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Prevalence and risk factors of type 2 diabetes mellitus in a rural and an urban Nigerian community: Are the demographics changing?

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ABSTRACT

Background

The prevalence of Diabetes Mellitus (DM) is increasing at an alarming rate globally and in sub-Saharan Africa, Nigeria inclusive. Previous community-based studies in Nigeria, including studies in Abia State have demonstrated a high prevalence of DM, with no significant difference between the rural and urban areas in the previous study done in Abia State.

Objective

To evaluate the prevalence and risk factors of DM in urban and rural communities of Abia State, South-Eastern Nigeria.

Method

A cross-sectional comparative study of 2800 adults, comprising equal numbers of rural and urban residents of Abia State was conducted. Data was obtained using interviewer administered semi-structured questionnaires (Appendix 1). Blood pressure, anthropometric indices and fasting blood glucose were obtained for each of the participants. Data analysis was done using SPSS version 20.

Results

The mean age of the respondents was 48.54 ± 13.24 years, with the rural residents being significantly older than the urban, (54.23 ± 14.26 and 42.85 ± 13.24 years, respectively p<0:001). Male to female ratio was 1:2.5, (p<0.001). Diabetes mellitus was observed in 8% of the respondents (urban = 8.9% and rural = 7.2%, p=0.110). Independent predictors of DM in this study included age, family history of DM, daily intake of fruits in processed forms and hypertension in the urban area, while in the rural area are age and family history of DM.

Conclusion

The prevalence of DM is rising in Abia State, with no significant urban-rural difference as observed in previous studies in the state.

Keywords:Abia State, Diabetes Mellitus Type 2, Rural community, Urban community, Prevalence, Risk Factors, Demographic Factors

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INTRODUCTION

The prevalence of non-infectious diseases, also known as non-communicable diseases (NCDs), has been increasing globally in the past few decades. This includes diabetes mellitus (DM), hypertension, cardiovascular diseases (stroke, coronary heart diseases, peripheral artery disease), chronic obstructive pulmonary disease, asthma and cancer.[1-2] This has resulted in a double burden of diseases in developing countries, firstly by infections (communicable diseases), which have been the traditional health challenge in these countries and secondly by non-communicable diseases, with the potential of overwhelming the already inadequate and poorly financed health services in sub-Saharan Africa, Nigeria inclusive.[3-6] Diabetes mellitus is a chronic metabolic disorder, characterized by chronic hyperglycaemia, caused by an absolute or relative insulin deficiency or defective action of insulin, resulting in disturbances in carbohydrates, protein and fat metabolism[7].In 2015, about 537 million people lived with diabetes worldwide and it was projected to increase to 645 million by the year 2045.[8] Diabetes mellitus, like other NCDs, in addition to being chronic, also affects adults who have enormous economic and social responsibilities.[2,9] Diabetes caused 4.0 million deaths in 2017, which means one death from it every 8 seconds and over 70% of these deaths occurred in people under the age of 60. In Africa, 16 million people were living with DM at that time, while in Nigeria, it was reported that about 2 million people were living with diabetes, with about 60% of them undiagnosed.[8] The diabetic epidemic is centred around type 2 DM which is associated with preventable risk factors such as obesity, hypertension, dyslipidaemia, unhealthy diet, lack of physical activity and regular exercise. Old age, family history of diabetes mellitus, history of impaired glucose tolerance/ impaired fasting glucose are other risk factors associated with diabetes. Type 2 DM has insidious onset, often preceded by a long period of insulin resistance and often recognized late in countries lacking resources, with various short and long-term complications.[10] In these countries, diabetes is postulated to be a disease of the rich, but with the on-going lifestyle transition among all groups as a consequence of economic development, this chronic disease also affects the poor and is no longer believed to respect social status.[8, 11,12]

Urbanization, with the adoption of western lifestyles, has been responsible for the abandonment of the healthier traditional lifestyle by people in developing countries, leading to the development of NCDs including DM.[13,14] This traditional lifestyle was characterized by regular and vigorous physical activities, accompanied by subsistence on high fibre, and a whole grain-based diet rich in vegetables and fruits.[13,14] Urbanization has resulted in over-reliance on motorized transport, thereby limiting walking as a form of exercise and in consumption of unhealthy diets, rich in carbohydrates, fats, sugars and salts.[15] The health systems in many countries, including Nigeria, are not equipped to meet the rising challenges of diabetes and other NCDs care. At present, screening for diabetes around the world is largely opportunistic, that is, only those who present at health facilities receive it.

Previous studies on non-communicable diseases in Abia State demonstrated a high prevalence of DM and overweight and obesity which are important risk factors for DM.[16] No significant difference was observed in the prevalence of DM amongst urban and rural residents in the previous study, though higher among urban residents.[16] This study therefore sets out to determine the prevalence and risk factors of DM in rural and urban communities of Abia State and compare the current prevalence with the previous findings.

METHODOLOGY

The methodology is as previously published on pre-diabetes in the same population.[17] The study was carried out in Abia State, South-Eastern Nigeria, which is one of the 36 states in the Federal Republic of Nigeria, with three senatorial districts, namely Abia north, Abia south and Abia central and two main cities, namely Umuahia, the capital city and Aba, the commercial city.[18] It has 17 local

government areas (LGAs) and an approximate population of 2.8 million, with males forming 46.6% and females, 53.4%.[18] The study had a cross-sectional comparative design, involving adults aged 18 and above, who had lived in the study areas for at least 2 years. Terminally ill persons, those with mental illness, pregnant women and women in the post-partum period were excluded from the study. The sample size was calculated by using the formula for comparison of proportions between two groups,[19] to estimate a minimum sample size of 1382[17] for each group, using the previous prevalence of diabetes for rural and urban areas in Abia State.[16] This was rounded off to 1500, accounting for the 10% non-response rate. A total of 2800 participants, who gave consent and fulfilled the inclusion criteria were however studied, half of which were recruited from the urban community, while the other half were rural residents.A multistage (3 stages) cluster random sampling method was used to select the study participants, as follows.

1st stage: A list of all the 14 LGAs that houses the rural communities in Abia state was made. From the list, a simple random technique (balloting) was used to select Isiala Ngwa North LGA. Similarly, within the 3 LGAs that house the major cities in Abia state, a simple random technique (balloting) was used to select Aba North LGA.
2nd stage: All the administrative wards in the selected LGAs were listed (12 in Aba North and 10 in Isiala Ngwa North). A simple random technique (balloting) was used to select Ama-asaa ward (ward 01) in the rural area and Eziama (ward 01) in Aba North.

3rd stage: Catchment villages from the selected ward in the rural LGA (Ama-asaa) were listed. Five villages, (Umueke Amachi, Umuogele Amachi, Umunkolo Amachi, Usaka Umuofor and Umuosonyike were selected by simple random technique from this list. These five villages formed the unit of selection in the rural area. Catchment areas From Eziama ward in Aba North LGA, were listed. Umungasi and Brass were selected by simple random technique. Brass, Umungasi and their environs (Faulk's road and Umungasi-Abayi road) formed the unit of selection in the urban area. Community mobilization was done via announcements by town and market announcers and religious organizations in the selected areas, as well as house to house and street to street announcements. Recruitment of participants was done centrally at Amachi Nsulu Health centre and Usaka Umuofor town hall in the rural area, while in the urban area, it was done at Umungasi town hall and Abayi town hall. Recruited participants who gave consent to participate in the study were selected consecutively, till the required sample size was obtained. The study was carried out from January to March 2017.

An interviewer administered semi-structured questionnaire (modified WHO screening tool for non-communicable diseases) was used to collect the participant's data.[20] The questionnaires were pretested before use. Copies of the pretested tool were administered to all consenting participants. Recruitment and selection of the participants were done on the first day of contact with them. Socio-demographics, medical history, and physical examination, including anthropometric measurements were obtained for each of them while fasting blood glucose was done on the second day. Weight (Wt) in Kg and height (Ht) in cm were obtained using a weighing scale and stadiometer.[20] Body mass index (BMI) was calculated by dividing the weight (Wt) in kg by the square of the height (Ht^2) in metres viz $BMI=Wt/Ht^2$ (in kg/m^2). All values were taken to the nearest one decimal place.[20] Waist Circumference (WC) and Hip Circumference (HC) in centimetres (cm) were measured, using a flexible inelastic tape to the nearest 0.1cm.[21] Blood pressure (BP) was measured using Accoson mercury sphygmomanometer (standard cuff- 15x55cm). A resting systolic BP of 140mmHg and above and or a diastolic BP of 90mmHg and above was regarded as hypertension. Patients taking antihypertensive drugs were also regarded as hypertensive, even if their BP were below these cut off points.[20]

Fasting blood glucose was done between 6am and 9am on the second day of contact with the respondents. Pre-tested and pre-calibrated Accu-

chek Active® glucometers and finger pricked blood samples were used for the test. The OGTT was performed for eligible respondents (those who had normal FBG or FBG in the IFG range) by preparing a glucose solution using 82.5 g Allenbury's glucose D (an equivalent of 75 g anhydrous glucose), which was dissolved in 200 ml of clean drinking water and given to each eligible respondent to drink. Blood glucose was measured 2 h after intake of the glucose drink, using the same glucometer. This was recorded as the 2-hour post glucose load value. An oral glucose tolerance value within 140mg-199mg/dl (7.8-10.9mmol/L) was termed impaired glucose tolerance. Values lower than 140mg/dl (7.8mmol/L) were taken as normal while those ≥200mg/dl (11.1 mmol/L) were regarded as diabetes.

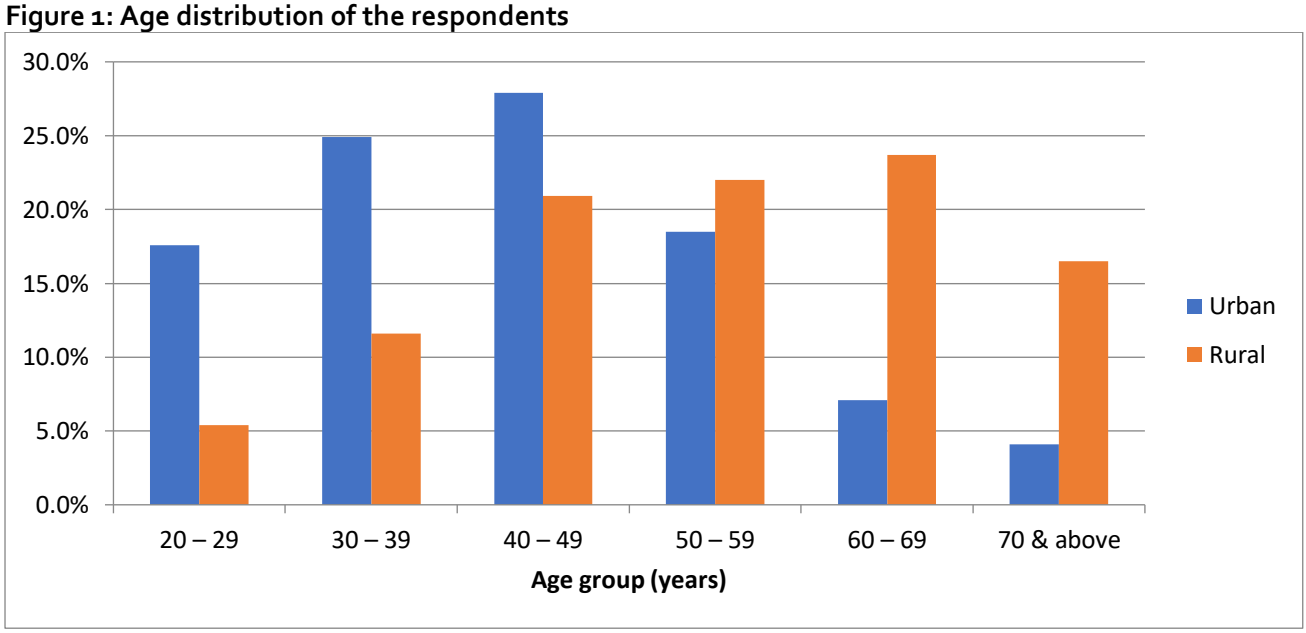
Data generated from the study was entered clean into Microsoft Excel spreadsheet and imported into SPSS for analysis, using SPSS version 20 (SPSS Inc. Chicago,Ill USA) statistical software.[22] The baseline socio-demographic and clinical characteristics of the participants were analyzed. Mean ± standard deviation was computed for normally distributed continuous variables. Proportions of the categorical variable were computed. Differences in anthropometric and clinical characteristics between urban and rural as well as Diabetes were analyzed using student's t test. The association of diabetes with age, anthropometric parameters (BMI, WC, HC, WHR), blood pressure, were determined using logistic regression and chi square. P value ≤ 0.05 was considered statistically significant. Results were presented in charts and tables.

Ethical clearance for the study was obtained from the Abia State Ministry of Health ethical committee, before commencing the work. Permission was also sought from the community leaders before the study was commenced.

RESULTS

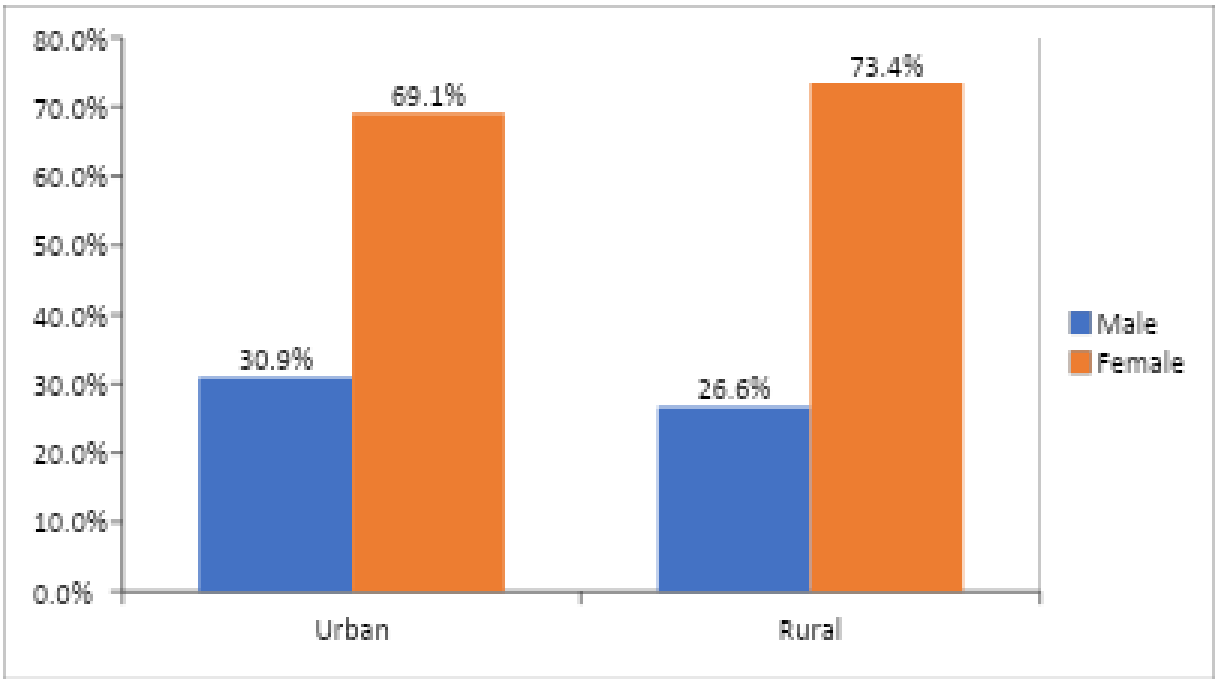
A total of 2800 participants, (1400 urban and 1400 rural) were studied. An oral glucose tolerance test (OGTT) was performed on 2424 respondents, who met the eligibility criteria (1117 urban and 1307 rural). The mean age ± SD of the participants was 48.54 ± 14.89 years, (urban= 42.85 ± 13.24 years, and rural=54.23 ± 14.26 years, p<0.001).

Figure 1: Age distribution of the respondents



Majority of the respondents in the urban areas were in the age range 30 to 49, while in the rural areas, they were in the age range of 50 to 69 years.

Figure 2: Gender distribution of the respondents



There were more females than males in both the urban and rural areas.

Table 1. Occupation, marital status and level of education among Urban and Rural respondents

	Urban n (%)	Rural n (%)	χ^2	P Value
Occupation				
Farming	159 (11.4)	961 (68.6)	998.164	< 0.001*
Fishing	0 (0.0)	12 (0.9)		
Business	850 (60.7)	303 (21.6)		
Housewife	48 (3.4)	11 (0.8)		
Retired	41 (2.9)	31 (2.2)		
Civil servant	280 (20.0)	80 (5.7)		
Student	22 (1.6)	2 (0.1)		
Marital status				
Single	324 (23.1)	57 (4.1)	356.515	< 0.001*
Married	939 (67.1)	926 (66.1)		
Widowed	125 (8.9)	417 (29.8)		
Separated	12 (0.9)	0 (0.0)		
Educational level				
No formal	109 (7.8)	85 (6.1)	1963.076	< 0.001*
Primary	242 (17.3)	1005 (71.8)		
Secondary	681 (48.6)	284 (20.3)		
Tertiary	368 (26.3)	26 (1.8)		

The main occupation of the respondents in the urban area was business (60.7%), while the main occupation of the respondents in the rural area was farming (68.6%). Majority of the respondents in both the rural and urban area were married. In terms of highest educational attainment, majority of the

respondents in the urban area had secondary education (48.6%), while those in the rural area had primary education (71,8%).

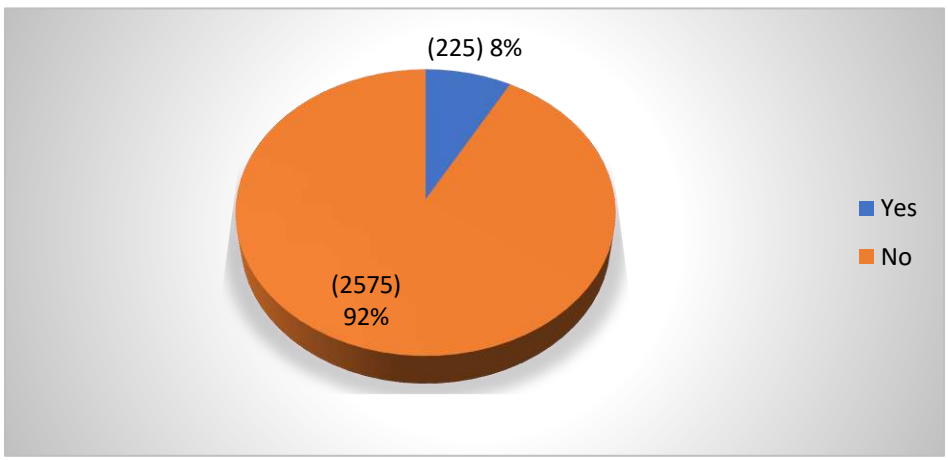
Table 2: Association of DM and its risk factors in the study population

	Diabetes		P value	OR	95% C.I for OR
	Yes n (%)	No n (%)			
BMI					
Normal	72 (32.0)	1071 (41.6)			
Underweight	5 (2.2)	96 (3.7)	0.591	0.775	0.306 – 1.964
Overweight	97 (43.1)	835 (32.4)	0.001*	1.728	1.257 – 2.375
Obesity	51 (22.7)	573 (22.3)	0.140	1.324	0.912 – 1.922
WC					
Abnormal	180 (80.0)	1398 (54.3)	< 0.001*	2.240	1.695 – 2.959
Normal	45 (20.0)	1177 (45.7)			
WHR					
Abnormal	97 (43.1)	651 (25.3)	0.211	1.219	0.894 – 1.663
Normal	128 (56.9)	1924 (74.7)			
HBP					
Yes	167 (74.2)	1809 (70.3)	< 0.001*	3.368	2.407 – 4.711
No	58 (25.8)	766 (29.7)			

p=significant. BMI=Body Mass Index, WC=Waist Circumference, WHR=Waist Hip Ratio, HBP=High Blood Pressure*

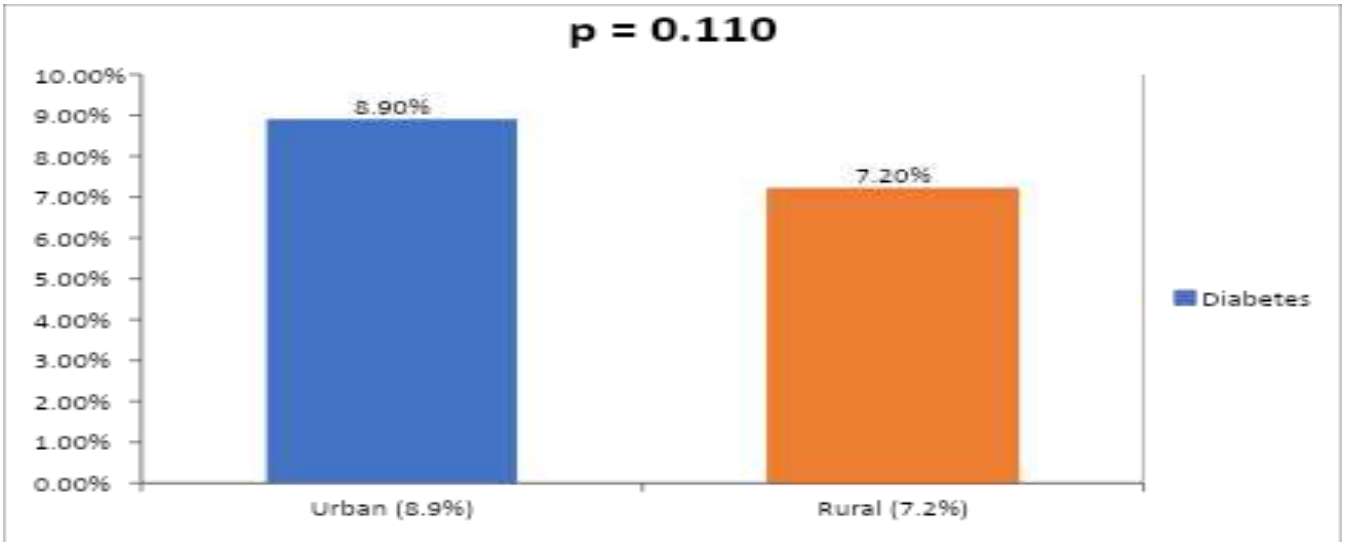
Overweight, abnormal WC and hypertension were significantly associated with diabetes in the study.

Figure 3: Prevalence of diabetes in Abia State



Diabetes mellitus was present in 8% of the study population.

Figure 4: Prevalence of diabetes in Urban and Rural Abia



Diabetes mellitus was observed more in the urban than the rural areas, but the difference was not statistically significant.

Table 3: Comparison of the frequency of some clinical and lifestyle characteristics with diabetes among the respondents in the urban area

	Diabetes Yes n (%)	No n (%)	P value	OR	95% C.I for OR
Family history of DM					
Yes	35 (20.2)	138 (79.8)	< 0.001*	3.243	2.111 – 4.981
No	89 (7.3)	1138(92.7)			
Previous history of DM					
Yes	108(100.0)	0 (0.0)	NA	NA	NA
No	16 (1.2)	1276(98.8)			
Age					
<46years	37 (4.4)	799 (95.6)	< 0.001*	0.254	0.170-0.379
≥46years	87 (15.4)	477 (84.6)			
Tobacco use					
Yes	116 (8.6)	1227(91.4)	0.165	0.579	0.2268-1.250
No	10 (14.0)	49 (86.0)			
Alcohol use					
Yes	124 (9.2)	1224(90.8)	NA	NA	NA
No	0 (0.0)	52 (100.0)			
Daily intake of fruits					
Yes	48 (14.0)	295 (86.0)	<0.001*	2.100	1.430-3.084
No	76 (7.2)	981 (92.8)			
Physical activity					
Yes	107 (9.3)	989 (90.7)	0.314	1.274	0.795-2.042
No	23 (7.4)	287 (92.6)			

p=significant, NA=Not applicable*

Family history of diabetes, age >46 years and daily intake of fruits are factors significantly associated with diabetes in the urban area.

Table 4: Comparison of the frequency of some clinical and lifestyle characteristics with diabetes among the respondents in the rural area

	Diabetes				
	Yes n (%)	No n (%)	P value	OR	95% C.I for OR
Family history of DM					
Yes	21 (25.6)	61 (74.4)	< 0.001*	5.327	3.089 – 9.188
No	80 (-6.1)	1238(93.9)			
Previous history of DM					
Yes	69 (100.0)	0 (0.0)	NA	NA	NA
No	32 (2.4)	1299(97.6)			
Age					
<46years	3 (0.8)	393 (99.2)	< 0.001*	0.071	0.022-0.224
≥46years	98 (9.8)	906 (90.2)			
Tobacco use					
Yes	97 (7.3)	1236(92.7)	0.687	1.236	0.441-3.468
No	4 (6.0)	63 (94.0)			
Alcohol use					
Yes	101 (7.8)	1202(92.2)	NA	NA	NA
No	0 (0.0)				
Daily intake of fruits		209 (92.5)	0.845	1.055	0.614-1.815
Yes	17 (7.5)	1090(92.8)			
No	84 (7.2)				
Physical activity					
Yes	91 (7.1)	1185(92.9)	0.702	0.875	0.443-1.729
No	10 (8.1)	114 (91.9)			

Family history of diabetes is associated with diabetes in the rural area, while age <46 years is protective.

Table 5: Multivariate analysis showing predictors of diabetes in urban and rural areas

			95% C.I for OR	
	P value	OR	Lower	Upper
Urban				
Physical activity	0.294	1.292	0.801	2.084
WC (abnormal)	0.195	1.424	0.834	2.432
HTN	< 0.001	3.093	1.832	5.221
Age group(<46)	< 0.001	0.405	0.247	0.664
Family history of DM	< 0.001	3.618	2.097	6.240
Daily fruits intake	< 0.001	3.040	1.887	4.897
Rural				
Physical activity	0.706	0.874	0.435	1.757
WC (abnormal)	0.187	0.622	0.307	1.260
HTN	0.285	1.477	0.722	3.019
Age group(<46)	< 0.001	0.080	0.023	0.279
Family history of DM	< 0.001	6.932	3.115	15.428

Independent predictors of diabetes in the urban areas include hypertension, family history of diabetes and daily intake of fruits, while younger age <46 years is protective. In the rural area, family history of diabetes is an independent predictor of diabetes, while younger age <46 is protective

DISCUSSION

The prevalence of diabetes mellitus, shown in this study is more than twice higher than the previous prevalence of 3.6% obtained in a community-based study, conducted in Abia State about 6 years earlier.[16] The majority of the participants in this study, (54%) were middle aged and elderly in contrast with the previous study where the majority (67%), were young and middle aged. The prevalence of DM may have been under- reported in the previous study in Abia State, as the participants were younger than those in this study. It may also be due to the ongoing global rise in the prevalence of DM and other non-communicable diseases in sub-Saharan Africa. A similar high prevalence of diabetes of 7% was reported in a recent study carried out in Calabar, Cross River Nigeria by Enang et al.[23] Nwatu et al in their recent study, involving a rural community in Enugu State reported a prevalence of DM of 4.8% [24], which is lower than what was observed in this study. The study in Enugu however did not include urban residents, which may explain the lower prevalence observed in their study. Nyenwe et al reported a crude and standardized prevalence rates of DM of 6.8% and 7.9% respectively in a study carried out in Port-Harcourt, Rivers State over a decade ago.[25] This is similar to what was observed in our study though there was no known prevalence of DM in Abia State when the Port-Harcourt study was carried out. Both Abia and Rivers States are in the same geographical region of Nigeria, (Southern Nigeria) and may have some similarities in terms of ethnicity and lifestyle. The prevalence of DM in this study however falls within the range of prevalence reported from a recent review of population based studies in Nigeria, over a 23 year period (1990 to 2013), by Dahiru et al.[26] The reported range of prevalence from the review was 0.8 to 11% in studies involving both rural and urban communities in Nigeria.[26] A rise in the prevalence of DM has been reported over a short time interval in other countries including sub-Saharan African countries for example, the prevalence of diabetes in Tanzania and Uganda, two sub-Saharan African countries with comparable socioeconomic status, was estimated at 7.8% (Tanzania) and 4.1% (Uganda) in 2013[27], but a more recent study, barely two years later demonstrated a prevalence of DM of 10.1% in Uganda and 8.3% in Tanzania.[28] Similarly, two large-scale national surveys conducted in China in 2007 and 2010 revealed that the prevalence of diabetes increased from 8.2% to 10.3% within three years.[29,30] The increased frequency of diabetes observed in this study, when compared with the previous studies in Abia state may be part of the rising trend of DM.

Among those found to have DM in our study, 32% were previously undiagnosed, while 68% knew that they had DM. The proportion of participants with DM in the urban area (8.9%) was slightly higher than that in the rural area (7.2%), with the difference not statistically significant. A previous community-based study done in Abia state, revealed an urban and a rural prevalence of DM of 4.4% and 3.0% respectively with no significant difference between the two as observed in this study[16] Though a more than two-fold increase in the frequency of DM has been observed in this study, when compared with the previous study, the trend is still the same, with the margin being closer than it was in the previous study. In low-income settings as seen in developing countries, diabetes is often postulated to be a disease of the rich, but with economic development and its consequent on-going lifestyle transition among all groups, diabetes now affects the poor also.[11,12,] Different trends in the prevalence of glucose abnormalities have been reported in other parts of the world, with some reporting higher prevalence of DM and pre-diabetes in rural communities. Alberts et al. reported a high prevalence of DM of 8.8% in a study conducted a few years ago in a poor rural black community of South Africa.[31] This was the highest reported prevalence of

DM among rural black Africans then. More recently, a community-based study in Uganda and Tanzania, two sub-Saharan African countries with comparable socioeconomic status, reported an overall prevalence of diabetes of 10.1%, which was highest among rural Ugandan residents (16.1%) compared to teachers in Tanzania (8.3%) and peri-urban Ugandan residents (7.6%).[28] The reasons that may be adduced for the higher prevalence in the rural areas include westernization, increasing age, higher life expectancy and hypertension. Variations in the prevalence of DM among ethnic rural communities may also be attributed to variations in dietary habits and influence of proximity to major urban centres.

Being overweight, having an abnormal WC and hypertension were the risk factors that were found to be significantly associated with diabetes in this study. This is similar to findings from previous studies in Nigeria, and in developed countries.[25, 32-35] Obesity is the most common cause of insulin resistance.[36] Apart from the degree of obesity the risk is also dependent on the distribution of body fat.[38] The correlation of the risk factors with the development of diabetes in never absolute, that is to say not 100%. However, the greater the number of risk factors present in an individual, the greater the chance of that individual, developing or having diabetes. On the other hand, the chance of an individual without any symptoms of diabetes and who have no risk factors, developing diabetes is low. Overweight, abnormal WC, hypertension, advancing age, alcohol consumption and family history of DM were significantly associated with DM in the urban area, while abnormal WHR, hypertension, advancing age, alcohol consumption and family history of DM were significantly associated with DM in the rural area. The independent predictors of diabetes in the urban area included hypertension, age, family history of diabetes and daily intake of fruits and vegetables while for the rural area, age and family history of DM were independent predictors of DM. The association of diabetes with hypertension, increasing age and family history of diabetes is similar to findings from previous studies. Sabir et al. observed that increasing age, increased BMI, increased WC and hypertension were associated with an increased risk of developing DM in a rural and an urban Fulani community respectively.[34,35] Nyenwe et al. also reported obesity, high WHR, family history of diabetes, increasing age and being of the Hausa or Ibibio tribe as factors associated with dysglycaemia.[25] Nwatu et al. observed that hypertension and advancing age were significant risk factors for pre-diabetes in a rural community in Enugu State, Nigeria.[24] Aging with its associated co-morbidities, predominantly hypertension, were important risk factors observed to be associated with diabetes among rural community residents in our study, while in the urban area where the population was predominantly younger than in the rural area, markers of obesity were predominant risk factors for DM.

Respondents in the urban area who consumed fruits daily were 2 times more likely to have diabetes than those who did not consume fruits daily. This association was however, not observed in the rural area. The significant association of daily intake of fruits with the development of diabetes in the urban areas is at variance with findings from other studies, where daily consumption of fruits and vegetables have been linked with reduction in the prevalence of diabetes.[39-41]However, a study by Hamer M and Chida Y in the United Kingdom, observed no significant reduction in the risk of type 2 diabetes with daily consumption of fruits and vegetables.[42] This variance may be as a result of the types of vegetables and fruits consumed, how they are consumed as well as the quantity. Though the portion and pattern of fruits and vegetable consumption were not assessed in our study, the majority of the fruits and vegetable vendors in Abia State were observed to display their goods mainly in blended forms of a cocktail of vegetables and fruits, packaged in bottles in the urban areas studied. Overconsumption of fruits and vegetables may occur when taken in this form and there may be additives in the processed fruits and vegetables, which may rather be harmful than protective. Further studies are needed on this. However, when people are counseled on fruits and vegetable consumption, the pattern of consumption as well as the daily servings should be emphasized.

Recommendations

More frequent risk assessment and screening for

diabetes should be carried out in Abia State and it should be more focused on the rural communities, due to the aging population and associated risks of glucose abnormalities. Fruits and vegetables should be consumed in the raw and natural forms. When giving counselling on fruits and vegetable consumption, this should be emphasized.

Conclusion

The prevalence of diabetes is high in Abia State, with a greater than two -fold increase observed in less than a 10 year interval, with no significant rural-urban difference as observed in a previous study in Abia State Th. Markers of insulin resistance are associated with diabetes in this study. Daily consumption of fruits and vegetables in processed forms may rather cause diabetes than protect against it.

Limitation of the study. Accu-chek glucometers which are point of care devices were used in testing for glucose in this study. The chosen study design constitutes another limitation.

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