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RESEARCH ARTICLE

Undiagnosed Type 2 Diabetes Mellitus Prevalence and Associated Risk Factors in an Urban and Rural Metropolis in Ghana

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Abstract

Introduction: Diabetes mellitus (Type 2) is a chronic disease characterized by high fasting blood glucose that can affect people without detection at onset until after some time in life. Early diagnoses and management usually lead to a better quality of life of an individual. The predisposing factors associated with the disease among same population can vary as a result of genetic composition and susceptibility of every single individual.

Methods: In this study, we determined the prevalence of undiagnosed Type 2 diabetes mellitus (UT2DM) (Hyperglycemia), pre-diabetes and impaired fasting glycaemia (IFG) in Ghanaian adults aged 18 to 50 years in the Tamale Metro polis using the World Health Organization criteria. A cross sectional design was used to collect data for a period of four months (January to May, 2018). Sampling of participating communities was done using Ghana Statistical Service designated Enumeration Areas (EA's)and random sampling technique was subsequently used to select households from the designated enumeration areas.

Results: The mean age of the study participants (300) was 34.4 ± 10.6 years. We found a prevalence of 4.7% of Undiagnosed Type 2 Diabetes Mellitus (UT2DM) in our study participants. The mean fasting blood glucose (FBG) of (4.76 ± 0.87 mmol/L) recorded among rural participants was lower than that of (5.02 ± 1.35 mmol/L) among urban participants. The participants from the urban areas had higher IFG (22.0%) compared to those from rural areas (10.8%). Low Fasting Blood Glucose (FBG) was also more prevalent in the urban areas (9.4%) compared to the rural areas (8.4%). IFG was found to be more prevalent in participants with positive history of pre-diabetes, 87.5%. Those who lived in the urban areas were 12 times more likely to develop UT2DM compared to those in the rural areas; OR = 12.0; CI = (1.02-1.80); P = 0.02. Obese people were 5.5 times more likely to develop UT2DM; OR = 5.5; CI = (1.17-2.76); P < 0.01. The elderly (41-50 years) had 2.5 times risk of developing UT2DM; OR = 2.5, CI (1.02-2.43); P = 0.04.

Conclusion: The prevalence of undiagnosed Type 2 diabetes mellitus was higher in the urban areas compared to the rural areas within the metropolis. The non-modifying predisposing risk factors such as family history of diabetes and age were the same for urban and rural dwellers. However, other risk factors such as overweight/obesity, lack of physical activities and unhealthy dietary practices were common among urban residents. Therefore, lifestyle changes that promote healthy dietary practices are therefore advocated for the urban dwellers to reduce their chances of developing UT2DM.

Keywords

Undiagnosed Type 2 Diabetes Mellitus (UT2DM), Tamale Metropolis, Pre-diabetes, Hypercholesterolemia, Impaired Fasting Blood Glucose (IFBG), Impaired Fasting Glycemia (IFG)

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Introduction

Pre-diabetes and impaired fasting blood glucose which consist of high fasting blood glucose levels and imbalance blood glucose in humans respectively has been identified to be on the increase [1]. This usually leads to the occurrence of full-blown diabetic conditions among human populations [2]. The causes are usually due to improper functioning of the liver as a result of broken beta cells with major predisposing factors such as extra weight, genetic composition that affects insulin functions and metabolic syndrome [3].

According to the World Health Organization the prevalence of diabetes in sub-Saharan Africa is estimated to lie between 0.02 and 1.9% [4]. Recent studies from Cameroon, Nigeria and Tanzania suggest that the prevalence of the condition may be more common in sub-Saharan Africa than previously thought [5]. In Ghana, information on the prevalence of Type 2 Diabetes Mellitus (T2DM) is usually available at the healthcare facilities but few studies have been conducted to give a regional breakdown of the problem. A study conducted among outpatient patients found diabetes prevalence of 0.3% among 4733 urban dwellers in Accra [6]. In a community sample of 5000 participants from a provincial capital of Ghana, Dodu, et al. reported a diabetes prevalence of 0.2% [7]. Adler reported that in pregnancy, undiagnosed or poorly controlled diabetes mellitus increases the risk of fetal death and other complications especially during delivery [8]. Looking at the information provided above, the prevalence of Type 2 diabetes mellitus in Ghana vary across the geographical regions. A prevalence of 6.3% was reported in the Greater Accra Region among urban individuals who were not aware of their status [1] and a prevalence of 3.3% reported among rural Ghanaians [9]. This therefore calls for more research that will give a country wide data on the prevalence of the condition.

The associated factors in diabetes mellitus are often complicated and interrelated and include; age, sex, body weight genetics, viral factors, immune deficiency, trauma and the environment [10,11]. The environmental factors however depend on the geographical location of an individual [12]. The etiology of Type 2 DM is meanwhile associated with lifestyle and dietary practices of an individual with an exposure [13]. Other factors such as obesity, hyperlipidemia, lack of physical activity have all been found to influence the onset of diabetes mellitus among adults [14]. The health debilitating consequences of diabetes are heart attack, stroke, kidney failure, vision loss and nerve damage [15].

Diabetes mellitus screening is not a routine activity in Ghana and so the test is performed at the request of a physician as part of diagnosis when a patient visits a health facility. This is one of the reasons why there is scanty data on the prevalence of the condition. In the rural areas the test for diabetes mellitus even gets worse when requested by medical practitioners since the test is not free and depends on the socio-economic status of the patient. This has resulted in greater number of people living in Ghana with diabetes mellitus undiagnosed soaring [1]. In this study therefore, we hypothesized that there is no difference in the prevalence of Type Diabetes Mellitus (T2DM) and its associated risk factors between rural and urban community dwellers within the Tamale Metropolis of Ghana.

Methodology

Research design

A cross-sectional survey approached was adopted and data collection was done from January to May 2018 in the Tamale Metropolis.

Study area and setting

Tamale Metropolis of the Northern Region of Ghana was the study area. The Metropolis had a total population of 223,252 as of December 2010 and majority are urban inhabitants [16]. It lies between latitude 9°16 and 9°34 North and longitudes 0°36 and 0°57 West. The Metropolis lies within the savannah woodland zone in the country, it is about 180m above sea level and has only one raining season [17].

Study population, sample size and sampling

The study population was made up of adult residents of the Metropolis aged 18-50 years. We estimated the sample size using Cochran's formula [18], on crude prevalence of 6.3% of diabetes mellitus in Ghana [1], alpha level of 1.96, an error margin of ± 0.03 at a confidence interval of 95%. The formula yielded a sample size of 252. We also factored in a non-response rate of 10% and rounded the sample size to 300 to increase the precision of the prevalence estimates.

Sampling procedure

Initially, we used the Ghana Statistical Service (GSS) 115 enumeration areas (EA's) of the Metropolis and later group edit into five main enumeration sites, namely; Tamale North (Site A), Tamale South (Site B), Tamale East (Site C), Tamale Central (Site D) and Tamale West (Site E) with guidance from the Ghana Statistical Service. In each of the enumeration sites, four (4) communities were randomly selected consisting of two (2) rural and two (2) urban communities respectively, except for enumeration site D which consisted of only urban communities. Therefore, all four (4) communities selected were urban in site D. In each community, a first household was randomly selected, thereafter, a sampling frame of 5 was obtained and used to select the remaining 4 households. Five (5) households were selected from each community and three (3) participants randomly selected from each household. In all, a total of fifteen (15) participants were sampled

from each community to give a total sample size of 300 participants.

Inclusion and exclusion criteria

Healthy individuals aged 18-50 years residents in the Tamale Metropolis, who gave consent to participate were recruited into the study. Individuals who were not residents in the Metropolis and severely-ill people were excluded from the study.

Training of data collectors and pretesting of instruments

A total of 4 data collectors, consisting of 2 laboratory technicians and 2 enumerators were used for the study. Prior to the start of the field work, these personnel were retrained to refresh their knowledge in order to enhance efficient data collection process. The instruments that were used for the study (seca-scales, microtoise, MUAC tapes and glucometers) were tested, used for a pre-test before they were subsequently used on the field for data collection. This was aimed at ensuring efficient data collection process.

Data collection

A pre-tested questionnaire which was designed by the research team and approved by the ethics committee of the college of basic and applied sciences of University of Ghana was used to collect both socio-demographic and biochemical data.

Socio-demographic characteristics

Data collection was done using a pretested structured questionnaire. This was on the participant's age, gender, educational background, family history of diabetes, hypertension, participants knowledge of diabetes and risk factors associated with the development of Type 2 Diabetes Mellitus (T2DM).

Socio-economic status assessment

Income earnings of participants were classified as stated by David and Roseto determine the socio-economic status of participants [19]. Participants who earned below 500cedis were of low status, between 500 to 100cedis were of middle status and above 1000cedis were classified as having high socio-economic status respectively.

Anthropometric measurements

Body weight (kg), height (cm), and waist circumference (cm) measurements were done using modified World Health Organization standards [4]. Body mass indices (BMI's) of the participants were calculated using the weight and height obtained as weight/height^2 (kg/m^2). This was then used to classify respondents into underweight, normal weight and overweight/obesity using WHO standards [20]. This criterion of measurement is categorized as follows: Normal weight = BMI of (18.5-24.9) Kg/m^2; Overweight = BMI of (25-29.9) Kg/m^2; Obesity = BMI ≥ 30 Kg/m^2. In using waist circumference (WC), central obesity was classified as follows: Normal central body mass = WC < 104 cm for males, WC = < 88 cm for females, Central obesity = WC = ≥ 104 cm for males and WC ≥ 88 cm or females.

Blood draw and processing

A phlebotomist took 2.0 milliliters (ml) of the venous blood from each participant and placed in EPDM test tubes. This was after the participants had done an overnight fasting (approximately between 10-12 hours). The samples were deposited in a vaccine carrier containing ice packs to provide appropriate temperature. The samples were then transported to the Tamale Teaching Hospital laboratory within 45 minutes after collection each day for laboratory analyses. At the laboratory, the samples in the tubes were centrifuged at 3000 rpm for 10 minutes at room temperature using normal standard centrifuging. The blood sera were separated into plain separator tubes and used for clinical laboratory analysis at the Tamale Teaching Hospital Laboratory. The levels of total cholesterol (TC), triglycerides (TG), high density lipoprotein cholesterol (HDL-C), low density lipoprotein cholesterol (LDL-C) were determined using an Automated Chemistry Analyzer (model numberURIT-8021A).

Determination of blood glucose

Blood glucose of participants were measured using a Glucometer (model number SN-2806405E) on fresh capillary blood samples that were drawn from each participant. The glucometer has test strips, blood samples were dropped on the strip and inserted into the glucometer to give a fasting blood glucose (FBG) contained in the sample. The results were measured digitally by the glucometer used. The serum glucose results were categorized and used to define the various indices in this study using the WHO 2015 classification as modified by Baynest as follows; Hypoglycemia was defined as fasting blood glucose levels of < 3.9 mmol/L; Normal glycaemia (Normoglycemia) was defined as fasting blood glucose of 3.9-5.5 mmol/L. Pre-diabetes was defined as fasting blood glucose of 5.6-6.9 mmol/L whiles Hyperglycemia (diabetes) was defined as fasting blood glucose ≥ 7 mmol/L [21].

Determination of undiagnosed Type 2 Diabetes Mellitus (UT2DM) and other indicators

Undiagnosed diabetes mellitus in this study basically refers to diabetes status of participants with no knowledge of their diabetes status prior to the study. This was determined using WHO classification [22], where fasting blood glucose ≥ 7 mmol/L in a patient defines Type 2 diabetes presence. Undiagnosed Type 2 Diabetes Mellitus was found to be 4.7% among study participants. Gestational diabetes which refers to fasting

blood glucose of ≥ 5.6 mmol/L in pregnant women was determined and its association to the development of UT2DM quantified. Impaired fasting blood glucose in this study was defined to consist of both hypoglycemia and hyperglycemia [21]. The association of these indicators to the overall development of diabetes mellitus was determined.

Determination of total blood cholesterol, triglycerides, HDL-C and LDL-C

Total Cholesterol, High-density Lipoprotein Cholesterol, HDL-C, Low-density Lipoprotein Cholesterol, LDL-C cholesterols and triglycerides levels in the blood samples were determined in this study using an automated chemistry analyzer. The cholesterol reagent kit was used for cholesterol determination, the HDL-C precipitant reagent kit was used for LDL precipitation for HDL-C determination and the triglycerides reagent kit was used to determine triglycerides. The instrument used was the automated chemistry analyzer (model number URIT-8021A). The procedures of work and preparation of the working reagents were strictly as described by the manufacturer. The diagnostic criteria adopted for diabetes mellitus, overweight/obesity and cholesterol fractions was ADA standards [10].

Quality control

The scale used to measure body weight of participants was standardized with a known object weight on each day the research team took body weight measurements on the field. In order to ascertain the reliability of the glucometer, a blood sample with known FBG level was used every day and the reading checked to reflect accurate measurement. For the chemistry analyzer, normal and abnormal reference control sera were used to determine the performance of both the reagent and the instrument in the determination process of total blood cholesterol, triglycerides, HDL-C and LDL-C.

Data analyses

The IBM Statistical Package for Social Sciences (SPSS) version 23.0 for windows was used for data entry and for all statistical analyses except for anthropometric values that were first entered into WHO Anthropometric software and later exported into SPSS. For continuous variables, means (π) and standard deviations (SD) were calculated, while for categorical variables, proportions were determined. Differences between means were assessed by independent t-sample test analysis and chi-square was used to determine differences between categorical variables. Multivariate analysis was used to determine the association between potential risk factors and impaired fasting blood glucose among study participants. Binary logistic regression analysis was used to determine association between potential risk factors and the development of undiagnosed Type 2 diabetes mellitus among study participants. A p-value of < 0.05 was considered statistically significant.

Ethical approval

Inform consent was sought from participants before they were enrolled into the study. Those who were enrolled signed the consent form and others thumb-printed the form to indicate their consent. Ethical approval of this research was granted by the Ethics Committee of the College of Basic and Applied Sciences, ECBAS, University of Ghana, Legon (ECBAS 017/17-18).

Results

Descriptive statistics on socio-demographic characteristics of participants by gender

A total of 300 participants were recruited into the study and their socio-demographic characteristic is shown in Table 1. The participants consisted of 44.7% males and 55.3% females. The overall mean age of our study participants was 34.4 ± 10.6 years. Mean age among male participants 32.0 ± 10.4 years was lower than that of mean age among female participants, 36.4 ± 10.3 years. The observed difference between the two means was statistically significant ($p < 0.01$). Most of the participants (83.7%) had low socio-economic status with females being the most affected category (88.6%). Our study participants consisted of various ethnic groups with Dagomba's been the most dominant ethnic group (90%). There was an observed statistically significant difference among ethnic groups in our sampled population ($P < 0.01$). There was also varying educational levels among participants with an observed significant difference between participant's educational status ($P < 0.01$).

Descriptive statistics of fasting blood glucose, lipid profile and anthropometric characteristics of participants by setting

An overall fasting blood glucose (FBG) levels among participants ranged from 3.2 to 14.2 mmol/L, with a mean value of 4.92 ± 1.19 mmol/L (Table 2). Mean fasting blood glucose (FBG) of rural participants, (4.76 ± 0.87 mmol/L) was lower than a mean of 5.02 ± 1.35 mmol/L observed among urban participants. Low FBG was more prevalent in urban areas (9.4%) compared to rural areas (8.4%). In all, more participants in the urban areas had IFG (22.0%) compared to the rural areas (10.8%). However out of a total of 10.8% of rural participants who had IFG only 0.8% had UT2DM (hyperglycemia) (FBG ≥ 7 mmol/L). Also, in a total of 22.0% of urban participants with IFG, 7.2% had UT2DM (hyperglycemia) with fasting blood glucose exceeding 7 mmol/L (Table 2).

Overall mean total cholesterol among participants was 4.62 ± 1.43 mmol/L**.** Urban participants had high mean total cholesterol, 4.97 ± 1.29 mmol/L compared to rural participants, 4.11 ± 1.49 mmol/L. The difference

Table 1: Descriptive statistics on socio-demographic characteristics of participants by gender.

Variables	Male (n = 134) [2]n (%)	Female (n = 166) n (%)	Total (N = 300) N (%)	X^2	p-value
Age (years)					
(Mean ± SD)[3]	32.0 ± 10.4	36.4 ± 10.3	34.4 ± 10.6	9.9	< 0.01**
18-30	70 (52.2)	59 (35.5)	129 (43.0)		
31-50	64 (47.8)	107 (64.5)	171 (57.0)		
Ethnicity					
Dagomba	127 (94.8)	143 (86.1)	270 (90.0)	11.1	0.01**
Gonja	1 (0.7)	11 (6.7)	12 (4.0)		
Mamprusi	2 (1.5)	6 (3.6)	8 (2.7)		
Akan	2 (1.5)	1 (0.6)	3 (1.0)		
Grusi	2 (1.5)	4 (2.4)	6 (2.0)		
Mou	0 (0.0)	1 (0.6)	1 (0.3)		
Educational status					
No formal Education	56 (41.8)	108 (65.1)	164 (54.7)	11.8	< 0.01**
Primary	7 (5.2)	20 (12.0)	27 (9.0)		
J.H.S	0 (0.0)	4 (2.4)	4 (1.3)		
S.H.S	47 (35.1)	25 (15.1)	72 (24.0)		
Tertiary	24 (17.9)	9 (5.4)	33 (11.0)		
Occupation					
Farmers	52 (38.8)	64 (38.6)	116 (38.7)	0.3	0.78
Civil servants	14 (10.4)	11 (6.6)	25 (8.3)		
Traders/Business personnel	32 (23.9)	63 (38.0)	95 (31.7)		
Students	18 (13.4)	4 (2.4)	22 (7.3)		
Others	18 (13.4)	24 (14.5)	42 (14.0)		
Socio-economic status					
Low	104 (77.6)	147(88.6)	251 (83.7)	9.8	0.05
Middle	14 (10.4)	12(7.2)	26 (8.7)		
High	16 (12.0)	7(4.2)	23 (7.6)		

SD: Standard Deviation, [1]Significance based on independent T-test for continuous variables and chi-square for categorical variables; [2]n (%) = proportions, [2]Mean ± standard deviation; **p-values significant at < 0.05. JHS: Junior High School; SHS: Senior High School; Tertiary: University/polytechnics

Table 2: Descriptive statistics of fasting blood glucose, lipid profile and anthropometric characteristics of participants by setting.

Variables (mmol/L)	Rural (n = 120) [2]n (%)	Urban (n = 180) n (%)	Total (N = 300) N (%)	p-value[1]
FBG				
(Mean ± SD)[3]	4.76 ± 0.87	5.02 ± 1.35	4.92 ± 1.19	0.06
< 3.9	10 (8.4)	17 (9.4)	27 (9.0)	
3.9-5.5	97 (80.8)	123 (68.4)	220 (73.3)	
5.6-6.9	12 (10.0)	27 (15.0)	39 (13.0)	
≥ 7	1 (0.8)	13 (7.2)	14 (4.7)	
Total cholesterol				
(Mean ± SD)	4.11 ± 1.49	4.97 ± 1.29	4.62 ± 1.43	< 0.01**
< 5.2	94 (78.3)	110 (61.1)	204 (68.0)	

≥ 5.2	26 (21.7)	70 (38.9)	96 (32.0)	
Triglycerides				
(Mean ± SD)	1.29 ± 0.75	1.80 ± 0.82	1.60 ± 0.83	< 0.01**
< 2.3	116 (96.7)	146 (81.1)	262 (87.3)	
≥ 2.3	4 (3.3)	34 (18.9)	38 (12.7)	
HDL Cholesterol				
(Mean ± SD)	0.72 ± 0.25	0.82 ± 0.23	0.78 ± 0.24	< 0.01**
< 1	106 (88.3)	146 (81.1)	252 (84.0)	
1-1.29	12 (10)	29 (16.1)	41 (13.7)	
≥ 1.3	2 (1.7)	5 (2.8)	7 (2.3)	
LDL Cholesterol				
(Mean ± SD)	2.82 ± 1.22	3.35 ± 1.15	3.14 ± 1.19	< 0.01**
< 3.4	84 (70.0)	108 (60.0)	192 (64.0)	
≥ 3.4	36 (30.0)	72 (40.0)	108 (36.0)	
	(Mean ± SD)	Mean ± SD	Mean ± SD	
Body mass index (Kg/m^2)	22.09 ± 3.89	23.90 ± 4.46	23.2 ± 4.3	< 0.01**
Waist circumference (cm)	81.50 ± 10.51	81.30 ± 11.93	81.41 ± 11.40	0.88
Fasting blood glucose (mmol/L)	4.76 ± 0.87	5.02 ± 1.35	4.92 ± 1.19	0.06
Total cholesterol (mmol/L)	4.11 ± 1.49	4.97 ± 1.29	4.62 ± 1.43	< 0.01**
Triglycerides (mmol/L)	1.29 ± 0.75	1.80 ± 0.82	1.60 ± 0.83	< 0.01**
HDL-Cholesterol (mmol/L)	0.72 ± 0.25	0.82 ± 0.23	0.78 ± 0.24	< 0.01**
LDL-Cholesterol (mmol/L)	2.82 ± 1.22	3.35 ± 1.15	3.14 ± 1.19	< 0.01**

FBG: Fasting blood glucose, HDL: High-density lipoprotein, LDL: Low-density lipoprotein, [1]Significance based on independent sample t-test, [2]proportions, [3]Mean ± SD indicates mean ± standard deviation, **p-values significant at p < 0.05. [1]Significance based on independent sample t test for continuous variables

Table 3: Factors associated with impaired fasting blood glucose of participants.

Variables	**Impaired FBG [2]n (%)**	**Normoglycemia n (%)**	**Total N (%)**	**p-value[1]**
Normal Weight	52 (24.5)	160 (75.5)	212 (70.7)	< 0.01**
Overweight	20 (28.6)	50 (71.4)	70 (23.3)	< 0.01**
Obese	8 (44.4)	10 (55.6)	18 (6.0)	
Age (years)				
18-30	31 (24.0)	98 (76.0)	129 (43.0)	0.03**
31-40	19 (22.6)	65 (77.4)	84 (28.0)	
41-50	30 (34.5)	57 (66.5)	87 (29.0)	
LSTM (years)				< 0.01**
< 10	14 (25.0)	42 (75.0)	56 (18.7)	0.04**
(10-20)	15 (27.8)	39 (72.2)	54 (18.0)	
> 20	51 (26.8)	139 (73.2)	190 (63.3)	< 0.01**
Ethnicity				
Dagomba's	65 (24.1)	205(75.9)	270 (90.0)	< 0.01**
Gonja's	9(75.0)	3(25.0)	12(4.0)	0.09
Other's	6(33.3)	12(66.7)	18(6.0)	
Other's	6(33.3)	12(66.7)	18(6.0)	
Yes	44 (30.8)	99 (69.2)	143 (47.7)	0.48
No	36 (22.9)	121 (77.1)	157 (52.3)	
Gender				
Males	36 (26.9)	98 (73.1)	134 (44.7)	0.03**
Females	44 (26.5)	122 (73.5)	166 (55.3)	

Residence				
Rural	23 (19.2)	97 (80.8)	120 (40.0)	0.02**
Urban	57 (31.7)	123 (68.3)	180 (60.0)	

FDM: Family History of Mellitus; FHPT: Family History of Hypertension; HPD diabe: History of Pre-Diabetes; HGD: History of Gestational Diabetes, FBG: Fasting Blood Glucose, [1]Significance based on Pearson's Chi-square test for categorical variables, [2]proportions; **p-values significant at < 0.05. LSTM: Length of stay in Tamale Metropolis; CI: Confidence interval, others = Manprusi's Grusi's, Akan's, Mou's

between the two means was statistically significant ($p < 0.01$). Prevalence of hypercholesterolemia (dyslipidemia) and hypertriglyceridemia was high in the urban areas compared to the rural areas. As many as 88.3% of the rural participants had low levels of high-density lipoprotein (HDL) as against 81.1% of the urban participants (Table 2). The means of HDL and LDL-cholesterols and triglyceride were higher for the urban population compared with the rural population. There was a statistical difference in lipid profiles between rural and urban participants (Table 2).

Factors associated with impaired fasting blood glucose of participants

Impaired fasting blood glucose was more prevalent (54.8%) among participants with positive family history of diabetes mellitus and this was statistically significant ($P < 0.01$) (Table 3). A positive association was observed between pre-diabetes, gestational diabetes and impaired fasting blood glucose among study participants. Impaired fasting blood glucose was also found in participants with positive history of pre-diabetes and gestational diabetes (87.5% and 75.0%) respectively. Residency of participants was associated with the development of impaired fasting blood glucose (hypoglycemia, pre-diabetes and hyperglycemia) among study participants ($p = 0.02$). It was again observed that impaired fasting blood glucose was more prevalent among participants who were overweight and obese (28.6% and 44.4% respectively). Statistically overweight/obesity was significantly associated with the development of impaired fasting blood glucose ($p < 0.01$). Age of participants was also found to be significantly associated with the development of impaired fasting blood glucose ($p < 0.01$).

Binary logistic regression of factors associated with UT2DM

We determined the predictors of undiagnosed type 2 diabetes mellitus among participants from both rural and urban residents. Gender, obesity, residency (rural/urban) and family history of hypertension predicted the development of UT2DM among participants. Females were about two times more likely to develop UT2DM compared to males, OR = 2.3; CI = 1.08-1.11; $P < 0.01$. Those who lived in urban areas had about twelve times more likelihood of developingUT2DM compared to those living in the rural areas OR = 12.0; CI = (1.02-1.80); P = 0.02.

Irrespective of place of residence, participants who were overweight had about three times more chances of developing UT2DM compared to those with normal body weight, OR = 2.5; CI = (1.06-1.14); $P < 0.01$. Also, participants who were obese were six times likely to develop UT2DM compared to those who had normal body weight OR = 5.5; CI = (1.17-2.76); $P < 0.0$. Age and ethnicity of participants predicted the development of UT2DM. The aged population (41-50 years) had three times likelihood of developing UT2DM compared to younger adults (18-30 years) OR = 2.5; CI = 1.02-2.43; P = 0.04. Individuals with family history of diabetes mellitus were seven times more likely to develop UT2DM OR = 6.8; CI = (1.13-6.01; $P < 0.01$) (Table 4).

Discussion

The current study determined the prevalence of undiagnosed Type 2 diabetes mellitus (UT2DM) and its associated risk factors in a rural and urban Metropolis of Ghana. We found an undiagnosed Type 2 diabetes prevalence (UT2DM) of 4.7% in our study participants. Our finding was similar to Type 2 diabetes mellitus prevalence's of 4.6% and 4.8% reported by [23] and [8] respectively. However it was lower than prevalence's of 6.3% and 6.4% reported by [24], and [1] respectively whose findings were solely on urban areas in Ghana.

Our findings show's a high prevalence of UT2DM among urban dwellers compared to rural residents. Geographical location of participants influenced the developing of Undiagnosed Type 2 diabetes mellitus. This finding is consistent with [6] who studied diabetes prevalence among South Africans. Urban lifestyles characterized by lack of physical activity, nutrition transition to energy dense foods and sedentary lifestyles all plays significant roles in metabolic syndrome which leads to the development of diabetes mellitus [25]. We observed lower prevalence of UT2DM in rural areas. This observation may be due to the normal levels of associated risk factors at tributable to the development of diabetes mellitus among rural participants. Urban and rural differences have been reported to predict the occurrence of Type 2 diabetes mellitus in a Japanese Study [26].

Recent studies suggest that higher than normal levels of low density lipoprotein (LDL), triglyceride (TG), total cholesterol (TC) and lower high density lipoprotein (HDL)are associated with diabetes mellitus since these factors can lead to insulin resistance in the body [9,27,28]. Hyperlipidemia was higher among our urban participants compared to rural participants (Table 3).

Table 4: Binary Logistic regression of factors associated with diabetes mellitus status.

Variables	Hyperglycemia (n = 14) [2]n (%)	Normoglycemia (n = 286) n (%)	Odds Ratio	95% CI.	p-value[1]
FDM					
Yes	2(14.3)	29(10.1)	0.6	0.08-3.99	0.58
No	12(85.7)	257(89.9)	1.0	Ref. Cat.	
FHPT					
Yes	7(50.0)	55(19.2)	4.7	1.08-20.32	0.04**
No	7(50.0)	231(80.8)	1.0	Ref. Cat.	
HPD					
Yes	3(21.40)	5(1.7)	1.8	0.22-45.73	0.40
No	11(78.6)	281(98.3)	1.0	Ref. Cat.	
HGD					
Yes	4(36.4)	4(2.6)	6.8	1.31-6.01	0.01**
No	7(63.6)	151(97.4)	1.0	Ref. Cat.	
KDM					
Yes	7(50.0)	116(40.6)	0.9	0.22-3.71	0.88
No	7(50.0)	170(59.4)	1.0	Ref. Cat.	
VPA					
Yes	7(50.0)	136(47.6)	0.7	0.19-2.51	0.60
No	7(50.0)	150(52.4)	1.0	Ref. Cat.	
Gender					
Females	11(78.6)	155(54.2)	2.3	1.08-1.11	< 0.01**
Males	3(21.4)	131(45.8)	1.0	Ref. Cat.	
Residence					
Urban	13(92.9)	167(58.4)	12.0	1.02-1.80	0.02**
Rural	1(7.1)	119(41.6)	1.0	Ref. Cat.	
Obesity					
Normal	3(21.4)	209(73.1)	1.0	Ref. Cat.	< 0.01**
Overweight	6(42.9)	64(22.4)	2.5	1.06-1.14	
Obese	5(35.9)	13(4.5)	5.5	1.17-2.76	
Age(yrs)					
18-30	1(7.1)	128(44.8)	1.0	Ref. Cat.	0.04**
31-40	4(28.6)	80(28.0)	1.3	0.68-0.94	
41-50	9(64.3)	78(27.2)	2.5	1.02-2.43	
LSTM (yrs)					
< 10	1(7.1)	55(19.2)	1.0	Ref. Cat.	0.84
10-20	2(14.3)	52(18.2)	0.6	0.42-2.02	
≥ 20	11(78.6)	179(62.6)	0.9	0.42-2.12	
Ethnicity					
Dagomba's	9(64.3)	261(91.3)	1.0	Ref. Cat.	0.03**
Gonja's	3(21.4)	9(3.1)	0.7	0.52-0.99	
Others	2(14.3)	16(5.6)	0.6	0.47-0.98	

FDM: Family History of Mellitus; FHPT: Family History of Hypertension; HPD diabe: History of Pre-Diabetes; HGD: History of Gestational Diabetes; LSTM: CI: Confidence Interval, Ref. Cat.: Reference category; [1]Significance based on binary logistic regression analysis, [2]proportions; **p-values significant at < 0.05

A total of 26.7% of the participants had IFG (hypoglycemia, pre-diabetes and hyperglycemia). This observation is consistent with an IFG prevalence of 26.4% among adult Nigerians in a study conducted by [20]. The prevalence of IFG in the present study is quite high considering the fact that it is undiagnosed and

the consequences of un-detection earlier could lead to cardiovascular diseases, kidney retinopathy and visual deterioration [29]. However the observed prevalence is lower than a prevalence of 57.0% reported among adult Ghanaians by [9]. Impaired fasting blood glucose was more prevalent among participants who had positive family history of diabetes mellitus (Table 2) and the findings are similar to those found among Cameroonian adults by [28]. The high prevalence of IFG may also be due to the high levels of obesity and lipidemia observed in the present study. Similar observations were made by [20] and [30] in separate Nigerian Studies that looked at the geographical prevalence of diabetes mellitus.

Our findings showed a pre-diabetes prevalence of 13.0% and this is similar to what was reported by Oyenusi, et al., (2016) in Cote d'Ivoire. Pre diabetes was more prevalent among urban participants (15.0%) than rural participants (10.0%) and this agrees with findings of 15.2% and 9.8% among urban and rural adults respectively in Saudi Arabia as reported by [31]. Sedentary lifestyles and unhealthy dietary practices leading to high risks among urban dwellers could be a contributory factor to this observation. Similar conclusions were made by [32] in a study that looked at factors influencing diabetes occurrence in Saudi Arabia.

Being a female predicted the development of undiagnosed diabetes among our participants. This may be due to the fact that female participants may have a history of gestational diabetes which may not have been fully resolved prior to our study [25]. Available data shows that Ghanaian females are more obese than men which predispose them to DM [4]. Obesity predicted development of diabetes in the current study [33], in a Cameroonian study found that obese subjects were about 2-4 times at risk of developing Type 2 diabetes. In a separate Ivorian studies, Oyensu and Odegard also found obese participants to have 6 folds risk of developing diabetes [5,34,35]. In a South African study carried out in the West province, Podoa also reported 6.5 times risk of developing diabetes among obese subjects [13]. It is believed that obesity leads to insulin resistance in the peripheral tissue and insulin secretory defect of the beta cell which predisposes an individual to diabetes mellitus [28].

Living in urban Tamale Metropolis predicted the development of UT2DM. This may be due to physical inactivity and poor dietary intake which increases an individual chance of developing hyperglycemia. Our findings are consistent with a comparative study by [36], whose findings showed that the prevalence of diabetes mellitus increases with urbanization, with those migrating from rural to urban communities having an increased risk (4 folds) of developing the disease. In an Arabian and Nigerian studies respectively Alotabi and Ogbera found environmental factors to be associated with the development of diabetes mellitus [30,32]. Our findings also revealed that family history of diabetes predicts UT2DM development irrespective of the type of residency status of participants. This was also observed by [26], whose studies were among siblings of patients with Type 2 diabetes. Subjects in the study had15fold risk of developing Type 2 diabetes mellitus. This finding of our study is also consistent with that of [12] who found a six-fold risk of developing diabetes mellitus among siblings in a Saudi Arabia study.

The current study despite the robust design adopted has some weaknesses. The inability to verify the diabetes status of respondents prior to enrollment may have an influence on our findings. We did not perform some important diabetes test such as oral glucose test to confirm our results. We are also unable to establish causation but rather associations with the risk factors since this was a cross-sectional study. Despite these few limitations, our findings are still valid and accurate in estimating the true state of UT2DM in the study area. We reject the null hypothesis and conclude that there is a statistically significant difference in the prevalence of undiagnosed type 2 diabetes UT2DM among rural and urban participants. Prediabetes and IFG are more prevalent in the urban areas compared with the rural areas. Some of the predictors of undiagnosed diabetes mellitus are genetic and inherent.

Conclusion

In this current study, we determined the prevalence of undiagnosed type 2 diabetes mellitus (UT2DM) in rural and urban Ghana, 4.7%. The prevalence was seemingly high in the urban areas than in the rural areas. This was observed as a result of the increasing trends of risk associated with the development of type 2 diabetes mellitus (UT2DM) in urban areas. Notable among these factors were overweight/obesity, old age, ethnicity and family history of diabetes mellitus.

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