ORIGINAL RESEARCH

Prevalence of prediabetes and associated risk factors among peri-urban dwelling adults in Blantyre, Malawi

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Abstract

Introduction

Prediabetes is a high-risk state for developing diabetes, yet its prevalence in Malawi remains understudied. This study was conducted to determine the prevalence of prediabetes and its associated risk factors in peri-urban communities of Blantyre, Malawi.

Method

A quantitative cross-sectional study design was employed, enrolling 204 participants from South Lunzu, Nkolokoti, and Misesa. Systematic probability sampling was conducted to recruit study participants. Data were collected using the WHO STEP-wise questionnaire. The following data were collected: demographic characteristics (age, sex, education, employment), lifestyle behaviours (smoking, alcohol consumption, physical activity), anthropometric measures (body mass index, waist circumference, waist-hip ratio), blood pressure, and Fasting Plasma Glucose (FPG) levels. Prediabetes was defined as an FPG level of 110-125 mg/dl. Bivariate and multivariate logistic regression analyses were performed to examine relationships between prediabetes and independent factors.

Results

The mean age of participants was 39±13.40 years (range: 18 – 76 years). Female participants constituted 76% (n=155) of the sample. The prevalence of prediabetes was 9.8% (n=20). Participants' characteristics included 3.4% active smokers, 18.6% alcohol consumers, 67.6% engaging in vigorous physical activity, and 81.9% in daily moderate physical activities. Additionally, 24.5% were obese, 53.9% had high waist circumference, and 23.0% had a high waist-hip ratio. Obesity was significantly associated with prediabetes (AOR=8.850 95% CI=1.172 – 29.208). All other variables were not significantly associated with prediabetes.

Conclusion

Results from this study reveal a significant association between obesity and prediabetes, highlighting the importance of maintaining a healthy weight to prevent prediabetes.

Keywords: Prediabetes, modifiable risk factors, non-communicable diseases, diabetes, WHO-STEPs tool

Introduction

Prediabetes is a condition where a person presents with elevated blood glucose levels, which are higher than normal ranges but lower than the level considered as diabetes[1,2]. According to the World Health Organization's (WHO) diagnostic criteria, fasting plasma glucose (FPG) of ≤ 6mmol/L (< 100mg/dl) is considered normal, 6.1 - 6.9 mmol/L (110-125mg/dl) is regarded as prediabetes and ≥ 7 mmol/L (> 126 mg/dl) is diabetes[1,3]. Individuals with prediabetes, if not properly managed could progress to diabetes[4]. Diabetes was regarded as a medical condition commonly affecting people from western countries; however, recent evidence shows an increased prevalence in low- and middle-income countries[5–7].

The prevalence of prediabetes in western countries has been widely studied, with rates of 7.2% reported in the United States of America and a rise in prevalence from 11.6% to 35.3% observed in Europe. In the African region, the prevalence of prediabetes has been reported in Uganda (13.8%), Tanzania (2.4%), Kenya (3.1%), Nigeria (21.5%) and South Africa (9.9%)[8–11]. Msyamboza et al. (2014) reported a prevalence of prediabetes of 4.2% in a study conducted in the northern and central regions of Malawi, which is lower than what was reported in other African countries[9,12]. The prevalence of prediabetes in Malawi, as reported by Msyamboza et al (2014), was assessed using an FPG level of ≥ 5.6 mmol/L - ≤ 6.1 mmol/L. According to the European Diabetes Epidemiology Group (EDEG), diagnosing prediabetes using an FPG of ≥ 5.6 mmol/L - ≤ 6.1 mmol/L is not recommended as it does not have a strong association with diabetes[13]. The current WHO guidelines recommend diagnosis of prediabetes using an FPG level of ≥ 6.1 mmol/L - ≤ 6.9 mmol/L1,[3]. This may suggest that the prevalence of prediabetes among Malawians could be different from what was reported by Msyamboza et al in 2014 which used a lower cutoff point for prediabetes. Thus, a need exists to determine the prevalence of prediabetes in Malawi using the current WHO diagnostic guidelines.

Previous reports show diet and physical activity levels as the

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major modifiable risk factors of various non-communicable diseases, including diabetes. Previous authors have suggested that eating food rich in fats and oil and adopting a more sedentary lifestyle increases the risk of developing diabetes. Additionally, some studies have shown that consumption of green leafy vegetables reduces the risk of diabetes by 14%. Furthermore, Helmrich et al (1991) reported that individuals who are physically active are less likely to develop impaired glucose regulation than those who less physically active. A common African diet involves whole grains and vegetables; however, with urbanisation, African diets are mostly rich in fats and other processed food[14]. The expansion in technology and improvement in education status have resulted in a change in job setting with more office work than manual labor. This leads to reduced physical active levels. Reports indicate that Malawi's urbanisation rate has increased from 3.5% to 16% since the 1950s[15]. This is an indication that there is an increase in the number of people who are residing in cities where there is more technology and jobs that require less manual labor. These changes have contributed to a sedentary lifestyle and have predisposed people to overweight and obesity, which are major risk factors for non-communication such as diabetes[16,17].

One of the nine global targets for the prevention of non-communicable diseases is to reduce the risk of mortality rate from non-communicable diseases by one-third by 2030[18]. However, in Malawi, studies have reported an increase in the prevalence of non-communicable diseases such as diabetes (5.7%)[19,20]. A rise in the risks of non-communicable diseases, for instance, hypertension (33%), physical inactivity (10%), tobacco smoking (14%), and overweight (22%), might indicate an implementation challenge or that the current strategies used in Malawi are not effective in mitigating the rise of diabetes prevalence[19–21]. Identifying the prevalence of prediabetes and its associated factors in various communities could help in developing effective strategies to mitigate the rise of diabetes among Malawians. Therefore, the aim of the study was to investigate the prevalence of prediabetes and its associated risk factors among urban dwellers in Blantyre, Malawi.

Methods

Study design and place

The current study employed a quantitative cross-sectional design. The study focused on individuals residing in three selected councillor wards, specifically South Lunzu, Nkolokoti, and Misesa, located in peri-urban Blantyre, Malawi. These peri-urban communities are located close to the Blantyre central business district and exhibit elements of both urban and rural lifestyles. The areas are highly populated (53, 831 in South Lunzu, 57,763 in Nkolokoti and 69, 660 in Misesa) and mostly comprise of people who make a living in town while opting for a low-cost settlement. Many residents in these areas engage in manual labour, while others choose occupations that involve sedentary activities, such as sitting for long periods to sell perishables, working as guards, farming on a small scale, or operating small businesses. Thus, the population is heterogenous, which enables researchers to collect diverse information on risk factors to prediabetes. Additionally, in Malawi, communities are a good source for collecting data on the prevalence of prediabetes because the majority of people do not attend routine medical checkups but only visit the hospital when the condition is worse, in this case when the person is already in a diabetic state.

Sample size and sampling technique

The sample size for this study was calculated to 263 using Cochran's formula. The following factors were considered: 95% confidence interval, estimated prevalence of prediabetes in Africa (22%)[22], a margin of error (5%) and a total population of 67, 153.

Study participants were selected using a systematic probability sampling technique. To create a sampling frame, data from Malawi Electoral Commission (MEC) was used. The dataset included all individuals (N = 67,153) aged 18 years or older who had registered for the 2020 Malawi tripartite election within the selected councillor wards. The sample size for each ward was calculated by dividing the total population of that ward by the total population of all the three wards and multiplied by the total sample size of 263: Nkolokoti 93, Misesa 113, and South Lunzu 57 (Figure 1). Using this sampling technique, participants were selected at random interval until the sample size for each ward was obtained. The sampling interval was calculated by dividing the total population (registered with MEC) of each ward by the sample size of the same ward. Therefore, the following are the sampling intervals used for each ward: Nkolokoti - 254th individual, Misesa – 256th individual and South Lunzu – 257th individual. The research team consulted each sampled individual (with assistance of chiefs) and invited them to convene at a designated location for data collection.

Study population

The study focused on adults residing in South Lunzu, Nkolokoti, and Misesa, registered with MEC for the 2020 Malawi tripartite elections. Individuals with known diabetes or those on diabetic medication were excluded. Additionally, participants who had not fasted for at least eight hours were not eligible to participate in this study.

Data collection

Data were collected by trained nurses using WHO STEP-wise protocol questionnaire for risk factors surveillance of non-communicable diseases[23]. Data collected included demographic characteristics (age, sex, education, employment), lifestyle behaviours (smoking, alcohol consumption, physical activity), anthropometric measures (body mass index, waist circumference, waist-hip ratio), blood pressure, and Fasting Plasma Glucose (FPG) levels.

Physical activity data were collected through participant self-reporting responses to standardised questions from WHO STEP-wise questionnaire. Based on participants responses, physical activity data were subjectively categorized into two intensity levels (vigorous and moderate intensity) based on perceived effect on breathing rate. Vigorous-intensity activities included those characterised by a large increase in breathing rate, sustained for at least 10 minutes, as perceived by the individual. Examples of such activities include running, hill climbing, cycling, and swimming. Moderate-intensity activities included those marked by a moderate increase in breathing rate, also sustained for at least 10 minutes, and included activities such as brisk walking.

Standing height and body weight were measured using a well-calibrated digital stadiometer (DBS00361, Model: 1127154). Standing height, measured to the nearest 0.1cm, was recorded from the base of the stadiometer to the highest point on the head of the participant. Body weight, measured to the nearest 0.1kg, was recorded after adjusting the stadiometer to zero. Body mass index (BMI) was then calculated by dividing

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weight (in kg) by standing height squared (in metres). Data on BMI were categorized as normal (BMI <25kg/m^2), overweight (BMI≥25kg/m^2 and BMI<30kg/m^2), and obese (BMI≥30kg/m^2)[24].

A retractable medical tape measure (Medisave, United Kingdom) was used to record waist and hip circumference. These measurements were done by two qualified physiotherapists, using a protocol described by WHO in 2008[25]. Waist circumference was measured at the midpoint between the top of the iliac crest and the lower margin of the last rib, at the end of a natural breath. Hip circumference was measured at the largest circumference of the buttocks. Central obesity was defined as a waist-to-hip ratio of at least 0.87 for men and at least 0.90 for women[26].

An automated WHO sphygmomanometer was used to measure the blood pressure of each study participant. Measuring blood pressure followed a protocol released by American College of Cardiology/American Heart Association (ACC/AHA) in 2017[27]. Before measurement, participants were requested to sit and rest for five minutes. They were then required to remove any clothing from their arm, which was placed on a table for support. The appropriate cuff size was selected based on the participant's arm circumference. The cuff was positioned at the midpoint of the upper arm, level with the sternum. Two consecutive blood pressure readings were taken, one minute apart, and the average value was recorded for analysis. Systolic pressure of < 130 mmHg and diastolic pressure of < 85 mmHg were considered normal[28].

A glucometer (SD codefree, Komachine, Korea) was used to measure FPG. Participants were requested to fast starting from 10:00 pm for at least 8 hours the night before the test in order to collect data on FPG. Tests were carried out the following morning starting at 6:00 am (at the study site) after subjectively confirming that they had not taken any food except water for the past 8 hours. A standard procedure for testing FPG was followed29. Alcohol swab was used to clean the participant's side of the fingertip of the ring finger. The fingertip was pricked with a lancet, and blood was collected by letting it touch the tip of the glucose testing strip. The nurse waited for a few minutes for the glucometer to show the reading. The nurse then shared and interpreted the results with the participant and documented them in the study questionnaire29. Blood sugar level of < 110 mg/dl was considered normal, 110-125 mg/dl for prediabetes, and > 126 mg/dl for diabetes. Data were collected between December 2021 and January 2022.

Data management and analysis

Data were captured using Kobo application which is a software used for collecting and monitoring data for research. This application has been used in a comparable study 30. Data were transferred to Microsoft excel spreadsheet for cleaning. The data were then exported to Statistical Package for Social Sciences (SPSS version 29) for analysis. Descriptive statistics such as frequencies, percentages, means, and standard deviations were used to summarize sociodemographic data (such as age, sex, and educational level), behavioural (physical activity levels) and physical measurement (weight, height, blood pressure, WC, hip circumference). Bivariate logistic regression was used to analyse the relationship between prediabetes and independent variables (demographic details, and physical measurement). Variables with p ≤ 0.20 at bivariable level were selected for inclusion into the multivariable logistic regression. Odds ratios were used to describe the association between independent variables and prediabetes. All statistical tests were two-sided and p values of ≤ 0.05 were considered statistically significant.

Ethical consideration

The study was approved by the College of Medicine Research and Ethics Committee (COMREC) in Malawi, with registration number P.10/20/3163. Permission was obtained from the District Commissioner of Blantyre city and Group village headmen of the selected councilor wards. Eligible participants were provided with an information sheet that detailed the aim of the study, the role and rights of participants, the risks, and the benefits of the study. Thereafter, participants were requested to sign an informed consent form indicating their willingness to participate in the study. To uphold confidentiality and ensure anonymity, participants were identified with coded numbers. All data collectors received full personal protection equipment to protect them from COVID-19 and to safeguard the safety of the participants. Data collectors and study participants were requested to use hand sanitizers, maintain social distance and put on face masks during data collection. Electronic data were stored in password protected computer accessible to research team only. Signed consent forms were stored in a lockable drawer at the Rehabilitation Science Department at Kamuzu University of Health Sciences.

Results

A total of 215 participants were enrolled in the study, 11 participants had diabetes and were thus excluded from the analysis. As such, data from 204 participants were analysed. Female participants constituted 76% (n = 155) of the sample. The mean age with standard deviation (SD) of the participants was 39±13.40 years, with a range of 18–76 years. A total of 41.2% (n = 84) of the participants identified primary school as their highest level of education; 70.6% (n = 144) were married; and 41.7% (n = 85) were self-employed (Table 1). Individuals with a history of active cigarette smoking accounted for 3.4% (n = 7), while those involved in alcohol consumption made up 18.6% (n = 38) of the sample (Table 2). Participants whose daily work involves vigorous physical activity constituted 67.6% (n = 138) of the sample, while those engaged in daily moderate physical activities account for 81.9% (n = 167). High systolic blood pressure in this study was observed in 44.6% (n = 91), whereas high diastolic blood pressure was observed in 53.9% (n = 110) of the participants (Table 3). A total of 24.5% (n = 50) were obese, while 53.9% (n = 110) presented with a high WC and 23.0% (n = 47) had a high waist-hip ratio.

The prevalence of prediabetes was determined to be 9.8% (n = 20), 11.5% (n = 16) in females, and 8.2% (n = 4) in males (Figure 2). Obesity (COR = 3.82, 95% CI = 1.296 – 11.311) and secondary education (COR = 0.153, 95% CI = 0.029 – 0.797) were the only variables demonstrating significant association with prediabetes at bivariate logistic regression (Table 4). Age, education, body mass index, systolic blood pressure, waist-hip ratio, and waist circumference (all with p<0.2) were selected for inclusion in a multivariate regression analysis. No significant multicollinearity was observed between these variables (Table 5). At multivariate regression analysis, only obesity revealed a significant association with prediabetes (AOR=8.850, 95% CI=1.172 – 29.208).

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Table 1: Descriptive statistics for education level, employment status, and marital status

Variable	Sex		
	Female N=155 (%)	Male N=49 (%)	Total N= 204 (%)
Education level			
No education	33 (21.3)	6 (12.2)	39 (19.1)
Primary	62 (40.0)	22 (44.9)	84 (41.2)
Secondary	57 (36.8)	17 (34.7)	74 (36.3)
Tertiary	3 (1.9)	4 (8.2)	7 (3.4)
Marital status			
Never married	11 (7.1)	4 (8.2)	15 (7.4)
Married	104 (67.1)	40 (81.6)	144 (70.6)
Separated/divorced	21 (13.5)	4 (8.2)	25 (12.3)
Widowed	19 (12.3)	1 (2.0)	20 (9.8)
Employment status			
Student	4 (2.6)	0	4 (1.9)
Not employed	73 (47.1)	12 (24.5)	85 (41.7)
Self employed	66 (42.6)	19 (38.8)	85 (41.7))
Employed	12 (7.7)	17 (34.7)	29 (14.2)
Retired	0	1 (2.0)	1 (0.5)

Table 2: Descriptive statistics for smoking history, alcohol consumption, vigorous and moderate physical activities

Variable	Sex		
	Female N=155 (%)	Male N=49 (%)	Total N= 204 (%)
Smoking status			
No	155 (100)	42 (85.7)	197 (96.6)
Yes	0	7 (14.3)	7 (3.4)
Alcohol consumption			
No	146 (94.2)	20 (40.8)	166 (81.4)
Yes	9 (5.8)	29 (59.2)	38 (18.6)
Engaging in vigorous physical activities			
Yes	108 (69.7)	30 (61.2)	138 (67.6)
No	47 (30.3)	19 (38.8)	66 (32.4)
Engaging in moderate physical activities			
Yes	133 (85.8)	34 (69.4)	167 (81.9)
No	22 (14.2)	15 (30.6)	37 (18.1)

Table 3: Descriptive statistics for systolic blood pressure, diastolic blood pressure, body mass index, waist circumference, and waist-hip ratio

Variable	Sex		
	Female N=155 (%)	Male N=49 (%)	Total N= 204 (%)
Systolic blood pressure			
1. Normal	91 (58.7)	22 (44.9)	113 (55.4)
2. High	64 (41.3)	27 (55.1)	91 (44.6)
Diastolic blood pressure			
1. Normal	77 (49.7)	17 (34.7)	94 (46.1)
2. High	78 (50.3)	32 (65.3)	110 (53.9)
Body mass index			
1. Normal	57 (36.8)	31 (63.3)	88 (43.1)
2. Overweight	51 (32.9)	15 (30.6)	66 (32.4)
3. Obese	47 (30.3)	3 (6.1)	50 (24.5)
Waist-circumference			
1. Normal	58 (37.4)	36 (73.5)	94 (46.1)
2. High	97 (62.6)	13 (26.5)	110 (53.9)
Waist-hip ratio			
1. Normal	128 (52.6)	29 (59.2)	157 (77.0)
2. High	27 (17.4)	20 (40.8)	47 (23.0)

Table 4: Logistic regression analysis showing association between participants characteristics and prediabetes

N=204

Variable	COR	CI	P-value	AOR	CI	P-value
Age						
18-37	1.0 (Ref)			1.0 (Ref)		
38-57	1.823	0.673-4.939	0.238	1.272	0.428-3.782	0.665
58-77	1.130	0.219-5.822	0.033*	0.400	0.042-3.779	0.424
Sex						
1. Male	1.0 (Ref)					
2. Female	1.295	0.412 – 4.074	0.658			
Education level						
1. No education	1.0 (Ref)			1.0 (Ref)		
2. Primary	0.829	0.282 – 2.432	0.732	0.957	0.295–3.106	0.942
3. Secondary	0.153	0.029 – 0.797	0.026*	0.154	0.027–0.871	0.034*
4. Tertiary	0.182	0.093 – 9.041	0.941	1.030	0.094–11.261	0.980
Smoking status						
1. No	1.0 (Ref)					
2. Yes	1.370	0.370 – 5.070	0.638			

Table 4: Cont....

Alcohol consumption						
1. No	1.0 (Ref)					
2. Yes	0.751	0.209 – 2.706	0.662			
Body mass index						
1. Normal	1.0 (Ref)			1.0 (Ref)		
2. Overweight	0.914	0.247 – 3.377	0.893	1.006	0.221 – 4.588	0.994
3. Obese	3.829	1.296 – 11.311	0.015*	5.850	1.172 – 29.208	0.031*
Systolic blood pressure						
1. Normal	1.0 (Ref)			1.0 (Ref)		
2. High	0.499	0.184 – 1.356	0.173	0.484	0.159 – 1.477	0.202
Diastolic blood pressure						
1. Normal	1.0 (Ref)					
2. High	0.841	0.458 – 1.541	0.574			
Waist-Hip ratio						
1. Normal	1.0 (Ref)					
2. High	0.820	0.260 – 2.583	0.734			
Waist circumference						
1. Normal	1.0 (Ref)			1.0 (Ref)		
2. High	2.139	0.788 – 5.809	0.136	0.641	0.154 – 2.663	0.540
Vigorous physical activities						
1. Yes	1.0 (Ref)					
2. No	0.690	0.268 – 1.780	0.443			
Moderate physical activities						
1. Yes	1.0 (Ref)					
2. No	0.632	0.214 – 1.863	0.603			

Table 5: Multicollinearity test for independent variables

Variable	Collinearity statistics	
	Tolerance	Variance inflation factor
Age	0.920	1.087
Education	0.924	1.082
Body mass index	0.722	1.386
Systolic blood pressure	0.987	1.013
Waist-hip ratio	0.944	1.059
Waist circumference	0.675	1.482

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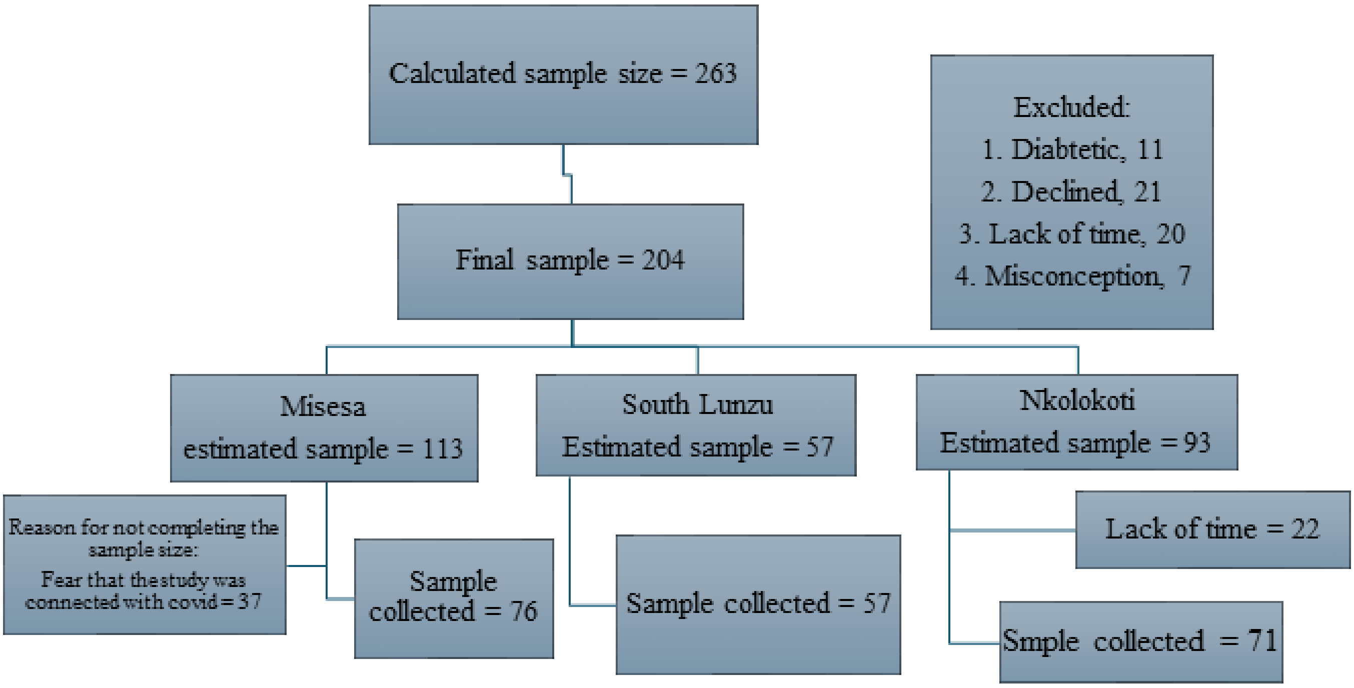

Figure 1: Flowchart outlining participant inclusion and exclusion process

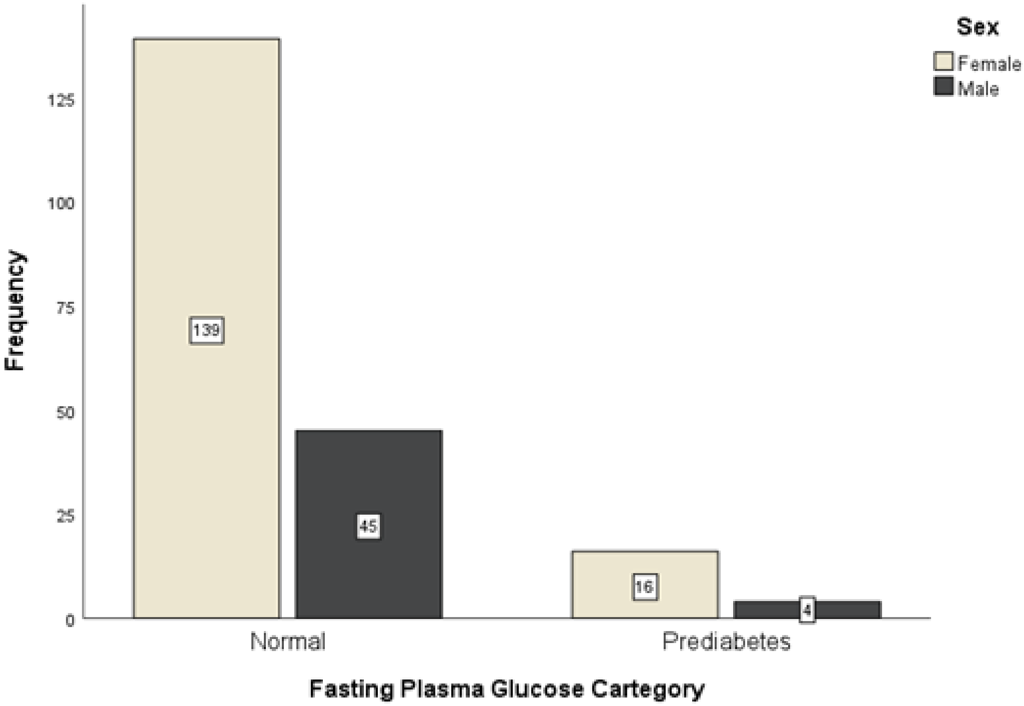

Figure 2: Distribution of prediabetes and normal fasting plasma glucose categories.

Discussion

This study assessed the prevalence of prediabetes and its associated risk factors among peri-urban adult population in Blantyre, Malawi. The prevalence of prediabetes in this study was 9.5%. Recent studies conducted in rural Uganda and Nigeria reported a relatively similar prevalence of 9.2%[10,31]. This is contrary to a study from Ethiopia, which reported a higher prevalence of prediabetes (12%)[32]. Variations in prediabetes assessment criteria may account for the differences in prevalence rates among these studies. The American Diabetes Association (ADA) prediabetes assessment criteria use a broader FPG range compared to the WHO criteria, leading to a higher number of individuals being categorised as prediabetic. This study and those conducted in Uganda and Nigeria used the WHO prediabetes assessment criterion (FPG of 110–125 mg/dl), whereas the Ethiopian study used the ADA criterion (FPG of 100–125 mg/dl). In another study, Chiwanga et al.[9] reported a higher prediabetes prevalence of 13.8% among people in Tanzania and Uganda. Although Chiwanga et al.[9] used the WHO criteria for assessing FPG, participants in their study were recruited from both rural and peri-urban regions.

The prevalence of prediabetes is increasing globally. This increase is driven by a number of factors, such as urbanisation. According to Riha et al, urbanization leads to lifestyle changes, including sedentary work and increased access to processed foods, which contribute to the risk of developing prediabetes[33]. Many processed foods comprise of high amounts of refined carbohydrates and added sugars, which may cause a rapid rise in blood glucose levels[34]. Consequently, frequent glucose spikes may lead to excess insulin production, eventually causing body cells to become

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less responsive to insulin. Additionally, skeletal muscles play an essential role in glucose uptake by actively absorbing glucose from the bloodstream during physical activity[35]. As such, individuals with sedentary lifestyles may present with reduced glucose uptake by skeletal muscles, leading to elevated blood glucose levels[36]. Urbanization has been observed in various parts of Africa leading to a noticeable increase in the prevalence of prediabetes across the continent[37]. For instance, using WHO criteria (FPG of 110–125 mg/dl), prediabetes prevalence in Nigeria increased from 6% in 2017 to 10.4% in 2021[38,39]. The high prevalence observed in Nigeria is comparable to the pooled prevalence of 13% reported among low- and middle-income countries[40]. Aside from urbanisation, the rise in prevalence of prediabetes has also been linked to genetic factors. Individuals with a family history of diabetes, particularly those born to diabetic parents, have been reported with higher risk of developing prediabetes[41].

A national survey in Malawi conducted in 2014 reported a prevalence of 4.2%[19]. No national survey has specifically measured prediabetes in Malawi in the past decade. Although this study found an increased prevalence of prediabetes, it is important to note that participants were recruited from peri-urban areas in Blantyre, Malawi, which may not be representative of the entire population. The observed increase in prevalence may be associated with reduced physical activity, as reported in this study. Additionally, due to improved socio-economic status of people in urban areas, such as income level, education, and healthcare availability, might influence diabetes screening and diagnosis by affecting individuals' awareness of this disease, and easy access to healthcare facilities.

This present study found that, obesity was associated with prediabetes in both bivariate and multivariate analysis. Obese participants had a 5.8-fold increased likelihood of prediabetes (95% CI: 1.172 – 29.208, p = 0.031) compared to non-obese participants. A similar observation was reported in a national survey in Namibia where obese participants were 1.77 times likely to develop (95% CI: 1.34–2.28) compared to their counterparts[42]. Although the odds ratio for Namibian study was low, its narrow range of confidence interval suggest a higher certainty of the estimation compared to our study. Additionally, some of the variables (wealth index of family and occupation) included in the multivariate regression of the Namibian study were not measured in our study. Majority of the participants in this study did not meet the recommended levels of physical activity and were not engaged in vigorous physical activities. These factors may have contributed to the increased BMI observed in this study. Obesity is a medical condition characterized by excessive accumulation of body fat in the adipose tissues. These tissues secrete proinflammatory cytokines, which plays a role in vasodilation[43]. However, in obesity, a prolonged inflammatory response can contribute to chronic low-grade inflammation which may lead to an inflamed endothelium, a layer of cells responsible for blood flow regulation. This impairs the endothelium which disrupts insulin signaling, a key factor in the development of insulin resistance[43]. Future studies should consider exploring interventions that result in reduced body weight such as exercise and dietary change which may indirectly reduce the prevalence of prediabetes. A recent scoping review reported that sports-based health promotion interventions can facilitate positive social change that leads to improved health behaviors[44]. Hence, similar interventions should be considered for a physically inactive population, like the one observed in the current study.

In this study, secondary education was identified as a protective factor (CI: 0.027–0.871, p = 0.034), indicating low risk of prediabetes among those participants with secondary education. This finding is contrary to what was reported in a national survey in the United States of America where individuals from the black population who had at least a secondary education (95% CI: 27.5– 29.7) had a higher risk of prediabetes compared to those without a secondary education (95% CI: 14.0 – 18.9, p = 0.001)[45]. On the other hand, the same study reported no significance difference between those with or without secondary education among Asian population. This observed difference may be attributed to cultural or genetic factors. Though individuals with formal education may end up in less physically demanding jobs, which promote a sedentary lifestyle, this does not necessarily increase their risk. This could be because the risk of prediabetes may be reduced through other mechanisms associated with education, such as increased health literacy and improved access to health care services[33]. For instance, in Malawi, those with secondary education may work as office attendants, shopkeepers and security guards. Office work is reported to contribute to a sedentary lifestyle due to long periods of sitting while working[46].

Age was not associated with prediabetes (95% CI: 0.042 - 3.779, p = 0.424) in multivariate logistic regression. This finding is contrary to previous study in India which reported a significant association between age and prediabetes (95% CI: 2.37 - 25.52, p = 0.001)[47]. However, that study analysed the risk factor using bivariate logistic regression. Although in our study, a significant association was observed for individuals aged 58 – 77 at bivariate level (95% CI: 0.22 – 5.82, p = 0.033), the wide confidence interval might indicate a high variability, weakening the strength of the association. The observed difference might be due to a small sample size recruited in our study (n = 204) compared to a larger sample (n = 544) reported in the Indian study. Additionally, the mean age in our study (39±13.40 years) is lower compared to the mean age in the Indian study (46.43±13.31 years) may have contributed to this difference. Aging is a known risk factor for metabolic diseases due to the physiological changes that come with it. For instance, as the age advances, there is an increase in body fat accumulation around viscera organs which may interfere with insulin signaling and potentially contribute to a reduction in insulin sensitivity[48]. Aging is also associated with decreased skeletal muscle activities because of reduced mobility which may lead to high sugar levels in the body as inactive muscles absorb less glucose. However, the variability in confidence interval for age, observed in this study shows lack of precision in the estimation of the association. Hence, future studies with larger sample size in Malawi should be considered to improve the effect size of the risk factors such as age.

Despite reports from other studies that show cigarette smoking as a risk factor for prediabetes,[49] the current study observed no significant association between cigarette smoking status and prediabetes. This could be because only a small percentage of this population smoked. A nationwide study conducted among 5,206 adult Malawians in 2011 indicated that the majority (11%) of smokers were from rural areas, compared to 7% from urban areas [21]. In another study, in Malawi, smoking was associated with low education levels, male gender, and increasing age[50]. Since this study took place in peri-urban areas where most people had attained secondary education and included more female participants, this could explain the low number of smokers and the lack of association with prediabetes. Similar to most African countries, smoking is less common among females in Malawi than it is among males[51,52]. Most participants in this study were females, which may explain why only a small percentage reported a history of cigarette smoking. A similar study in Uganda also showed no association of smoking with prediabetes[31]. In that study, the small number of smokers may have contributed to the findings.

Strength and limitations

The study employed a systematic random sampling method, which potentially minimized sample selection bias. Additionally, it utilised the updated WHO recommendation for categorising fasting plasma glucose levels, thereby enhancing the accuracy in estimating the prevalence of prediabetes. Although a cross-sectional design utilized in this study limited the ability to determine causal relationships underlying prediabetes, it allowed for the identification of associations related to prediabetes. Self-reported measures were used to collect data on some independent variables, such as physical activity levels and other behavioral characteristics. As such, the results should be interpreted with caution due to the potential for reporting bias.

Conclusion and Recommendation

The prevalence of prediabetes among individuals living in peri-urban Blantyre, Malawi was 9.8%. This study found that prediabetes is associated with obesity. Efforts to mitigate this risk factor may help to control the rising prevalence of prediabetes in peri-urban areas in Blantyre, Malawi. A cohort study with large sample size is required to assess the effect of other independent variables on prediabetes. Additionally, qualitative studies are needed to explore individuals' perspectives on their preferred approaches to engaging in health behaviors such as physical activity.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Author contributions

GMB conceptualized the study, collected, and analysed the data, wrote the first draft of the manuscript, and edited all drafts. TK conceptualized the study, collected data, and edited all versions including the final draft. E.C designed the study, analysed the data, and reviewed all drafts. AM and NKB designed the study, mentored GMB through the data collection process and reviewed all drafts. All authors have read and approved the final manuscript.

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References

1. Bansal N. Prediabetes diagnosis and treatment: A review. World J Diabetes. 2015.

2. Tuso P. Prediabetes and Lifestyle Modification: Time to Prevent a Preventable Disease. Perm J. 2014.

3. WHO. Definition and Diagnosis of Diabetes Mellitus and Intermediate Hyperglycemia: report of a WHO/IDF consultation. World Health Organization. 2006.

4. Rooney MR, Rawlings AM, Pankow JS, Echouffo Tcheugui JB, Coresh J, Sharrett AR, et al. Risk of Progression to Diabetes among Older Adults with Prediabetes. JAMA Intern Med. 2021;181(4).

5. Shaw JE, Sicree RA, Zimmet PZ. Global estimates of the prevalence of diabetes for 2010 and 2030. Diabetes research and clinical practice. 2010 Jan 1;87(1):4-14.

6. Rooney MR, Fang M, Ogurtsova K, Ozkan B, Echouffo-Tcheugui JB, Boyko EJ, Magliano DJ, Selvin E. Global prevalence of prediabetes. Diabetes Care. 2023 Jul 1;46(7):1388-94.

7. Ley SH, Hamdy O, Mohan V, Hu FB. Prevention and management of type 2 diabetes: Dietary components and nutritional strategies. The Lancet. 2014.

8. Shen J, Kondal D, Rubinstein A, Irazola V, Gutierrez L, Miranda JJ, et al. A Multiethnic Study of Pre-Diabetes and Diabetes in LMIC. Glob Heart. 2016.

9. Chiwanga FS, Njelekela MA, Diamond MB, Bajunirwe F, Guwatudde D, Nankya-Mutyoba J, et al. Urban and rural prevalence of diabetes and pre-diabetes and risk factors associated with diabetes in Tanzania and Uganda. Glob Health Action. 2016.

10. Nwatu CB, Ofoegbu EN, Unachukwu CN, Young EE, Okafor CI, Okoli CE. Prevalence of prediabetes and associated risk factors in a rural Nigerian community. Int J Diabetes Dev Ctries. 2016.

11. Mohamed SF, Mwangi M, Mutua MK, Kibachio J, Hussein A, Ndegwa Z, et al. Prevalence and factors associated with pre-diabetes and diabetes mellitus in Kenya: Results from a national survey. BMC Public Health. 2018;18.

12. Guariguata L, Whiting D, Weil C, Unwin N. The International Diabetes Federation diabetes atlas methodology for estimating global and national prevalence of diabetes in adults. Diabetes Res Clin Pract. 2011.

13. Forouhi NG, Balkau B, Borch-Johnsen K, Dekker J, Glumer C, Qiao Q, et al. The threshold for diagnosing impaired fasting glucose: A position statement by the European Diabetes Epidemiology Group. Diabetologia. 2006.

14. Mbogori T, Mucherah W. Nutrition Transition in Africa: Consequences and Opportunities. Global Journal of Transformative Education. 2019.

15. Kanyuka M, Office NS. 2018 Malawi population and housing census Main report. Genetics in Medicine. 2018.

16. Guthold R, Stevens GA, Riley LM, Bull FC. Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1·9 million participants. Lancet Glob Health. 2018.

17. Chan M. Global report on diabetes. World Health Organization. 2014.

18. Frieden TR, Cobb LK, Leidig RC, Mehta S, Kass D. Reducing

Premature Mortality from Cardiovascular and Other Non-Communicable Diseases by One Third: Achieving Sustainable Development Goal Indicator 3.4.1. Global Heart. 2020;15.

19. Msyamboza KP, Mvula CJ, Kathyola D. Prevalence and correlates of diabetes mellitus in Malawi: Population-based national NCD STEPS survey. BMC Endocr Disord. 2014;

20. Gowshall M, Taylor-Robinson SD. The increasing prevalence of non-communicable diseases in low-middle income countries: The view from Malawi. International Journal of General Medicine. 2018.

21. Msyamboza KP, Ngwira B, Dzowela T, Mvula C, Kathyola D, Harries AD, et al. The burden of selected chronic non-communicable diseases and their risk factors in malawi: Nationwide steps survey. PLoS One. 2011.

22. Tabak AG, Herder C, Rathman W, Brunner EJ, Kivimaki M. Prediabetes: A high-risk state for developing diabetes. Lancet. 2014.

23. WHO. The WHO STEPwise approach to noncommunicable disease risk factor surveillance. STEPS Instrument. 2017.

24. Jan A, Weir CB. BMI Classification Percentile And Cut Off Points. StatPearls. 2021.

25. World Health Organization. Report of a WHO expert consultation, Geneva. Waist circumference and waist–hip ratio. 2008;8-11.

26. Qiao Q, Nyamdorj R. The optimal cutoff values and their performance of waist circumference and waist-to-hip ratio for diagnosing type II diabetes. European Journal of Clinical Nutrition. 2010;64.

27. Whelton PK, Carey RM, Aronow WS, Casey DE, Collins KJ, Dennison Himmelfarb C, et al. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA Guideline for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. J Am Coll Cardiol. 2018;71(19).

28. Kaneko H, Itoh H, Yotsumoto H, Kiriyama H, Kamon T, Fujiu K, et al. Association of isolated diastolic hypertension based on the cutoff value in the 2017 american college of cardiology/ american heart association blood pressure guidelines with subsequent cardiovascular events in the general population. J Am Heart Assoc. 2020;9(19).

29. Mathew TK, Prasanna T. Blood glucose monitoring. StatPearls; StatPearls Publishing. 2020.

30. Derese BD, Tadesse F, Dadi GB, Ayalew M, Borie YA, Alemayehu TS, et al. Quality of Chronic Disease (Diabetes & Hypertension) Care in Health Care Facilities in High Disease Burden Areas in Sidama Region: Cross-Sectional Study. J Multidiscip Healthc. 2024;17.

31. Ampeire IP, Kawugezi PC, Mulogo EM. Prevalence of prediabetes and associated factors among community members in rural Isingiro district. BMC Public Health. 2023;23(1).

32. Worede A, Alemu S, Gelaw YA, Abebe M. The prevalence of impaired fasting glucose and undiagnosed diabetes mellitus and associated risk factors among adults living in a rural Koladiba town, northwest Ethiopia. BMC Res Notes. 2017;10(1).

33. Riha J, Karabarinde A, Ssenyomo G, Allender S, Asiki G, Kamali A, et al. Urbanicity and Lifestyle Risk Factors for Cardiometabolic Diseases in Rural Uganda: A Cross-Sectional Study. PLoS Med. 2014;11(7).

34. Bhardwaj B, Evan L O, James H O. Death by carbs: added sugars and refined carbohydrates cause diabetes and cardiovascular disease in Asian Indians. Mo Med. 2016;113(5):395.

35. Merz KE, Thurmond DC. Role of skeletal muscle in insulin resistance and glucose uptake. Compr Physiol. 2020;10(3).

36. Banda J, Bunn C, Crampin AC, Gill JMR, Gray CM. Qualitative study of practices and attitudes towards physical activity among prediabetic men and women in urban and rural Malawi. BMJ Open. 2023;13(1).

37. Peer N, Nguyen KA, Hill J, Sumner AE, Cikomola JC, Nachega JB, et al. Prevalence and influences of diabetes and prediabetes among adults living with HIV in Africa: a systematic review and meta-analysis. Journal of the International AIDS Society. 2023;26.

38. Bashir MA, Yahaya AI, Muhammad M, Yusuf AH, Mukhtar IG. Prediabetes Burden in Nigeria: A Systematic Review and Meta-Analysis. Frontiers in Public Health. 2021;9.

39. Rasaki SO, Kasali FO, Biliaminu SA, Odeigah LO, Sunday AA, Sule AG, et al. Prevalence of diabetes and pre-diabetes in Oke-Ogun region of Oyo State, Nigeria. Cogent Med. 2017;4(1).

40. Joseph A, Christian S, Bhagiaswari K, Chanda EM, Jaison J, Elezebeth M. The burden of prediabetes in low- and middle-income countries: a systematic review and meta-analysis. Eur J Clin Nutr. 2025; 1-20.

41. Bener A, Zirie M, Al-Rikabi A. Genetics, obesity, and environmental risk factors associated with type 2 diabetes. Croat Med J. 2005;46(2).

42. Adekanmbi VT, Uthman OA, Erqou S, Echouffo-Tcheugui JB, Harhay MN, Harhay MO. Epidemiology of prediabetes and diabetes in Namibia, Africa: A multilevel analysis. J Diabetes. 2019;11(2).

43. Prieto D, Contreras C, Sanchez A. Endothelial Dysfunction, Obesity and Insulin Resistance. Curr Vasc Pharmacol. 2014;12(3).

44. Hansell AH, Giacobbi PR, Voelker DK. A Scoping Review of Sport-Based Health Promotion Interventions With Youth in Africa. Vol. 22, Health Promotion Practice. 2021.

45. Formagini T, Brooks JV, Roberts A, Bullard KMK, Zhang Y, Saelee R, et al. Prediabetes prevalence and awareness by race, ethnicity, and educational attainment among U.S. adults. Front Public Health. 2023;11.

46. Parry S, Straker L. The contribution of office work to sedentary behaviour associated risk. BMC Public Health. 2013;13(1).

47. Muthunarayanan L, Ramraj B, Russel J. Prevalence of prediabetes and its associated risk factors among rural adults in Tamil Nadu. Archives of Medicine and Health Sciences. 2015;3(2).

48. Karakelides H, Irving BA, Short KR, O'Brien P, Sreekumaran Nair K. Age, obesity, and sex effects on insulin sensitivity and skeletal muscle mitochondrial function. Diabetes. 2010;59(1).

49. Kondo T, Nakano Y, Adachi S, Murohara T. Effects of tobacco smoking on cardiovascular disease. Vol. 83, Circulation Journal. 2019.

50. Ngambi W, Mwase T, Chinkhumba J, Udedi M, Chigaru F, Banda J, et al. Prevalence of noncommunicable diseases risk factors and their determinants in Malawi: Evidence from 2017 WHO Stepwise survey. Int J Noncommun Dis. 2022;7(3).

51. Bosdriesz JR, Mehmedovic S, Witvliet MI, Kunst AE. Socioeconomic inequalities in smoking in low- and mid-income countries: Positive gradients among women? Int J Equity Health. 2014;13(1).

52. Muula AS. Prevalence and determinants of cigarette smoking among adolescents in Blantyre City, Malawi. Tanzan Health Res Bull. 2007;9(1).

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