, Ousman Nyan, A. E. Ohwovoriole. High Glucose Abnormalities and Its Risk Factors in Adult Patients Attending Outpatient Clinics in Banjul, the Gambia. *Open Science Journal of Clinical Medicine.* Vol. 3, No. 4, 2015, pp. 145-152.

Abstract

Background: By virtue of its potency as a risk factor and prognostic importance, the presence of an abnormal glucose tolerance in a patient deserves serious attention and makes its diagnosis a priority. *Objective:* To determine the prevalence of previously undiagnosed diabetes mellitus (PUDM), impaired fasting glucose (IFG) and impaired glucose tolerance (IGT) among patients attending clinics in Banjul, The Gambia and determine the risk factors associated with these states of abnormal glucose tolerance. Design: Cross-sectional study. *Setting:* Outpatient clinics of Royal Edward Francis Small Teaching Hospital and Medical Research Council Laboratories in Banjul. *Methods:* Two hundred and eight consecutive patients with hypertension on treatment and 108 non-hypertensive patients aged over 25years were enrolled. A questionnaire was filled and anthropometric measurements were taken. The standard oral glucose tolerance test (OGTT) was done. The WHO glucometabolic criteria was used in classifying the participants as normal OGTT, PUDM, IFG and IGT. *Results:* The mean (±SD) of blood glucose at 0min (FBG) was 5.7 (± 2.4) mmol/l while the mean (± SD) blood glucose at 120min (2HBG) was 7.7 (±2.2) mmol/l. Eighty percent had FBG of < 6.1mmol/l, 10% had FBG ≥6.1 - < 7.0mmol/l while another 10% had ≥ 7.0mmol/l. Sixty percent of participants had 2HBG < 7.8mmol/L, 32% had ≥ 7.8 - < 11.1 mmol/l and the remaining 8% ≥ 11.1mmol/l. Fifty-three percent had a normal OGTT, 4% had IFG, 29% had IGT and 15% had PUDM from the OGTT using the WHO criteria. PUDM and IGT were associated with hypertension but IFG was not associated with any of the risk factors. *Conclusion:* The prevalence of PUDM, IFG and IGT in patients attending clinics in Banjul was high. The major risk factor for PUDM and IGT was hypertension.

Keywords

Systemic Hypertension, Impaired Fasting Glucose, Impaired Glucose Tolerance, Diabetes Mellitus, Oral Glucose Tolerance Test

1. Introduction

Type 2 diabetes mellitus (DM), impaired fasting glucose (IFG) and impaired glucose tolerance (IGT) are associated with significant morbidity and mortality. [1], [2] "IFG and IGT represent intermediate states of abnormal glucose regulation that exists between normal glucose homeostasis and DM". [3] The World Health Organisation (WHO) therefore describes them as intermediate hyperglycaemia [2] while, the American Diabetes Association (ADA) refers to them as pre-diabetes. [4] These pre-diabetes states are associated with increased risk of developing DM and other cardiovascular disease. [4]

DM, pre-diabetes and obesity were rare in sub-Saharan Africa but appear increasingly prevalent with urbanization. [5], [6] IFG, IGT and DM, like other Non-Communicable Diseases (NCD) tend to be chronic, and mainly affect adults who are socially and economically responsible for the care of young as well as the elderly, so their impact and repercussions cut across all the age groups. [7]

Reported prevalence studies of DM and intermediate hyperglycaemia in The Gambia are few. To date, two main studies have been conducted and reported from The Gambia.

The first was a nationwide survey in 1996, while the second in late 1996 and 1997 was in one urban and one rural community of the country. A national prevalence rate of 0.3% for DM was obtained in the nationwide study, while in the community study a prevalence of 7.9%, 8.7%, 2.2% and 0.8% were recorded for urban men, urban women, rural men and rural women, respectively. The community study also reported in addition an IGT prevalence of 28% from an adapted oral glucose tolerance test (OGTT). These studies used a variety of techniques and definitions to identify DM and the intermediate hyperglycemic states. For instance the OGTT was an adapted one where, the subjects were not fasted overnight and therefore the authors could not report on the prevalence of IFG. [7] - [12] These definitions and criteria for the diagnosis of these abnormalities have since been significantly modified. [2]

These studies also demonstrated that the average Gambian is tall and slim, a characteristic that should mitigate against the occurrence of DM and pre-diabetes, as obesity is well known to be strongly associated with glucose intolerance. [13] The mean body mass index (BMI) was 21.6 in the first survey and 20.8 in the second while, the prevalence of obesity was 4.6% and 2.6%, respectively. However the prevalence of obesity in urban women was the highest with a prevalence of 12.2%. [7] - [12]

As part of our study to determine the relationship between left ventricular hypertrophy and insulin resistance we conducted the standard OGTT in hypertensive and non-hypertensive Gambians who were seen at outpatient clinics. [14], [15] The objective of this study was to determine the prevalence of previously undiagnosed diabetes mellitus (PUDM), IFG and IGT among patients attending clinics in Banjul, The Gambia and determine the risk factors associated with these states of abnormal glucose tolerance.

2. Materials and Methods

This is a cross sectional study conducted at the Medical Research Council (MRC) Laboratories, Fajara and the Royal Edward Francis Small Teaching Hospital (REFTH), Banjul, The Gambia. The detailed methodology has been published in our previous articles. [14], [15] Patients with hypertension reporting at the REFTH hypertension clinic were consecutively recruited into the study. The recruitment for the non- hypertensive patients was at the Gate Clinic of the MRC Laboratories, Fajara. These participants were patients reporting with minor infectious diseases who had no cardiovascular disease or DM. The participants were recruited from January to May 2000. The exclusion criteria for the study were cardiovascular disease (excluding hypertension) or labile hypertension, severe inter-current illnesses, systemic or metabolic diseases and morbid obesity. Patients who were not known DM patients but who were found to be so after OGTT were included.

By using the appropriate local language a field worker administered a questionnaire and this was followed by a physical examination undertaken by one physician. An electric scale (Secca ^{r} 770, CMS London) was used to measure the weight of participants wearing light clothes and without footwear. Standardised stadiometers was used in measuring height to the nearest 0.5 cm after participants have removed their footwear and head gear or cap. A plastic tape measure was used to record hip and waist circumferences to the nearest 0.5 cm. A digital blood pressure machines (Omron ^{r} HOM – 705 CP, Japan) was used in measuring blood pressure on the left arm. [16] Three readings were taken and the mean of the later two readings was used in the analysis. [17]

A standard OGTT was performed utilising 75g anhydrous glucose in 300- 350 ml of water. [18] The glucose levels on a fasting, 30 min and 120 min venous plasma samples were determined immediately upon taking the samples using a Haemocue analyser (Haemocue AB, Sweden).

The following definitions were adopted for this study.

1. Hypertension is systolic blood pressure (SBP) ≥ 140 and / or diastolic blood pressure (DBP) ≥ 90 mmHg in subjects who are not taking antihypertensive medication. [19]

2. Overall Obesity is Body Mass Index (BMI) ≥ 30 kg / m ^{2}. [20]

3. Central Obesity or High Waist-Hip Ratio (WHR) is WHR > 0.9 for males and > 0.8 for females. [20]

4. High Waist Circumference (WC) is WC ≥ 94cm in men or ≥ 80 cm in women. [21]

5. WHO 1999 Glucometabolic Classification [1], [2]

i. Normal glucose regulation is fasting venous blood glucose < 6.1 mmol/L and 2h post glucose capillary whole blood < 7.8 mmol/L.

ii. Impaired fasting glucose is fasting venous glucose ≥ 6.1 mmol/L and < 7.0 mmol/L and 2h post glucose capillary whole blood < 7.8 mmol/L.

iii. Impaired glucose tolerance is fasting venous glucose < 7.0 mmol/L and 2h post glucose capillary whole blood ≥ 7.8 mmol/L and < 11.1 mmol/L.

iv. Diabetes mellitus is fasting venous blood glucose ≥ 7.0 mmol/L and or 2h post glucose capillary whole blood ≥ 11.1 mmol/L.

The data was analysed using Microsoft Excel 2010 and Stata version 8.0 statistical package (Stata Corporation, College Station, Texas, USA).The percentages were calculated for discrete variables and these were compared using Pearson Chi-square test. The mean and standard deviation were used for continuous variables, and were compared using standard t-test. Further analysis using univariate and multivariate logistic and linear regression were done. P-values of less than 0.05 were taken as statistically significant.

The study was approved by The Gambia Government / MRC Ethical Committee. All the participants after careful consideration and explanation gave a formal consent by signing or thumb printing on an informed consent form.

3. Tables

Table 1. *The clinical characteristics of participants.*

Parameter	Number (%)
Sex (n = 316)	
Male	109 (34.5)
Female	207 (65.5)
Age Range (yr)	27 - 85
Family history of diabetes	44 (13.9)
History of thirst	73 (23.1)
History of polyuria	110 (34.8)
Smoking	73 (23.1)
BMI ≥ 30	82 (26.0)
High waist circumference	216 (68.4)
HIGH WHR	220 (69.6)
Hypertension	208 (65.8)
	Mean (±sd)
Age (years)	53.6 (±12.0)
Weight (kg)	71.0 (±16.1)
Height (m)	1.6 (±0.1)
BMI (kg/m2)	26.5 (±6.2)
Waist circumference (cm)	92.7 (±13.0)
Hip circumference (cm)	105.5 (±12.8)
WHR	0.88 (±0.06)
SBP (mmHg)	137.2 (±27.9)
DBP (mmHg)	83.3 (±14.5)
Blood glucose at 0 min (mmol/L)	5.7 (±2.4)
Blood glucose at 120 min (mmol/L)	7.7 (±2.2)

Table 2. *The results of OGTT at 0 and 120 minutes.*

	Number (%)
Blood glucose at 0 min (mmol/L)	
< 6.1	253 (80.1)
≥ 6.1 - < 7.0	33 (10.4)
≥ 7.0	30 (9.5)
Blood glucose at 120 min (mmol/L)	
< 7.8	180 (60.0)
≥ 7.8 - < 11.1	97 (32.3)
≥ 11.1	23 (7.7)

Table 3. *The prevalence of IFG, IGT and PUDM by sex, hypertension, age, BMI, waist circumference and waist-hip ratio.*

	Normal (%)	**IFG (%)**	**IGT (%)**	**PUDM (%)**	**Total**
Number	166 (52.5)	14 (4.4)	90 (28.5)	46 (14.6)	316
Sex					
Male	57 (52.9	5 (4.6)	34 (31.2)	13 (11.9)	109
Female	109 (52.7)	9 (4.4)	56 (27.1)	33 (15.9)	207
Hypertension					
Yes	95 (45.7)	9 (4.3)	66 (31.7)	38 (18.3)	208
No	71 (65.7)	5 (4.6)	24 (22.2)	8 (7.4)	108
Age Group (years)					
20 – 39	27 (67.5)	1 (2.5)	9 (22.5)	3 (7.5)	40
40 – 49	43 (60.6)	2 (2.8)	16 (22.5)	10 (14.1)	71
50 – 59	55 (54.5)	9 (8.9)	22 (21.8)	15 (14.9)	101
60 – 69	27 (40.3)	0 (0)	26 (38.8)	14 (20.9)	67
70 - 90	14 (37.8)	2 (5.4)	17 (46.0)	4 (10.8)	37
BMI					
Underweight	15 (65.2)	1 (4.4)	7 (30.4)	0 (0)	23
Normal	65 (52.4)	7 (5.7)	36 (29.0)	16 (12.9)	124
Overweight	46 (52.9)	4 (4.6)	24 (27.6)	13 (14.9)	87
Obesity	40 (48.8)	2 (2.4)	23 (28.1)	17 (20.7)	82
Waist circumference					
Normal	54 (54.0)	5 (5.0)	30 (30.0)	11 (11.0)	100
High	112 (51.9)	9 (4.2)	60 (27.8)	35 (16.2)	216
Waist-Hip ratio					
Normal	54 (56.3)	5 (5.2)	28 (29.2)	9 (9.4)	96
High	112 (50.9)	9 (4.1)	62 (28.2)	37 (16.8)	220

Table 4. *The association between IFG, IGT and PUDM and various variables.*

	PUDM			**IFG**			**IGT**		
	OR	**CI**	**P**	**OR**	**CI**	**P**	**OR**	**CI**	**P**
Age	1.03	1.00 – 1.06	0.08	1.01	0.96 – 1.06	0.67	1.04	1.01 – 1.06	< 0.01
Sex	1.33	0.65 – 2.72	0.44	0.94	0.30 – 2.94	0.92	0.86	0.51 – 1.47	0.58
Hypertension	3.55	1.56 – 8.08	< 0.01	1.35	0.43 – 4.19	0.61	2.06	1.17 – 3.60	0.01
Family history of diabetes	1.44	0.62 – 3.36	0.40	N/A	N/A	N/A	0.82	0.38 – 1.77	0.62
History of thirst	1.36	0.69 – 2.70	0.38	0.39	0.08 – 1.79	0.22	0.66	0.36 – 1.20	0.18
History of polyuria	0.89	0.45 – 1.74	0.73	0.25	0.05 – 1.16	0.08	0.58	0.33 – 1.02	0.06
Smoking	1.72	0.81 – 3.64	0.16	1.19	0.31 – 4.51	0.80	1.77	0.97 – 3.22	0.06
BMI ≥ 30	1.97	0.97 – 3.98	0.06	0.52	0.11 – 2.43	0.41	1.11	0.61 – 2.00	0.74
High WHR	2.50	1.05 – 5.98	0.04	0.85	0.27 – 2.67	0.78	1.13	0.64 – 1.98	0.67
High Waist circumference	1.53	0.72 – 3.25	0.26	0.87	0.28 – 2.71	0.81	0.96	0.56 – 1.66	0.90

Table 5. *Univariate analysis with FBG and 2HBG as the outcome variables.*

	FBG		2HBG	
	r	**P**	**r**	**P**
Sex	-0.02	0.42	0.02	0.49
Hypertension	0.04	0.22	0.11	0.05
Age	0.002	0.16	0.002	0.12
Weight	0.001	0.18	0.001	0.17
Height	0.26	0.14	-0.26	0.18
BMI	0.002	0.45	0.01	0.05
Waist circumference	0.002	0.03	0.003	0.01
Hip circumference	0.0004	0.70	0.001	0.21
Waist-Hip ratio	0.81	< 0.001	0.68	< 0.01
SBP	0.001	0.10	0.002	< 0.01
DBP	0.001	0.49	0.003	0.02
FBG	N/A	N/A	0.71	< 0.001
2HBG	0.25	< 0.001	N/A	N/A

4. Results

From outpatient clinics 208, consecutive patients (138 females) with hypertension on treatment and 108 non-hypertensive patients (69 females) were enrolled for our initial study [14], [15] and all these patients were included in this analysis. The mean (± standard deviation (sd)) age of the participants was 53.6 (12.0) years.

A family history of diabetes was given by 14% of participants, 23% gave a history of excessive thirst and 35% a history of polyuria. Smoking was common among the participants (23%). The prevalence of general obesity (BMI ≥ 30) was 26%, prevalence of high WC was 68% while prevalence of central obesity (high WHR) was almost 70%. The mean (± sd) BMI was 26.5 (6.2), WHR was 0.88 (0.06), SBP 137.2 (27.9) mmHg, DBP 83.3 (14.5) mmHg, blood glucose at 0 min (FBG) was 5.7 (2.4) mmol/L, while the mean (±sd) blood glucose at 120 min (2HBG) was 7.7 (2.2) mmol/L (Table 1).

Most of the participants (80%) had FBG of < 6.1 mmol/L, 10% had FBG of ≥ 6.1 - < 7.0 mmol/L while another 10% had ≥ 7.0 mmol/L. At 120 min of OGTT, 60% of the subjects blood glucose had < 7.8 mmol/L, 32% had blood glucose ≥ 7.8 - < 11.1 mmol/L and the remaining 8% ≥ 11.1 mmol/L (Table 2). Sixteen participants had FBG which were higher than 11.1 mmol/L, so the standard OGTT was not done and they were all classified as DM. Using the WHO glucometabolic classification, the majority of participants (53%) had a normal GTT, the prevalence of IFG was 4%, the prevalence of IGT was 29% and the prevalence of PUDM was 15% from the OGTT (Table 3).

Table3 also shows the proportion of participants with PUDM, IFG and IGT in the various subgroups. There were no sex differences in the various groups, but there were significantly more hypertensives in the PUDM group ($p < 0.01$), while there were significantly more non-hypertensives in those with normal results ($p < 0.001$). There was a clear pattern of increasing prevalence of PUDM with increasing age, BMI, WC and WHR, while the reverse was seen in the normal group. The pattern for IFG and IGT was not clear.

The results of univariate logistic regression analysis with PUDM, IFG and IGT as the outcome variables are shown in Table 4. PUDM was associated with hypertension and high WHR, while IGT was associated with age and hypertension. IFG was not associated with any of the variables and none of the participants with IFG gave a family history of diabetes so it was not possible to calculate the corresponding OR. After controlling for age, sex and hypertension in multivariate logistic regression analysis PUDM was associated with smoking (OR=3.25, CI 1.19 – 8.85, p=0.02), but not with high WHR (OR=2.03, CI 0.72 – 5.73, p=0.18) and IGT was associated with history of polyuria (OR=0.54, CI 0.03 – 0.96, p=0.04). IFG was still not associated with any of the variables in multivariate analysis.

In univariate linear regression analysis (Table 5), FBG was significantly associated with WC and WHR, while 2HBG was associated with hypertension, BMI, WC, WHR, SBP and DBP. There was a strong and statistically significant correlation between FBG and 2HBG ($p< 0.001$). In multiple regression analysis with FBG as the outcome variable, there was still a significant association with WHR (r=0.59, p=0.03) but not WC (r=0.001, p=0.41) after controlling for age, sex and hypertension. 2HBG was not associated with any of the variables after adjusting for age, sex and hypertension.

5. Discussion

This study has analysed the OGTT results of 316 Gambian patients reporting at outpatient clinics in Banjul and has determined the proportion of participants with PUDM, IFG and IGT. It has also explored the relationship between various risk factors and these abnormal glucose tolerance states. The prevalence of PUDM in adult Gambians of 15% found in this study was high, but similar to the reports from the previous Gambian study. We found a prevalence of 12% in men, 16% in women, 18% in patients with hypertension and 7% in those without hypertension. A prevalence of 0.3% was recorded in nationwide prevalence study in The Gambia, but in the community study in Banjul, the prevalence of DM (both diagnosed and undiagnosed) was 8% in men and 9% in women for all participants, while for participants with hypertension the prevalence was 17% and 19% in men and women, respectively. [7] - [12] These higher prevalence rates found in these Banjul studies may be partly due to urbanization and adoption of western lifestyle as has been reported by other writers. [22] In addition, the prevalence of the PUDM found in this study was significantly higher in hypertension than in normotensive patients that has been reported elsewhere. The development of Type 2 DM was about 2.5 times less likely in normotensives than in their hypertensives counterparts in a large prospective cohort study that included 12,550 adults. [23]

Pre-diabetes may manifest as IFG and or IGT. These are not clinical entities by themselves, but represent risk factors for DM and other cardiovascular diseases. [3], [4] In this study, the prevalence of IFG was found to be 4% when the WHO criteria was applied. This rate is much lower compared to other studies. [24] - [26] There were no significant sex difference in the prevalence of IFG and the prevalence was similar to participants with hypertension and the normotensive participants. In US studies, IFG was more common in men than women, a phenomenon which is attributed to the higher fasting plasma glucose in US men. [27] - [29] This sex difference was also reported in an Australian study. [30]

This study recorded an IGT prevalence of 29% which is very high but compares to reports from other studies from Ghana (15.8%), Nigeria (15%), Australia (10.6%) and US (15.6%). [23] - [30] The prevalence of IGT was higher in males compared to females and higher in the hypertensive subjects than in the normotensives though the difference in the sexes was not statistically significant. IGT is known to be more prevalent in women than in men. [3], [28] An overall prevalence of 28% from an adapted OGTT was reported in the community study in The Gambia, with 35.5% prevalence in the underweight participants, 25.4% in participants with normal BMI and 50.3% in the obese participants. [7] - [12]

The pattern of increasing prevalence of PUDM in the various subgroups of the risk factors was clear, increasing with increasing age, BMI, WC and WHR. However, a similar pattern was not seen with IFG and IGT. These relationships were less clear on applying formal statistical test with the exception of PUDM and IGT which were significantly more common in participants with hypertension. This was confirmed in all the univariate and multivariate models.

The previous Gambian studies have shown that hypertension was more common in DM patients than in the general population and that DM was significantly associated with hypertension before and after adjustment for age and sex. These studies also found that among the urban Gambian participants, there was frequent co-existence of obesity, hyperlipidaemia, physical inactivity, hypertension and DM. The earlier study also had 3.3% of the participants reporting a family history of DM and these participants had a significantly higher mean BMI, mean total blood cholesterol, mean blood triglyceride and mean 2HBG. [7] - [12] Though our study found a higher proportion of participants with a family history of DM (14%), this was not associated with PUDM, IFG nor IGT. Sabir and associates identified age and obesity as the major risk factors for DM and pre-diabetes in the northern Nigerian population [26], while in Ghana, Amoah found DM, IFG and IGT were associated with increasing age, SBP, DBP and BMI. [24], [25]

This study also explored the relationship between FBG and 2HBG and various risk factors using univariate and multivariate linear regression analysis. FBG was significantly associated with WC and WHR in univariate analysis and after adjusting for age, sex and hypertension, the association with WHR was still significant while, WC was no longer significant. In univariate regression analysis 2HBG on the other hand was significantly associated with BMI, SBP, DBP, WC and WHR, but in multivariate analysis after controlling for age, sex and hypertension all these associations were no longer statistically significant. These findings also did not show any clear pattern.

The major strength of this study was the performance of the standard OGTT in 316 participants with no history of DM in The Gambia, a country with very few cardiovascular studies. There have been very few OGTT studies with such large number of participants. Although there was a previous study in The Gambia only an adapted OGTT was undertaken, measuring only the 2HBG after a 75g glucose load. [3] - [8] The main weakness of this study was the fact that it was a hospital based cross - sectional study which was fraught with various biases including selection and proximity biases. The study apart from hypertension did not demonstrate convincingly any major risk factor for PUDM, IFG and IGT in this Gambian population. Therefore there is generally the need for more cardiovascular studies in The Gambia, preferably large community-based studies and specifically ones utilising the standard OGTT to investigate further risk factors for these abnormal glucose tolerance states.

6. Conclusion

The prevalence of IFG, IGT and PUDM in the urban adults attending outpatient clinics in Banjul The Gambia was high. PUDM and IGT were associated with hypertension but IFG was not associated with any of the risk factors. This is likely to be the result of the change in lifestyle of these urban Gambians.

There is therefore the need to increase screening, detection, treatment and control of these conditions.

Acknowledgements

This study was funded by the Medical Research Council (MRC), UK. We are grateful to Dr. Hilton Whittle, Prof. J. W. Acheampong, Dr.T. Corrah, Dr. S. Allen, Dr. K. McAdam, Dr. Alieu Gaye, Mr. Winston Banya and Mr. Ben Sam.

References

[1] Alberti KG, Zimmet PZ. Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1: diagnosis and classification of diabetes mellitus provisional report of a WHO consultation. *Diabet Med.* 1998 Jul;15(7):539-53.

[2] World Health Organisation. Definition and diagnosis diabetes mellitus and intermediate hyperglycaemia: Report of a WHO/IDF Consultation, Geneva, Switzerland. 2006.

[3] Nathan DM, Davidson MB, DeFronzo RA, Heine RJ, Henry RR, Pratley R, Zinman B; American Diabetes Association. Impaired fasting glucose and impaired glucose tolerance: implications for care. *Diabetes Care*. 2007 Mar;30(3):753-9.

[4] American Diabetes Association. Diagnosis and classification of diabetes mellitus. *Diabetes Care*. 2006 Jan;29 Suppl 1:S43-8.

[5] Cook AR. Notes on the diseases met with in Uganda, central Africa. *J Trop Med* 1901 ; 4: 175-178.

[6] International Diabetes Federaton atlas. Available at http://www.diabetesatlas.org/contact and accessed on 3rd October, 2010.

[7] van der Sande MA, Bailey R, Faal H, Banya WA, Dolin P, Nyan OA et al. Nationwide prevalence study of hypertension and related non-communicable diseases in The Gambia. *Trop Med Int Health*. 1997 Nov;2(11):1039-48.

[8] van der Sande MA, Walraven GE, Milligan PJ, Banya WA, Ceesay SM, Nyan OA et al. Family history: an opportunity for early interventions and improved control of hypertension, obesity and diabetes. *Bull World Health Organ*. 2001;79(4):321-8.

[9] van der Sande MA, Ceesay SM, Milligan PJ, Nyan OA, Banya WA, Prentice A et al. Obesity and undernutrition and cardiovascular risk factors in rural and urban Gambian communities. *Am J Public Health*. 2001 Oct;91(10):1641-4.

[10] van der Sande MA, Milligan PJ, Nyan OA, Rowley JT, Banya WA, Ceesay SM et al. Blood pressure patterns and cardiovascular risk factors in rural and urban gambian communities. *J Hum Hypertens*. 2000 Aug;14(8):489-96.

[11] van der Sande MA, Walraven GE, Bailey R, Rowley JT, Banya WA, Nyan OA et al. Is there a role for glycosuria testing in sub-Saharan Africa? *Trop Med Int Health*. 1999 Jul;4(7):506-13.

[12] van der Sande MA, Milligan PJ, Walraven GE, Dolmans WM, Newport M, Nyan OA et al. Geographical variation in prevalence of hypertension within The Gambia. *J Hum Hypertens*. 2001 Oct;15(10):733-9.

[13] Tuomilehto J, Lindström J, Eriksson JG, Valle TT, Hämäläinen H, Ilanne-Parikka P et al Finnish Diabetes Prevention Study Group. Prevention of type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance. *N Engl J Med*. 2001 May 3;344(18):1343-50.

[14] Nkum BC, Nyan O, Corrah T, Ankrah TC, Allen S, Micah FB., et al. Resting electrocardiographic and echocardiographic findings in an urban community in the Gambia. *Journal of Science and Technology*. 2009; 29:130-140.

[15] Nkum BC, Micah FB, Ankrah TC Nyan O. Left ventricular hypertrophy and insulin resistance in adults from an urban community in The Gambia: cross-sectional study. PLoS One. 2014 Apr 4;9(4):e93606.

[16] Hammond IW, Devereux RB, Alderman MH, Lutas EM, Spitzer MC, Crowley JS., et al. The prevalence and correlates of echocardiographic left ventricular hypertrophy among employed patients with uncomplicated hypertension. *J Am Coll Cardiol*. 1986; 7: 639-650.

[17] Mayet J, Shahi M, Foale RA, Poulter NR, Sever PS, McG Thom SA. Racial differences in cardiac structure and function in essential hypertension. *Br Med J*. 1994; 308:1011-1014.

[18] World Health Organisation. Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1: diagnosis and classification of diabetes mellitus. Report of a WHO consultation. 1999.

[19] Chalmers J, MacMahon S, Mancia G, Whitworth J, Beilin L, Hansson L et al. 1999 World Health Organization-International Society of Hypertension Guidelines for the management of hypertension. Guidelines sub-committee of the World Health Organization.*Clin Exp Hypertens*. 1999 Jul-Aug;21(5-6):1009-60.

[20] Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults--The Evidence Report. National Institutes of Health.*Obes Res*. 1998 Sep;6 Suppl 2:51S-209S.

[21] Alberti KG, Zimmet P, Shaw J; IDF Epidemiology Task Force Consensus Group. The metabolic syndrome – a new worldwide definition. Lancet 2005 Sep 24-30;366(9491):1059-62.

[22] Schulz LO, Bennett PH, Ravussin E, Kidd JR, Kidd KK, Esparza J et al. Effects of traditional and western environments on prevalence of type 2 diabetes in Pima Indians in Mexico and the U.S. *Diabetes Care*. 2006 Aug;29(8):1866-71.

[23] Gress TW, Nieto FJ, Shahar E, Wofford MR, Brancati FL. Hypertension and antihypertensive therapy as risk factors for type 2 diabetes mellitus. Atherosclerosis Risk in Communities Study. *N Engl J Med*. 2000 Mar 30;342(13):905-12.

[24] Amoah AG. Undiagnosed diabetes and impaired glucose regulation in adult Ghanaians using the ADA and WHO diagnostic criteria. *Acta Diabetol*. 2002 Apr;39(1):7-13.

[25] Amoah AG, Owusu SK, Adjei S. Diabetes in Ghana: a community based prevalence study in Greater Accra. *Diabetes Res Clin Pract*. 2002 Jun;56(3):197-205.

[26] Sabir AA, Isezuo SA, Ohwovoriole AE. Dysglycaemia and its risk factors in an urban fulani population of northern Nigeria. *West Afr J Med*. 2011 Sep-Oct;30(5):325-30.

[27] Harris MI, Flegal KM, Cowie CC, Eberhardt MS, Goldstein DE, Little RR et al. Prevalence of diabetes, impaired fasting glucose, and impaired glucose tolerance in U.S. adults. The Third National Health and Nutrition Examination Survey, 1988-1994. *Diabetes Care*. 1998 Apr;21(4):518-24.

[28] Cowie CC, Rust KF, Byrd-Holt DD, Eberhardt MS, Flegal KM, Engelgau MM et al. Prevalence of diabetes and impaired fasting glucose in adults in the U.S. population: National Health And Nutrition Examination Survey 1999-2002. *Diabetes Care*. 2006 Jun;29(6):1263-8.

[29] Karve A, Hayward RA. Prevalence, diagnosis, and treatment of impaired fasting glucose and impaired glucose tolerance in nondiabetic U.S. adults. *Diabetes Care*. 2010 Nov;33(11):2355-9.

[30] Dunstan DW, Zimmet PZ, Welborn TA, De Courten MP, Cameron AJ, Sicree RA et al. The rising prevalence of diabetes and impaired glucose tolerance: the Australian Diabetes, Obesity and Lifestyle Study. *Diabetes Care*. 2002 May;25(5):829-34.