Journal of Community Medicine and Primary Health Care. 32 (1) 47-58

JOURNAL OF COMMUNITY MEDICINE AND PRIMARY HEALTH CARE

ORIGINAL ARTICLE

Risk assessment of type 2 diabetes and validation of a non-invasive risk-prediction tool among women in an urban community in Delta State, Nigeria

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Keywords

American Diabetic Association Risk Tool; Prediabetes; Undiagnosed diabetes; Women, Nigeria.

ABSTRACT

Background: Early identification of high-risk individuals is essential in the prevention and control of type 2 Diabetes Mellitus (T2DM). This study assessed the risk of T2DM and validated the American Diabetes Association (ADA) risk tool among urban Nigerian women.

Methods: This was a cross-sectional study of 159 consenting women aged ≥18 years, consecutively recruited at a medical outreach in Sapele, Delta State, Nigeria. The risk of T2DM was assessed with a modified ADA risk tool. Respondents' weight, height, blood pressure and blood glucose levels were measured. Data were analyzed using SPSS version 23.0.

Results: The participants had a mean age of: 41.5(±13.2) years, body mass index: 27.3(±5.38) kg/m^2, SBP: 128(±19.4) mmHg and DBP: 81(±10.8) mmHg. Five (3.1%) reported a history of gestational diabetes, 21 (13.2%) had a first degree relative with T2DM, 26 (16.4%) were physically inactive, and 37 (23.3%) reported a history of hypertension/use of anti-hypertensives. Forty-eight (30.2%) had a high-risk for prediabetes and undiagnosed DM. The ADA risk tool was found to be useful with sensitivity (81.8%), specificity (73.6%), and ROC area under the curve (0.848, 95%CI: 0.743–0.953). Respondents with a high-risk of prediabetes and undiagnosed DM had significantly higher mean BMI (30.7 vs 25.9kg/m^2), SBP (141.9 vs 122.5mmHg) and DBP (85.9 vs 79.1 mmHg).

Conclusion: The performance of the ADA Risk Tool was useful in this study. One-in-three respondents had a high-risk of prediabetes and undiagnosed DM. Overweight/obesity, older age, gestational diabetes and hypertension were significantly associated with a high-risk for prediabetes and undiagnosed DM among women.

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INTRODUCTION

Type 2 diabetes mellitus (DM) is a non-communicable disease with growing global public health significance. The burden of DM is highest in low- and middle-income countries. Indeed, about 80% of the 425 million persons with DM live in these developing economies.[1] The prevalence of DM in Nigeria is increasing.[2] In a systematic review and meta-analysis of the epidemiological burden of DM in Nigeria, Uloko et al estimated the overall pooled prevalence of DM from 23 studies spanning

between 1999 and 2016 as 5.77%.[3] Compared to the reported national prevalence of 2.2% in 1992, the pooled prevalence was a 2.6-fold increase.[4] Uloko et al also noted variations in the pooled prevalence of DM across the six geopolitical zones in Nigeria; highest in South-South (9.8%) and lowest in North-West (3.0%).[3] Complications of DM contribute towards a substantial proportion of non-communicable related-deaths, morbidities and disabilities. In 2017, an estimated 4 million deaths were attributed to DM, chiefly from stroke, heart and kidney diseases.[1] Indeed, DM is a cardiovascular disease risk equivalent.

Globally, approximately 50% of persons living with DM are undiagnosed. The proportion of undiagnosed DM, however, has regional differences; being highest in Africa (69.2%).[1] In the same vein, many are unaware of their risk of DM and as such, do not take proactive measures to prevent the disease.[1] Type 2 DM is associated with urbanization and lifestyle choices that promote the consumption of unhealthy diet, overweight/obesity, and physical inactivity.[1] In low- and middle-income countries like Nigeria and India, urban populations are at an increased risk of developing DM. [3, 5] Although, there is no gender predilection in the development of type 2 DM, the adverse consequences of the disease are severely more in women than men. For example, women with DM are 50% more likely to die prematurely from cardiovascular disease than their male counterparts. [6-8] This may be partly explained by the fact that women with myocardial infarction complicating DM present with atypical symptoms and are less likely to receive prompt treatment as outlined in evidenced-based guidelines compared to their male counterparts.[8, 9] Gender inequity and lack of empowerment in women also influence their health-seeking behaviours and access to healthcare.[10] Indeed, more women than men die from DM. Of the nearly 4 million DM related deaths in 2017, there were 0.3 million more deaths in women than men.[1]

The definitive diagnosis of DM is made usually by biochemical tests of blood samples for blood glucose and glycated haemoglobin (HbA1C). However, there are several useful non-invasive risk-prediction tools for screening for prediabetes and undiagnosed diabetes in community surveys and clinical practice.[11-16] Ethnic differences affect the usefulness and practicability of a risk-prediction tool. For example, compared to the American Diabetes (ADA) risk tool, and the National Health and Nutrition Examination Survey Risk Score, the Finnish Diabetes Risk Score (FINDRISC) tool is most useful when screening Caucasian population.[12] Although the ADA risk assessment tool was developed for use in Caucasian and black populations, it has also been validated for use among other ethnic groups in Asia.[15, 16] This gives credence to its usefulness across a range of diverse populations. The ADA risk tool has also been found to have better accuracy compared to other diabetes risk assessment tools including the Rotterdam

model and the FINDRISC tool when used to screen women for prediabetes, and undiagnosed DM.[15] Like most other risk prediction tools, the ADA risk assessment tool is simple, easy and quick to administer.[13]

This study, therefore, aimed primarily at assessing the risk of prediabetes and undiagnosed DM among women in an urban community in Delta State, South-South, Nigeria, using the American Diabetes (ADA) risk tool. The accuracy of the ADA risk tool will also be assessed as this tool has not been previously validated for use among Nigerians.

METHODOLOGY

The cross-sectional study was conducted in Sapele, Delta State, South-South, Nigeria. Sapele is one of the urban communities in the oil-rich Delta State. The estimated population of Sapele is over 161,000 persons. The study population was selected from a cluster of women who attended a free medical outreach programme in Sapele. The programme, which held in May 2019, was put together by the women's group of a faith-based organization and targeted women primarily.

Women aged at least 18 years were consecutively recruited for the study. Women with a known history of diabetes mellitus and non-consenting women were excluded from the study. The Cochrane formula was employed to determine the minimum sample size for this study.[17] Applying the prevalence rate of type 2 diabetes mellitus of 9.8% in South-South Nigeria,[3] and assuming a 95% confidence interval, an alpha (type 1) error margin of 5%, and a non-response rate of 10%, the minimum sample size for this study is 137.

Ethical approval was obtained from the Delta State University Teaching Hospital (DELSUTH) Health Research Ethics Committee (HREC). Refusal to participate in the study did not in any way interfere with the activities of the medical outreach, which included health talk on diabetes mellitus and other non-communicable diseases, and screening for cervical cancer.

The study questionnaire was a modified American Diabetes Association (ADA) Risk Tool.[13] The ADA risk assessment tool is a simple 7-item questionnaire for assessing the risk of prediabetes and undiagnosed DM. Unlike the ADA risk assessment tool, the study questionnaire had questions in six domains. Sex, which is scored one (1) for males and zero (0) for females in the ADA risk tool, was not included in the study questionnaire. All the respondents in this study were females and would have been scored zero. The six domains tested in this study were age, history of gestational diabetes (GDM), family history of DM, high blood pressure, body weight status, and physical activity. Each question had points apportioned to the provided response. Age group was scored 0, 1, 2, and 3 points for <40, 40-49, 50-59, ≥60 years, respectively. A positive history of GDM, family history of DM, high blood pressure, or use of antihypertensive medications, physically inactivity attracted one (1) point each.

Respondents who had never been pregnant or had no known history of GDM were scored zero (0). Respondents who had no known family history of DM and those who were not hypertensive were scored zero (0).

The physical activity level of the respondents was assessed by asking if they engaged in any form of physical exercise (as part of their work, means of transportation, or for recreation) that makes their heartbeat and breathing faster continuously for at least 10 minutes. Respondents who did not engage in these physical activities regularly (at least three days in a typical week) were tagged physically inactive and scored one (1) point. The weight status of each respondent was determined from a chart on the ADA risk tool using their weight and height and attracted scores ranging from 0 – 3 points. Points scored by each respondent were summed up. The total minimum and maximum scores obtainable are zero (0) and ten (10), respectively. A maximum total score of 0-3 implies a low risk of prediabetes or type 2 DM, while maximum scores of ≥5 suggest a high risk of type 2 DM. However, respondents with total scores of 4 and above were likely to have prediabetes or a high risk of undiagnosed type 2 DM. Thus, a score of 5 and above precludes prediabetes.

Although the ADA Risk Tool was originally intended to be self-administered, the modified version (study questionnaire) was administered to the respondents by the interviewer. After that, all the respondents had physical measurements performed. Anthropometric measurements obtained were weight and height. Before measuring the weight and height, each respondent was asked to remove footwear, headgears/caps, any heavy clothing and empty their pockets. While standing erect on the middle of the weighing scale, weights were recorded to the nearest 0.1kg. While still barefooted and with no headgear/caps on, the hair (if any) was pressed down, and the height measured using a metre rule to the nearest 0.1cm.

Using the ADA risk tool, the weight status of the respondent was noted and appropriately scored. Also, the body mass index was calculated for all respondents and categorized using the World Health Organization (WHO) classification as underweight (<18.5kg/m2), normal weight (18.5 – 24.9 kg/m2), overweight (25.0 – 29.9 kg/m2), and obese (≥30.0 kg/m2).11

The blood pressure of respondents was measured thrice at an interval of 1 minute using the Omron® sphygmomanometer in the seated position after initial rest of at least 5 minutes. The average blood pressure reading was computed and categorized according to the Joint National Committee 7 classification15 as follows: normal (SBP <120mmHg and DBP <80mmH), prehypertension (SBP 120-139mmHg, or DBP 80-89mmHg), stage 1 hypertension (SBP 140-159mmHg, or DBP 90-99mmHg), and stage 2 hypertension (SBP ≥160mmHg, or DBP ≥100mmHg). Respondents who were on anti-hypertensive medications were scored 1 point irrespective of their blood pressure reading. Finally, all the respondents had point-of-care testing for

blood glucose using a capillary blood sample. Blood glucose level was categorized using the American Diabetes Association classification: [16] Random blood glucose (mg/dl) levels <140, 140-199 and ≥200 were classified as normal, prediabetes and diabetes, respectively. Fasting blood glucose (mg/dl) levels <110, 110-125 and ≥126 were classified as normal, prediabetes and diabetes, respectively.

Obtained data were inputted to a spreadsheet. The analysis was done using the International Business Machine (IBM) Statistical Package for Scientific Solutions (SPSS) version 22 (IBM SPSS Corp., Armonk NY, USA). Summaries of categorical variables were presented as frequencies and percentages in tables and charts. Associations between categorical variables such as history of gestational diabetes and the risk of prediabetes/undiagnosed DM were tested using the Chi-square test. Summaries of continuous variables such as age, body mass index and blood pressure were expressed as means and standard deviation of means.

Differences in mean were tested using the independent T-test. Bivariate correlation of factors associated with diabetes risk was done using Pearson's correlation coefficient. Binary logistic regression analysis was used to explore the relationship between the risk of prediabetes and undiagnosed DM and the predictors of risk factors associated with the development of type 2 DM. Statistical significance noted at a p-value level of less than 5%.

RESULTS

One hundred and fifty-nine women were recruited for the study. Their mean age was 41.5 (±13.2) years. (Table 1) Five (3.1%) of the women reported a history of gestational diabetes, while 21 (13.2%) had a first degree relative (parents or siblings) with DM. A positive personal history of hypertension or use of antihypertensive medications was obtained from 37 (23.3%) of the respondents. Twenty-six (16.4%) of the respondents reported that they were physically inactive.

Table 1 shows the biophysical characteristics of the respondents. One hundred and twenty-seven (79.9%) of the respondents' blood glucose levels were within the normal range, with an overall mean blood glucose level of 102 (±36.4) mg/dl. The mean BMI of the respondents was 27.3 (±5.38) kg/m^2. One hundred and five (66.0%) of the respondents were overweight and obese. The mean SBP and DBP were 128 (±19.4) mmHg and 81 (±10.8) mmHg, respectively.

The ADA risk score for the respondents ranged between 0 and 6, with a mean score of 2.51 (±1.66). The frequency distribution of the diabetes risk score is shown in figure 1. The risk of prediabetes and undiagnosed DM was low (ADA risk score 0-3) in 111 (69.8%) respondents and high (ADA risk score ≥4) in 48 (30.2%). Among the respondents with a high risk of prediabetes and undiagnosed DM, 22 (45.8%) had an ADA risk score of ≥5. Thus, 26 (16.4%) of all the respondents were at risk of prediabetes.

Table 1: Biophysical characteristics of the study population

Variable	Category	Frequency (%)
Age group (years)	<40	69 (43.4)
	40-49	49 (30.8)
	50-59	24 (15.1)
	≥60	17 (10.7)
	Mean (±SD)	41.5 (±13.2)
Blood Glucose* (mg/dl)	Normal	127 (79.9)
	Prediabetic	19 (11.9)
	Diabetic	13 (8.2)
	Mean (±SD)	102 (±36.4)
Body Mass Index (kg/m^2)	Underweight	4 (2.5)
	Normal	50 (31.4)
	Overweight	57 (35.8)
	Obese	48 (30.2)
	Mean (±SD)	27.3 (±5.38)
Blood Pressure (mmHg)	Normal	44 (27.7)
	Pre-HTN	63 (39.6)
	Stage 1 HTN	37 (23.3)
	Stage 2 HTN	15 (9.4)
	Mean SBP (±SD)	128 (±19.4)
	Mean DBP (±SD)	81 (±10.8)

n=159, *Random / Fasting blood glucose, DBP: Diastolic Blood Pressure, SBP: Systolic Blood Pressure, SD: Standard Deviation

Compared to diagnostic testing for prediabetes and diabetes using blood glucose levels, the ADA risk tool had specificity and sensitivity of 73.6% and 81.8%, respectively. Using the receiver operating characteristics (ROC), the area under curve (AUC) was 0.848 (95% CI: 0.743 – 0.953). (Figure 2)

Table 2 shows the association between the risk for prediabetes and undiagnosed DM and biophysical/other profile of respondents. The proportion of respondents with high risk for prediabetes and undiagnosed DM increased with age from 2 (2.9%) among those aged <40 years to 14 (82.4%) among those aged ≥60 years. The association between age and risk for prediabetes and undiagnosed DM was statistically significant (χ^2=65.149, p<0.001). All the respondents who reported a history of GDM were high risk. The association between GDM and the risk category for prediabetes and undiagnosed DM was statistically significant (χ^2=11.938, p=0.001). About 60% of the respondents who were obese had high risk.

The association between BMI category and risk for prediabetes and undiagnosed DM was statistically significant (χ^2=32.005, p<0.001). The proportion of respondents with high risk for prediabetes and undiagnosed DM increased with increasing blood pressure (BP) readings from 5 (10.4%) among those whose BP were <120/80mmHg (normal) to 10 (66.7%) among those whose BP readings were ≥160/100mmHg (stage 2 hypertension). The association between BP readings and risk for prediabetes and undiagnosed DM was statistically significant (χ^2=21.915, p<0.001). Family history of DM and physical inactivity did not significantly differ among respondents with high and low risk for prediabetes and undiagnosed DM. (Table 2)

Binary logistics regression showed that increasing age, being overweight and obese, and a positive history of hypertension were significant independent predictors of the risk for prediabetes and undiagnosed type 2 DM. (Table 3)

The mean BMI, SBP, DBP, pulse pressure, and blood glucose of respondents with a high risk of prediabetes and undiagnosed

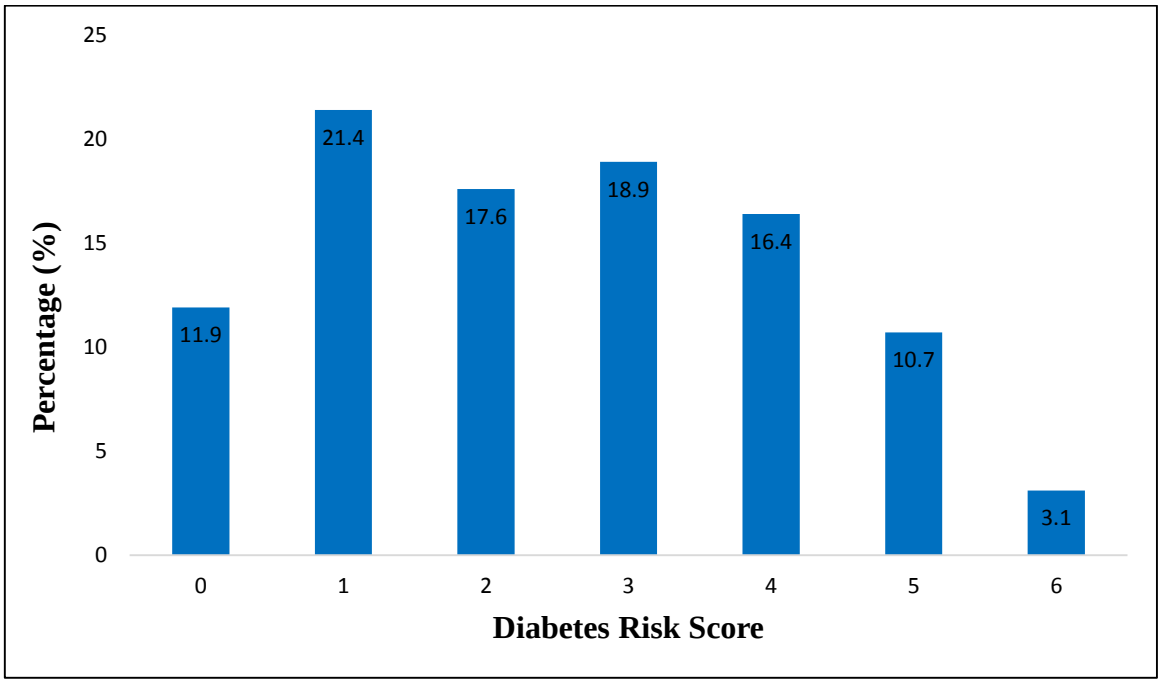

Figure 1: Diabetes risk score of the respondents using the ADA risk assessment tool

diabetes (ADA risk score ≥4) were significantly higher than those with low risk. (Table 4) The correlation between diabetes risk score and blood glucose, blood pressure (systolic and diastolic), body mass index was statistically significant, as shown in table 5.

DISCUSSION

The need for early identification of high-risk individuals is of the utmost importance in the drive to effectively prevent and reduce the disease burden associated with DM.

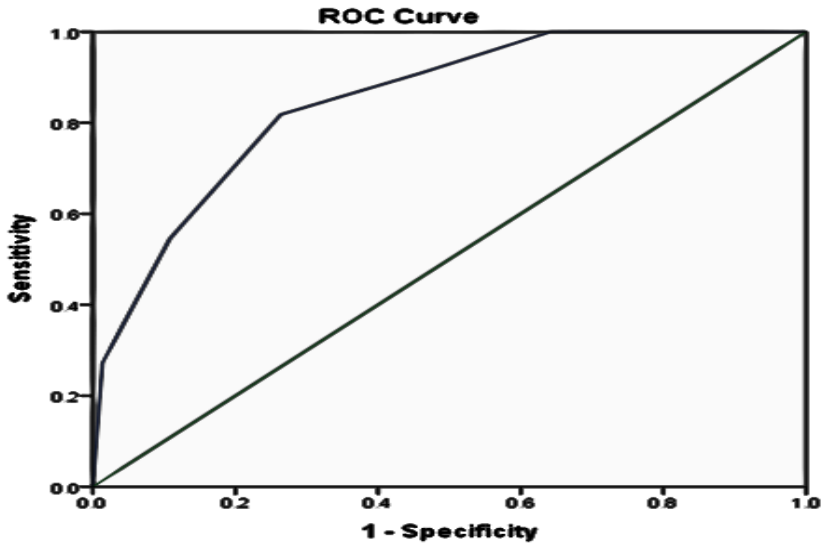

Figure 2. ROC curve for American Diabetes Association (ADA) Risk Score among study population

Table 2: Association between respondents' biophysical/other profile and risk of prediabetes and undiagnosed DM

Variable	Category	Risk of Prediabetes & Undiagnosed DM		p-value
		High (n=48)	Low (n=111)	
Age group (years)	<40	2 (2.9)	67 (97.1)	<0.001
	40-49	15 (30.6)	34 (69.4)	
	50-59	17 (70.8)	7 (29.2)	
	≥60	14 (82.4)	3 (17.6)	
Family History of DM	Yes	10 (47.6)	11 (52.4)	0.062
	No	38 (27.5)	100 (72.5)	
History of Gestational DM	Yes	5 (100.0)	0 (0.0)	0.001
	No	43 (27.7)	111 (72.1)	
History of hypertension/use of anti-hypertensives	Yes	26 (70.3)	11 (29.7)	<0.001
	No	22 (18.0)	100 (82.0)	
Physical Inactivity	Yes	12 (46.2)	14 (53.8)	0.053
	No	36 (27.1)	97 (72.9)	
BMI	Underweight	1 (25.0)	3 (75.0)	<0.001
	Normal	5 (10.0)	45 (90.0)	
	Overweight	13 (22.8)	44 (77.2)	
	Obese	29 (60.4)	19 (39.6)	
Blood Pressure	Normal	5 (11.4)	39 (88.6)	<0.001
	Pre-HTN	16 (25.4)	47 (74.6)	
	Stage 1 HTN	17 (45.9)	20 (54.1)	
	Stage 2 HTN	10 (66.7)	5 (33.3)	
Blood Glucose	Normal	29 (22.8)	98 (77.2)	<0.001
	Prediabetic	9 (47.4)	10 (52.6)	
	Diabetic	10 (76.9)	3 (23.1)	

BMI: Body Mass Index, DM: Diabetes Mellitus, HTN: Hypertension

Table 3: Logistic regression for likely predictors of the risk of prediabetes and undiagnosed DM

Variable	Category	B	Standard error	Wald	Odds ratio	p-value
Age (years)	<40	**Reference**		17.709		0.001
	40-49	2.788	1.310	4.528	16.242	0.033
	50-59	7.787	2.222	12.284	2408.477	<0.001
	≥60	10.073	2.438	17.073	23697.944	<0.001
BMI	Underweight	**Reference**		13.218		0.004
	Normal	-5.311	12.716	0.174	0.005	0.676
	Overweight	-6.648	1.877	12.546	0.001	<0.001
	Obese	-5.277	1.605	10.806	0.005	0.001
GDM	History of GDM	-17.082	14895.496	0.000	0.000	0.999
HTN	History of HTN	-4.352	1.298	11.247	0.013	0.001

BMI: Body Mass Index, GDM: Gestational Diabetes Mellitus, HTN: Hypertension

Table 4. Mean differences in the biophysical profile of respondents with high and low risk for prediabetes and undiagnosed DM

Variables	Mean (±SD)		95% CI	p-value
	Low Risk	High Risk		
Age (years)	40.5 (±12.8)	43.9 (±14.0)	-7.92 to 1.07	0.134
BMI (kg/m^2)	25.9 (±4.6)	30.7 (±5.5)	-6.50 to -3.14	<0.001
SBP (mmHg)	122.5 (±15.1)	141.9 (21.7)	-25.22 to -13.40	<0.001
DBP (mmHg)	79.1 (±9.8)	85.9 (±11.6)	-10.32 to -3.22	<0.001
Pulse Pressure (mmHg)	43.4 (±10.9)	556.0 (±15.9)	-16.85 to -8.24	<0.001
Blood glucose (mg/dl)	94.2 (±14.5)	120.8 (±58.7)	-38.51 to -14.74	<0.001

BMI: Body Mass Index, CI: Confidence Interval, DBP: Diastolic Blood Pressure, SBP: Systolic Blood Pressure, SD: Standard Deviation,

Table 5. Correlation of diabetes risk score and associated factors

	Pearson's Correlation Coefficient (R)	p-value
Age	0.710	<0.001
BMI	0.590	<0.001
SBP	0.499	<0.001
DBP	0.341	<0.001
Pulse Pressure	0.433	<0.001
Blood Glucose	0.346	<0.001

BMI: Body Mass Index, DBP: Diastolic Blood Pressure, SBP: Systolic Blood Pressure

The American Diabetes Association (ADA) Risk Tool is an easily administered, cheap, and non-invasive tool to screen persons with high risk for developing type 2 DM.[13] Although there is no previous literature validating its use in Nigeria, findings from the index study validate its accuracy and usefulness. The receiving operating characteristics (ROC) area under curve of 0.848 affirms that the accuracy of ADA Risk Tool as a good and useful screening for prediabetes and undiagnosed diabetes among urban Nigerian women. The ADA risk tool has also been validated to be useful in other regions of the World.[13-16, 21] For example, its usefulness has been validated in predicting the 3-year incidence of prediabetes and diabetes among Taiwanese women.[15] There is, however, a need for further research to validate the usefulness of the ADA risk tool among Nigerian men as well as in rural populations in Nigeria.

Using the ADA Risk Tool at a cut-off score of 4.0, the risk assessment of prediabetes and undiagnosed diabetes in this study was high (30.2%). This finding supports earlier reports that women and urban dwellers are at a high risk of developing DM as the study population was drawn from among female urban dwellers. Previous studies involving both genders have also shown that women have a higher risk of DM than men.[22, 23] Also, the prevalence of DM in developing economies is generally higher in urban than rural areas.[3, 5, 24] In the index study, 8.4% of the study population had blood glucose readings in the diabetic range. This figure, although lower, is not much different from

the pooled prevalence of DM of 9.8% in South-South Nigeria.[3]

Urbanization has been linked with several unhealthy lifestyles that result in obesity, and by extension, the development of DM. In this study, 66.0% of the women had high BMI (≥25.0kg/m^2). The women who had high-risk of prediabetes and undiagnosed DM had significantly higher mean BMI. They also had higher mean systolic and diastolic blood pressures as well as higher blood glucose compared with the low-risk women. Indeed, BMI, blood pressure, age, and blood glucose levels showed significant correlation with the ADA risk scores in this study. However, the significant predictors of high risk for prediabetes and undiagnosed DM were advancing age, high BMI (overweight and obese), and a positive history of hypertension. Age was, however, the strongest predictor identified.

Considering that over 40% of the women in this study were aged less than 40 years, the future risk for diabetes in the community is likely to increase with time. This is particularly worrisome and calls for urgent interventions to forestall the looming disaster, particularly as women have been shown to have worse adverse cardiovascular outcomes from complications of DM.[6 - 8]

This study is not without its limitations. Firstly, sampling was by convenience, non-probability method, and can limit the generalization of inferences made. The choice to study only women also limited the generalization of the performance of the ADA risk tool in men. Also, recall bias and lack of awareness of the correct response to some of the questions like the family history of DM and history of gestational diabetes cannot be entirely excluded.

This study validates the American Diabetes Association (ADA) Risk Tool as a good and useful screening tool for prediabetes and undiagnosed diabetes among Nigerian women in urban settings. Using this tool, one-in-three women in the population studied had a high risk of prediabetes and undiagnosed diabetes. The ADA risk tool is, therefore, strongly recommended for routine screening of women to identify those at risk of type 2 diabetes. It is advocated that the use of the ADA risk tool be incorporated into antenatal services in Nigeria for a wider reach. Further research is needed to validate the usefulness of the ADA risk tool among Nigerian men.

Overweight and obesity, older age, history of hypertension were significant predictors of high-risk for prediabetes and undiagnosed DM among women. Promotion of healthy lifestyle choices, maintenance of healthy weight, and normal blood pressure should be in the front burner in the prevention of type 2 diabetes.

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