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ORIGINAL ARTICLE

# Prevalence of prediabetes and associated risk factors in a rural Nigerian community

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**Abstract** There is very scanty population-based data on the prevalence of prediabetes, a forerunner to type 2 diabetes, in both rural and urban Nigeria. The purpose of the study was to determine the prevalence and risk factors for prediabetes in a rural Nigerian population. A cross-sectional, village by village, clan-based stratified convenient sampling was done in Ihuokpara, a rural community in Nkanu East Local Government Area of Enugu State, Nigeria. A total of 824 adult men and women participated. Questionnaires were used to obtain sociodemographic data, awareness of diabetes, and common symptoms including family history of diabetes. Fasting plasma glucose and 2-hour post 75g-glucose-load plasma glucose levels were measured after the subjects' blood pressure and anthropometric indices were obtained. Fasting lipid profile was also assessed in a subset of the study population. Males constituted 34.7 % of the 824 participants. The mean age of the subjects was 51.1±16.2 years. Prevalence of impaired fasting glucose (IFG) was 9.2 %, while that of impaired glucose tolerance (IGT) was 15.8 %. The overall prevalence of prediabetes (both IGT and IFG) was 21.5 %. Hypertension was prevalent at 45.3 % and was the strongest predictor of prediabetes. Obesity was prevalent at 5.8 % and overweight at 16.7 %, while 15.7 % had central obesity. Prevalence of prediabetes was high in the community with hypertension emerging as the possible driving force.

**Keywords** Prediabetes · Risk factors · Prevalence · Rural · Nigeria

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## Introduction

Prediabetes, also known as intermediate hyperglycemia [1], is a high-risk state for diabetes, characterized by blood glucose values higher than normal but lower than cutoff values diagnostic of diabetes mellitus (DM) [2]. It is typically clinically "silent" though already causing adverse effects on many organ systems and often heralds type 2 diabetes mellitus (T2DM) [2]. Up to 70 % of people with prediabetes may develop T2DM during their lifetime [3]. Prediabetes is usually promoted by some risk factors [3, 4], and research shows that intensive lifestyle and pharmacological interventions can prevent or delay progression to T2DM [5–8]. These risk factors include overweight/obesity, physical inactivity, high blood pressure, dyslipidemia, age ≥45 years, family history of diabetes in first-degree relatives, polycystic ovary syndrome, gestational diabetes, inadequate night's sleep <5.5 h/night, and race, especially the Afro-Caribbean and Hispanic [3, 4].

The World Health Organization (WHO) estimates that the number of people with diabetes will increase from 382 million in 2013 to 592 million people by 2035 [9]. Diabetes is a nagging health concern in Nigeria, which represents one sixth of the total population of sub-Saharan Africa, with a population of 171 million people [10]. Currently, the low- and middle-income countries bear the greatest burden of prediabetes and ultimately diabetes, and Sub-Saharan Africa has been projected to record the most increases in prediabetes and diabetes prevalence in the near future [9].

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Worldwide, diabetes accounted for about USD 548 billion dollars in healthcare expenditures in 2013, 11 % of the total healthcare expenditures in adults [9]. Prediabetes is therefore an urgent health and economic concern especially in developing countries where majority of cases are found [9] given its role as a forerunner of T2DM.

Insulin resistance (IR) and reduced glucose sensing at the beta cell, resulting in impaired insulin secretion, are the two central factors in its pathophysiology that eventually result in hyperglycemia [11, 12], and prediabetes confers a high risk for coronary heart disease, peripheral vascular disease, and stroke.

However, many governments and public health planners still remain unaware of the future potential for increases in diabetes and its complications in their countries. In Nigeria, data on prediabetes is still very scanty.

This epidemiologic study assesses the prevalence of prediabetes using the WHO case definition [1, 13] including the prevalence and significance of some risk factors for prediabetes, among a cross-section of rural dwellers in Southeast Nigeria. The study will contribute to the few available data on prediabetes in the country and thus assist policy makers in allocating limited resources towards preventive measures.

## Materials and methods

### Study area

The study, concluded in March 2013, was carried out in Ihuokpara, a rural community in Nkanu East Local Government Area (LGA) of Enugu state, Nigeria, about 35 km from the state capital. The community has a difficult terrain, typified by inaccessible muddy paths with very sparse social amenities like access roads, electricity supply, adequate housing, and pipe-borne water with an estimated population of 12,000 people [14]. It has eight villages which include Uzam, Ndibinagu-Uzam, Amankwo, Amangene, Amafor, Ndibinagu-Amafor, Ndiagu, and Amunakwa. The indigenes are predominantly subsistent farmers.

### Study design

The study was cross-sectional.

### Study population

Adults aged 18 years or older, residents in the community, were recruited. Pregnant women, nursing mothers, and adults who refused consent were excluded from the study.

### Ethical consideration

Approval was obtained from the health research and ethics committee of the University of Nigeria Teaching Hospital. The paramount ruler of the community and town union representatives also gave their approval.

### Sample size

The minimum sample size was 348 using Fisher's formula for a cross-sectional study [15] and the prevalence rate of 34.6 % for prediabetes Seychelles [16]. However, to allow for study design effect, the sample size was increased to 800 subjects.

### Sampling technique

Due to poor enumeration of houses in this community with difficult terrain, a multistage stratified convenient sampling technique was employed. A clan-based recruitment of subjects from each of the eight villages was done at the village muster point, with constituent families in a clan required to present a minimum of two qualified adults. Awareness for the study was created for 2 weeks before its commencement with the help of the paramount ruler, through announcements at strategic locations within the communities by town criers.

### Data collection

On the day preceding the start of the study, subjects were informed to eat dinner not later than 10 p.m. and to present on each morning of the study, which was to commence by 7 a.m., without eating any food or drink. Subjects had a recruitment briefing by the study investigators and assistants, totaling 20 pre-trained medical personnel, and verbal informed consent was obtained. Out of the 800 subjects required, 824 eventually completed the study.

A modified WHO-STEPs questionnaire was administered to obtain the subject's demographic history and assessed knowledge, common symptoms and family history of diabetes, physical activity levels, and general dietary habits. Blood pressure, weight, height, and waist circumference of the subjects were obtained using standard procedures [17, 18].

Weight was measured using a pre-calibrated weighing scale on a flat surface with the subject wearing light clothing and recorded to the nearest 0.5 kg. Height was measured to the nearest 0.1 m with a stadiometer with subject not wearing shoes or a headgear.

Waist circumference was measured to the nearest 0.5 cm with a non-stretchable tape, midpoint between the last rib and the superior iliac crest, along the midaxillary line.

Blood pressure was measured using Accoson mercury sphygmomanometers, with subjects well relaxed and the mean of two readings taken 5 min apart recorded.

Blood glucose was estimated using capillary blood obtained by fingertip pinprick, using pre-standardized Accu-Check Active® glucometers and test strips, pre-calibrated by the manufacturer, Roche Diagnostics GmBH, Germany, © 2011 using the hexokinase method. Hence, results corresponded to blood glucose concentrations in venous plasma as per the recommendations of the International Federation of Clinical Chemistry and Laboratory Medicine.

After obtaining the fasting plasma glucose (FPG) value, each subject underwent an oral glucose tolerance test (OGTT) using 75 g of anhydrous glucose powder, dissolved in 250 mL of clean cold water. A second finger prick blood sample obtained 2 h post glucose load was then measured.

Lipid profile assessment was done in a subset of the study population, totaling 80, representing 10 % of the subjects, selected by systematic sampling. Fasting blood samples were collected from the antecubital veins of the subjects into plain bottles and dispatched in ice packs, to the chemical pathology laboratory of the University of Nigeria and sera quickly separated, refrigerated, and assayed within 24 h of collection. Total cholesterol (TC), hig-density lipoproteins (HDL-C) and triglycerides (TG) were measured by enzymatic method, while low-density lipoprotein (LDL-C) values were estimated with Friedewald formula [19]. However, when plasma triglyceride concentration exceeded 4.5 mmol/L (400 mg/dL), direct measurement of the LDL-C was done instead of estimation with Friedwald formula.

### Definitions of study criteria

Impaired fasting glucose (IFG) represents a FPG between and including 6.1–6.9 mmol/L (110–125 mg/dL), with a 2-h plasma glucose, post 75 g glucose load of <7.8 mmol/L (<140 mg/dL), WHO criteria [1]. Impaired glucose tolerance (IGT) represents a 2-h (post load) plasma glucose of >7.8–<11.0 mmol/L (140–199 mg/dL), with FPG of <6.1 mmol/L (<110 mg/dL), WHO criteria [1].

Diabetes mellitus was defined by a FPG >7.0 mmol/L (>126 mg/dL) or 2-h plasma glucose >11.1 mmol/L (>200 mg/dL), WHO criteria [1]. Hypertension represents a systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg, according to the WHO/International Society of Hypertension guidelines [20].

Obesity was defined according to the 1999 WHO criteria. Cutoff values for BMI were as follows: overweight, BMI 25.0–29.99 kg/m$^2$; and obesity, BMI≥30 kg/m$^2$ [21]. Central obesity was based on the International Diabetes Federation (IDF) guidelines where waist circumference of ≥94 cm for males and ≥80 cm for females were considered raised [22].

Dyslipidemia was defined according to the National Cholesterol Education Programme Adult Treatment Panel III; NCEP ATP III guidelines are as follows: TC >5.1 mmol/L (200 mg/dL), LDL-C >3.3 mmol/L (130 mg/dL), HDL-C <1.0 mmol/L (40 mg/dL) in males and <1.3 mmol/L (50 mg/dL) in females, and TG >1.7 mmol/L (150 mg/dL) [23].

### Statistical analysis

Data was entered in MS Excel 2007, analyzed using SPSS software version 17.0 (SPSS Inc. Chicago, IL, USA), and summarized as means and standard deviations for quantitative variables or percentages for categorical variables. Differences between categorical variables were analyzed with chi-square or Fisher's exact test. Differences between continuous variables were analyzed using the Student's *T* test. Binary logistic regression was used to assess factors predictive of IFG or IGT. A *p* value of <0.05 was considered statistically significant.

## Results

### Sociodemographic characteristics

The demographics of the study population were typical of rural communities in Nigeria [24]. Out of the 824 subjects, 286 (34.7 %) were males while 538 (65.3 %) were females. The mean age of the subjects was 51.1±16.2 years, and 70 % of them were either middle aged (45–65 years) or elderly (>65 years). Seventy-three percent of the subjects were subsistent farmers (males, 76.2 %; females, 70 %), and 46.4 % had no formal education while 40.8 % had only elementary education.

Majority of the subjects (96.1 %) regularly engaged in informal physical activities like trekking, cycling, and farming up to 4–6 h/day, 5 days a week. More than 80 % of the subjects added uncooked salt to already cooked meals on a daily basis, while only 13.7 % consumed fruits daily. Ninety percent of the subjects had heard about diabetes and knew its common symptoms. Family history of diabetes was difficult to ascertain because as many as 218 (26.5 %) were not sure of their family history. However, only 56 (6.8 %) reported a positive family history of diabetes mellitus.

### Prevalence of prediabetes

The mean FPG of the subjects was 5.3±0.9 mmol/L (94.8±16.4 mg/dL), while the mean 2-h post glucose load level was 6.8±2.2 mmol/L (122.7±39.7 mg/dL). The prevalence of IFG was 9.3 %, while that of IGT was 15.8 %. The overall prevalence of prediabetes (both IFG and IGT) was 21.5 %, and diabetes was present in 40 (4.8 %) persons (Table 1).

**Table 1** Prevalence of prediabetes and diabetes using different diagnostic criteria

| Variable | Male, *n* (%) | Female, *n* (%) | Total, *n* (%) | $p^b$ |
|---|---|---|---|---|
| Using FPG | | | | |
| NGT[a] | 251 (87.7) | 479 (89.0) | 729 (88.5) | 0.95 |
| IFG | 27 (9.4) | 50 (9.3) | 77 (9.3) | |
| DM | 8 (2.9) | 9 (1.7) | 18 (2.2) | |
| Using OGTT | | | | |
| NGT[a] | 240 (83.9) | 425 (79.0) | 665 (80.7) | 0.22 |
| IGT | 39 (13.6) | 91 (16.9) | 130 (15.8) | |
| DM | 7 (2.5) | 22 (4.1) | 29 (3.5) | |
| FPG and OGTT | | | | |
| NGT[a] | 217 (75.9) | 390 (72.5) | 607 (73.7) | 0.43 |
| IGT and IFG | 57 (19.9) | 120 (22.3) | 177 (21.5) | |
| DM | 12 (4.2) | 28 (5.2) | 40 (4.8) | |

[a] Normal glucose tolerance

[b] *p* value is for comparison among genders

### Prevalence of risk factors for prediabetes

Hypertension was found in 45.3 % of the subjects, 47.2 % of males and 44.2 % of females ($p$=0.42); 16.7 % were overweight, while 5.8 % were obese. Central obesity was noted in 33.6 % of the subjects. The prevalence of dyslipidemia among the subset of 80 subjects was 32.5%, and 30 % had raised TC (Table 2).

### Risk factors associated with IFG, IGT, and prediabetes

The factors associated with IFG, IGT, and prediabetes were investigated. Increasing age and hypertension were significant risk factors for IFG ($\chi^2$=0.37, $p$=0.04 and $\chi^2$=0.02, $p$=0.015, respectively) but not for IGT ($\chi^2$=0.75, $p$=0.69 and $\chi^2$= 0.001, $p$=0.98, respectively) (Table 3).

Further assessments of the risk factors predictive of prediabetes were carried out using stepwise binary logistic regression with the following variables: age group, hypertension, overweight/obesity, high TC, high LDL-C, hypertriglyceridemia, and dyslipidemia (Table 4).

## Discussion

In this study, a high prevalence of prediabetes (IFG and IGT) at 21.5 % was found in this rural Nigerian community. This suggests that the diabetes epidemic is on the increase in Nigeria as IGT and IFG are strong predictors of diabetes and may be present in an individual several years before the development of diabetes [3]. The finding of such a high prevalence in a rural community is worrisome and suggests that even higher figures may occur in urban areas.

The increasing adoption of "westernized diet", comprising highly refined carbohydrates and high sugar and fat content, now noticed in African settings is said to be contributory to the rising prevalence of obesity and type 2 diabetes in developing nations such as Nigeria. The high prevalence of prediabetes found may have been contributed in part by such dietary factors.

The prevalence of prediabetes is known to increase with age [4, 25, 26]. The high percentage of middle aged and elderly subjects in this study is likely to have influenced the high prevalence value obtained.

The prevalence of IGT (15.8 %) was higher than IFG (9.3 %) similar to results from a Chinese study [27], and although IFG was found to be more prevalent in males and IGT in females, the gender-based prevalence was not significant ($p$=0.95—IFG) and ($p$=0.22—IGT). This trend is also reported in other African studies, especially for IGT [28, 29].

A significant association between increasing age and IFG ($p$=0.036) was obtained but not for IGT or prediabetes. Age

**Table 2** Prevalence of clinical risk factors for prediabetes

| Risk factor | Males, *n* (%) | Females, *n* (%) | Total, *n* (%) | *p* |
|---|---|---|---|---|
| Age >45 years | 196 (68.5) | 350 (65.1) | 546 (66.3) | 0.32 |
| Hypertension | 135 (47.2) | 238 (44.2) | 373 (45.3) | 0.42 |
| Elevated systolic BP | 128 (44.8) | 218 (40.5) | 346 (42.0) | 0.24 |
| Elevated diastolic BP | 92 (32.2) | 142 (26.4) | 234 (28.4) | 0.08 |
| Central obesity | 33 (11.5) | 244 (45.4) | 277 (33.6) | <0.001[b] |
| Overweight/obese | 70 (24.5) | 146 (27.1) | 216 (26.2) | 0.71 |
| Elevated TC[a] | 3 (11.5) | 21 (38.9) | 24 (30.0) | <0.001[b] |
| Elevated LDL[a] | 1 (3.8) | 11 (20.4) | 14 (17.5) | 0.003[b] |
| Elevated TG[a] | 3 (11.5) | 6 (11.1) | 9 (11.3) | 0.91 |
| Low HDL[a] | 0 (0) | 5 (9.3) | 5 (6.3) | 0.06 |
| Dyslipidemia[a] | 4 (15.4) | 22 (40.7) | 26 (32.5) | 0.08 |

[a] Lipid profile done in a subset of subjects ($n$=80); males 26, females 54

[b] Significant values

**Table 3** Factors associated with IFG, IGT, and prediabetes

| RISK factor | IFG | | IGT | | Prediabetes | |
|---|---|---|---|---|---|---|
| | $\chi^2$ | $p$ | $\chi^2$ | $p$ | $\chi^2$ | $p$ |
| Increasing age | 0.37[a] | 0.036[c] | 0.75 | 0.69 | 4.57 | 0.1 |
| Gender | 0.005 | 0.95 | 1.51 | 0.22 | 0.001 | 0.98 |
| Hypertension | 4.89 | 0.015[c] | 11.55 | 0.01[c] | 12.18 | <0.001[c] |
| Reduced physical activity | 3.94 | 0.05 | 0.83 | 0.36 | 0.22 | 0.64 |
| Overweight/obesity | 5.05 | 0.08 | 11.2 | 0.004 | 3.72 | 0.16 |
| Elevated total cholesterol[b] | 5.27 | 0.07 | 2.4 | 0.29 | 1.08 | 0.58 |
| Elevated LDL[b] | 6.97 | 0.03[c] | 0.98 | 0.61 | 2.85 | 0.24 |
| Elevated TG[b] | 4.3 | 0.81 | 1.82 | 0.40 | 1.97 | 0.37 |
| Dyslipidemia[b] | 4.99 | 0.08 | 1.59 | 0.45 | 1.18 | 0.55 |

[a] Chi-square for trend

[b] $n$=80 (males 26; females 54)

[c] Significant values

≥45 years is an independent risk factor for prediabetes as increasing age is associated with deterioration in beta cell function and a tendency to becoming insulin resistant. Additionally, increasing age tends to be associated with reduced levels of physical activity with consequent weight gain, all of which may result in prediabetes. The above results agree with other studies on age and prediabetes [25, 26].

There was a significant association between hypertension and prediabetes, similar to findings from a local study [28]; however, diastolic hypertension was found to contribute more to prediabetes compared to systolic hypertension. Among the subjects, a high prevalence of hypertension (45.3 %) was found with males having a higher (though not significant) prevalence than females ($p$=0.42). The Afro-Caribbean race is a risk factor for hypertension [30], and the high prevalence of HBP is similar to other studies done in Nigeria [31, 32]. Additionally, low socioeconomic status defined by low educational attainment, low occupational status, low income, and poor neighborhood characteristics, typical of this rural area, has also been shown to be associated with HBP [33]. The mechanism may be via a sympathetic nervous system response involving repeated and sustained cardiovascular reactivity to chronic stressors [33]. Again, the chronic consumption of uncooked table salt—a known factor driving hypertension in blacks—noted in majority of the subjects may also contribute to the high prevalence of hypertension seen.

**Table 4** Binary logistic regression showing predictors of prediabetes

| Risk factor | $B$ | Wald coeff | CI | $p$ |
|---|---|---|---|---|
| Age >45 years | 0.71 | 3.05 | 0.49–1.04 | 0.08 |
| Hypertension | 1.8 | 7.87 | 1.19–2.76 | 0.005[b] |
| Overweight/obesity | 1.09 | 0.21 | 0.74–1.61 | 0.65 |
| High TC[a] | 1.45 | 0.12 | 0.18–11.8 | 0.73 |
| High LDL[a] | 0.36 | 1.08 | 0.05–2.5 | 0.30 |
| Dyslipidemia[a] | 0.84 | 0.02 | 0.07–9.48 | 0.89 |

[a] $n$=80 (males 26; females 54)

[b] Significant values

In this study, there was a low prevalence of obesity and obesity was not significantly associated with prediabetes, as also found in a previous local study [34]. The low obesity prevalence may be due to the high physical activity levels noted in the subjects, and surprisingly, obesity was not contributory to prediabetes as it is a major risk factor, especially in developed countries. A significant positive correlation between BMI and waist circumference ($r$=0.65, $p$<0.001) was found, and the females had a significantly higher prevalence value for central obesity than the males ($p$<0.001). Maybe as the bread winners, the male subjects more regularly engaged in higher physical activity levels than the females who were, culturally, the homemakers. Additionally, the females are encouraged to eat large meal portions in order to gain weight, to reflect family affluence. Also, traditional African families are known to have large numbers of children with little effort at child spacing. Repeated pregnancies may thus contribute to obesity in the women as weight gained during each pregnancy is increasingly retained.

A significant association between LDL-C and IFG ($p$=0.003) was found. Elevated TC was the major lipid abnormality, similar to findings of other African studies [35], and the least lipid abnormality was seen in the HDL-C levels at 6.3 %. This is contrary to the findings seen in some African studies and elsewhere, where in one instance, low HDL-C emerged as the major lipid derangement prevalent at 21.7 % [36]. The high levels of physical activity noted in the subjects may account for the low prevalence of HDL-C dyslipidemia, as aerobic exercises are known to increase HDL-C levels.

In conclusion, findings from this study suggest that the major determinant for prediabetes, in this rural community, may be hypertension. Hence, it is likely that measures such as campaigns for reduction in salt intake may be beneficial. Screening for other cardiovascular risk factors should be routine in subjects with prediabetes as it is a risk factor not only for diabetes but also for cardiovascular disease and stroke.

Our study population was pooled by multi-stage convenient sampling which may not be truly representative of the community. However, efforts were made to sample each constituent village separately to get a fair representation. In addition, the cross-sectional nature of the study might have made it difficult to establish strong associations unlike in longitudinal studies.

Glucometers were used to estimate the subject's blood glucose levels using capillary whole blood, instead of venous plasma. However, the strips used had been pre-calibrated by the manufacturers to convert glucose values from whole capillary blood to equivalent venous plasma glucose values.

Fasting lipid profile was only done in 80 subjects, representing 10 % of the study population, due to financial constraints.

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**Conflict of interest** The authors declare that they have no competing interests.

**Author contributions** NCB, OEN, UCN, and YEE were involved in the concept, design, definition of intellectual content, literature search, data acquisition and analysis, manuscript preparation, editing, and review. OCI and OCE were involved in the concept and design, literature search, manuscript preparation, editing, and review. All authors read and approved the final manuscript.

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