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Effect of Lifestyle Modification and Medication Adherence on Glycaemic Control among Type-2 Diabetes Patients Attending Primary Care Setting in Northern Nigeria

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Abstract **Original Research**

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder characterized by insulin resistance and impaired insulin secretion, leading to hyperglycaemia (elevated blood glucose levels). It is linked to a high rate of disease burden, especially in underdeveloped nations like Nigeria. It is assuming a pandemic proportion globally, with a burden not only affecting the quality of life of individuals with the disease but also adding financial burdens to their families and the nation's economy. Achieving good glycaemic control is the main aim of diabetes management. Yet, it has been found that most diabetic patients' glycaemic levels are poorly controlled, largely due to a lack of commitment to lifestyle modification and adherence to medications. This study determined the effect of lifestyle modification and medication adherence on glycaemic control among type 2 diabetic patients among adult type 2 DM patients attending General Outpatient Clinic at Usmanu Danfodiyo University Teaching Hospital Sokoto. This study was a hospital-based cross-sectional study of 250 adults with type 2 DM Aged 18 years and above, selected using systematic random sampling over 12 weeks. The respondents' diabetes lifestyle, medication adherence and glycaemic control were measured using the Simple Lifestyle Indicator Questionnaire (SLIQ), Morisky Medication Adherence-8 (MMAS-8) and HbA1c index (glycated haemoglobin), respectively. Data were analysed using the International Business Machine Corporation Statistical Product and Service Solutions (IBM®SPSS statistics) version 26. A p-value of < 0.05 at a 95% confidence interval was considered statistically significant. There was a 100% questionnaire response rate, and the mean age of the respondents was 54.4± 10.5, with a female majority (58%).. Among the study respondents, only (23.2%) had good glycaemic control. Clinical attendance, family history of diabetes, lifestyle modification and medication adherence were statistically significant at bivariate analyses. Both medication adherence and regular clinical attendance were statistically significant at the logistic regression level, hence independent predictors of good glycaemic control. The respondents with low medication adherence were 83% less likely to have good glycaemic control than those with high medication adherence (AOR =0.17, CI=0.05-0.65). Conversely, the respondents with medium medication adherence were 70% less likely to have good glycaemic control than those with high medication adherence (AOR= 0.30, CI = 0.15-0.59). The respondents who have unhealthy lifestyles were 46% less likely to have good glycaemic control than those with healthy lifestyles (AOR=0.54, CI= 0.29-1.01), although it was not statistically significant, P=0.52. The respondents with non-regular clinical attendance were 91% less likely to have good glycaemic control then those with regular clinical attendance (AOR =0.09, CI=0.811-3.065), respondents with family history of diabetes were 57% times more likely to have good glycaemic control then respondents with no family history of diabetes (AOR =1.57, CI=0.011-0.645). The findings indicate that influence of medication adherence and lifestyle modification on glycaemic control cannot be over-emphasized. Hence, family physicians and other health care providers should educate diabetes patients on lifestyle modification and medication adherence benefits to achieve good glycaemic control. This will ultimately improve the quality of life of type 2 diabetic patients.

Keywords: : Medication adherence, Lifestyle modification and Glycaemic control

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Introduction

Diabetes mellitus is the collective term for heterogeneous metabolic disorders whose main finding is hyperglycaemia. The cause is either, a disturbed insulin secretion, a disturbed insulin effect, or usually both.[1] It is a complex metabolic disorder associated with obesity and an increased risk of micro vascular complications such as retinopathy, nephropathy, neuropathy and macro vascular complications such as cardiovascular comorbidities. Its primary clinical characteristic is hyperglycaemia and individual components of the insulin resistance metabolic syndrome.[2]

The World Health Organization (WHO) in 2019 classified diabetes into two major types: type 1 (T1DM) and type 2 (T2DM) diabetes; others include the hybrid form of DM, other specific types, and unclassified DM .[3]

The burden of diabetes mellitus is rising globally and at a much faster rate in developed regions, such as Western Europe. The gender distribution is equal, and the incidence peaks at around 55. The global prevalence of type 2 diabetes is projected to increase to 7079 individuals per 100,000 by 2030, reflecting a continued rise across all regions of the world.[4]

Due to urbanization and population ageing, Sub-Saharan Africa is predicted to increase diabetes prevalence from 3.8% in 2000 to 4.4% in 2030.[5] One-third of all the cases of diabetes are in rural communities, while two-thirds are in urban centre [6]

Due to its chronic nature, the severity and dire consequences of its complications, the resources required to combat it, and the patients' and families' financial burden, diabetes mellitus is a highly costly disease for the state's healthcare system as well.[3] Risk factors for T2DM include obesity, sedentary lifestyles, poor diets, and changes in lifestyle as a result of urbanization that influence the outcome of type 2 diabetes.[7] Treatment of T2DM includes pharmacological agents like oral hypoglycaemic agents and insulin. Non-pharmacological measures such as exercise, smoking cessation, alcohol reduction, and whole-grain intake can help manage T2DM.[3]

Lifestyle medicine uses interventions and integrates lifestyle practices within conventional medicine to lower disease risk. Lifestyle intervention is a practical, non-invasive way to manage weight, glycaemic control, and blood pressure and to reduce the risk of fatal complications in T2DM patients.[8] It serves as an adjunct to the management of illnesses. It can effectively treat chronic non-infectious diseases by addressing health risk behaviours through diet, physical activity, behaviour change, body weight control, treatment plan adherence, stress and coping, spirituality, mind-body techniques, and tobacco and substance abuse.[9]

Adherence to medication refers to the degree to which the patient conforms to treatment as prescribed.[10] Medication Adherence refers to how patients follow provider recommendations about day-to-day treatment concerning the timing, dosage, and frequency. It may be defined as “the extent to which a patient acts under the prescribed interval and dose of a dosing regimen.[11]

Glycaemic Controls defined by the International Diabetes Federation (IDF), global guidelines define glycaemic control as an HbA1C target of $<$7.0 (53 mol/mol).[12] In contrast, other procedures like the National Institutes for Health and Care Excellence (NICE) and the American Association of Clinical Endocrinology (AACE) apply more aggressive targets in newly diagnosed patients as an HbA1C target of 6.5% (48 mmol/mol).[12] reducing morbidity and death, as well as controlling and preventing diabetic complications, requires maintaining adequate glycaemic control.[13]

MATERIALS AND METHODS

The study was conducted at the General Outpatient Clinic of the department of family medicine, Usmanu Danfodiyo University Teaching Hospital Sokoto. This Hospital was Established in 1972, and it is a tertiary referral Centre with a patient capacity of 850 beds and a catchment population of about 7.5 million covering Sokoto, Kebbi, Zamfara and Niger.

Study design

The study was a hospital-based cross-sectional study conducted at the GOPC of Usmanu Danfodiyo University Teaching Hospital, Sokoto State. The predominant occupation in the area are farming, cattle rearing and mining activities. The major tribes in the Sokoto state are Hausa, Fulani with a small population of Igbo, Yoruba and other tribes. The majority of the people in the area practice Islam with few as Christians.

Study Population

All Consenting adults aged 18 years and above with type 2 diabetes mellitus for more than one year were included in the study while those respondents who were critically ill and pregnant women due to peculiarities of pregnancy were excluded from the study.

The sample size was calculated using Leslie Kish formula for the cross-sectional study.[14]

Sample size n = Z^2pq/d^2

Where:

n = desired sample size (when the population is > 10,000)

z = standard normal deviation, usually set at 1.96, corresponding to a 95% confidence interval.

p = Proportion of the T2DM patients with good medication adherence from the previous study is 19.8%= 0.198.[15]

q = complementary probability= 1-p

q = 1 – p = 0.802

d = degree of accuracy desired set at 0.05

Therefore,

n = (1.96) /0.05^2= 0.610/0.0025=244

However, the proposed study population was less than 10,000, as an inquiry at the hospital's health information and management department revealed that the estimated population of adults with type 2 diabetes attending the clinic was about 2,880 in the preceding year. Hence, the desired minimum sample size required was adjusted using the formulae.[16]

$n_f = \frac{n}{1+\frac{n}{N}}$

n_f = Final sample size.

n = Sample size when the study population is greater than 10,000 = 244

N = Estimate of the population of the area of study = 2,880

Therefore,

$\frac{244}{1+\frac{244}{2880}}$= 224.8≈225

To adjust the estimated minimum sample size for non-response using the formulae.[17]

$n_s=\frac{n}{R}$

Where n_s= adjusted sample size for response rate

n = calculated sample size = 225

R = anticipated response rate of 90% (0.90)

Therefore, $n_s=\frac{225}{0.9}$= 250

Thus, the minimum sample size for this study was 250

A systematic random sampling technique was used to select the study respondents from the study population who satisfied the inclusion criteria after calculating the sampling interval.

Thus, sample interval (K) =

According to the information obtained from the hospital's health information department, an average of 2880 adult diabetics were seen in a year. Therefore, (2880÷12) gave the sample population of approximately 240 adult type 2 diabetes patients per month, and 240×3= 720 adult patients for three months since the proposed data collection duration was for three months. Therefore, sample interval (K) =.$\frac{720}{250}$ =2.88 ≈3

So, every third respondent was selected until a sample size of 250 was reached.

To achieve a sample size of 250 over three months,

as patients were seen from Monday to Friday, the number of respondents interviewed daily was $\frac{250}{3\ months \times 4\ weeks \times 5\ days}$ =4.16 ≈4, approximately four patients daily.

On each clinic day, every adult diabetic patient that met the inclusion criteria was assigned a number from one to twelve (the expected total number of adult diabetics attending the clinic daily, i.e., sample frame).

The first patient's folder was selected using simple random sampling (balloting) between the first three T2DM patients to arrive at the clinic. After that, every 3rd adult T2DM folder was selected until the chosen sample size was obtained. The case files of adults with T2DM chosen patients at the end of each clinic were marked with a sticker to avoid multiple inclusions in the study. The next patient who met the criteria was used to replace those who did not meet the inclusion criteria. The process was repeated daily until a sample size of 250 was obtained.

A semi-structured, interviewer-administered questionnaire, drafted in the English language, was translated into Hausa by a certified interpreter and then back-translated into the English language for data collection. The questionnaire consisted of six sections. Section I assessed socio-demographic characteristics, including; age, gender, marital status, ethnicity, occupation, monthly earnings, health care financing, smoking and alcohol consumption, level of education, religion, family type, and size Section II assessed Clinical Characteristics, including; duration of diabetes, treatment modality, and regularity with clinic attendance, history of other medical condition and family history of diabetes.

Section III used the Morisky Medication Adherence Scale (MMAS-8) to assess medication adherence. This tool is an eight-item validated scale that helps to find out a patient's experiences with medications.. The 8-item Morisky Adherence Scale (MMAS-8) is a structured self-reported medication adherence measure expanded from the widely used 4-item Morisky Green and Levine adherence scale in 2008, resulting in better psychometric properties. The scale was initially developed for measuring medication adherence in hypertension but has since been used for measuring medication adherence in multiple chronic conditions, including Type 2 Diabetes. The Morisky medication adherence scale has a score range of 0 – 8. A score of 8 indicates good medication adherence, 6-7 indicates moderate medication adherence, and 0-5 indicates poor medication adherence.[18] The Morisky medication adherence scale is a reliable tool, with Cronbach's alpha coefficient of 0.7 indicating good internal consistency.[18] This tool has an excellent validity with a sensitivity of 93% and specificity of 53%. Because of its simplicity, sensitivity, validity and its other aforementioned psychometric properties, it was regarded as the most commonly used tool for measuring medication adherence in clinical settings.[18]

Section IV Use the simple lifestyle indicator questionnaire (SLIQ) to assessed Lifestyle Modification; The simple lifestyle indicator questionnaire (SLIQ) was developed in 2005 by two family physicians and a nutritionist in Ontario, Canada. It was designed to measure the individual components of a lifestyle that affect cardiovascular disease. It has 12 questions in 5 components: diet (3 questions), exercise (3 questions), alcohol consumption (3 questions), smoking (2 questions), and stress (1 question). The overall SLIQ score is based on the five category scores to provide equal weighting for each element. Each component has a category score of 0, 1, or 2, so overall SLIQ scores can range from 0 to 10. A score of ≤5 indicates an unhealthy lifestyle and the score indicates a healthy lifestyle.[19]The simple lifestyle indicator questionnaire is a reliable tool, with Cronbach's alpha coefficient of 0.58 for diet o.60 for physical activity, indicating moderate and acceptable internal consistency. The tools has test rates reliability of 0.63-0.97 indicating moderate to very high stability, external validity of r=0.77 indicating good agreement with independent professional assessment, concurrent validity for diet of r= 0.679 indicating good correlation with dietary assessment, concurrent validity for physical activity of r=0.455 indicating moderate correlation with podometer measurement, concurrent validity for alcohol of r=

0.665 indicating good correlation concurrent validity for stress of r=0.264 indicating significant but relative weak correlation. Because of these aforementioned psychometric properties, it was regarded as one of the tools in assessing lifestyle modification.[19]

Section V Clinical measurements; The data collected in this section included the patient's current weight, height, blood pressure, body mass index, waist circumference, hip circumference, and waist-hip ratio.

Section VI Laboratory investigations; The respondents' blood sugar and glycosylated haemoglobin values were recorded in this questionnaire section

Data Analyses

At the end of the study, the administered questionnaires were sorted out and coded before entry into the computer for analysis using version 26 of the International Business Machine Co-operation Statistical Product and Service Solutions (IBMSPSS statistics).[20] Data were presented in prose, tables and charts. The level of glycaemic control was represented with pie chat. Pearson chi-square statistical test was used to determine the association between glycaemic control and the independent variables such as sociodemographic characteristics, lifestyle modification, and medication adherence (categorical data). Fisher's test was used to determine the association for expected frequency in 2×2 table ≤ 5 in a cell and large contingency table with up to 20% of the cells having ≤ 5 expected frequencies. The level of statistical significance was set at a p-value of < 0.05 and a confidence interval (CI) of 95%. Variables with p-value < 0.05 in bivariate analysis with glycaemic control were entered into a multi-variable regression analysis to determine the independent predictors of good glycaemic control. The adjusted odd ratios (OR) and 95% CI for the predictor variables were calculated

Ethical Consideration

Ethical clearance was obtained from the ethical committee of Usmanu Danfodiyo University Teaching Hospital with ethical clearance number UDUTH/HREC/2023/1248/V1. Informed consent was obtained from patients to be involved in the study, and confidentiality of the information given was maintained. Participation in the study was voluntary, and patients might withdraw at any stage without penalty.

Result

Figure 1 shows a level of glycaemic control among study respondents, which out of the 250 respondents, 192(76.8%) had poor glycaemic control, while 58(23.20%) had good glycaemic control.

Table 1 shows the bivariate association between socio-demographic characteristics and glycaemic control among study respondents; overall, none of the variables had a statistically significant association with glycaemic control. The respondents within the age category of 60-69 years had a high number of good glycaemic controls, (27.5%) [$\chi^2=$ 2.283, $p=0.684$].Good glycaemic control was higher in females (24.8%), [$\chi^2=0.513$ $p=0.474$], respondents who identified their religion as Islam (21.4%), [$\chi^2=2.226$, $p=0.136$],respondents who were from other tribes like Zabarmawa, Igala, Ebira, Bini, and Nupe (38.9%), [$FX=3.196$, $p=$ 0.358], respondents identified as civil servants (26.3%), [$FX=2.238$, $p=0.693$]., respondents who were widows and widowers (34.6%), [$FX=4.127$, $p=0.387$], respondents who were from monogamous families (25.0%), [$\chi^2=0.618$, $p=0.432$], respondents with an Arabic level of education (33.3%) [$\chi^2=2.129$ $p=0.712$].and respondents with an average monthly income greater than ₦200,000. (36.8%) [$\chi^2=3.416$, $p=0.491$].

Table 2 shows the bivariate association between clinical characteristics and glycaemic control among study respondents; overall, clinical attendance and family history of diabetes were found to be significant. Good glycaemic control was high in respondents with regular clinical attendance

(27.0%), [χ^2=11.4 p=0.01], who had diabetes less than five years (26.9%) [χ^2=1.624, p=0.654], had no history of other medical condition (23.4%) [χ^2= 0.011, p=0.915], had normal BP (24.3%) [χ^2= 0.211, p=0.915], had obesity (26.2%) [χ^2=0.618, p=0.892], had normal waist-hip ratio (25.0%) [χ^2 =2.888, p=0.089], had no family history of diabetes (31.6%) [χ^2=4.303, p=0.038], and used pills for treatment (24.5%) [FE=2.213 p=0.87].

Tabs 3 shows the bivariate association between medication adherence, lifestyle modification, and glycaemic control among the study respondents. A statistically significant relationship exists between the respondents regarding medication adherence [χ^2 =17.44, p=0.001], lifestyle modification, [χ^2= 4.435, p=0.035] and glycaemic control.

Table 4 Shows multivariable models of independent predictors of good glycaemic control among respondents where medication adherence, lifestyle modification, clinical attendance, and family history of diabetes which were statistically significant on chi-square and were subjected to multiple logistics regression to remove the effect of confounders. Only medication adherence, p = 0.001 and regular clinical attendance, p =0.017 had a significant association with glycaemic control on logistic regression. The respondents with low medication adherence were 83% less likely to have good glycaemic control than those with high medication adherence (AOR =0.17, CI=0.05-0.65), the respondent with medium medication adherence was 70% less likely to have good glycaemic control than those with high medication adherence (AOR= 0.30, CI = 0.15-0.5), respondents with non-regular clinical attendance were 91% less likely to have good glycaemic control then those with regular clinical attendance (AOR =0.09, CI=0.811-3.065), respondents with family history of diabetes were 57% less likely to have good glycaemic control then respondents with no family history of diabetes (AOR =1.6, CI=0.011-0.645). The respondents who have unhealthy lifestyles were 46% less likely to have good glycaemic control than those with healthy lifestyles (AOR=0.54, CI= 0.29-1.01), although it was not statistically significant, P=0.52.

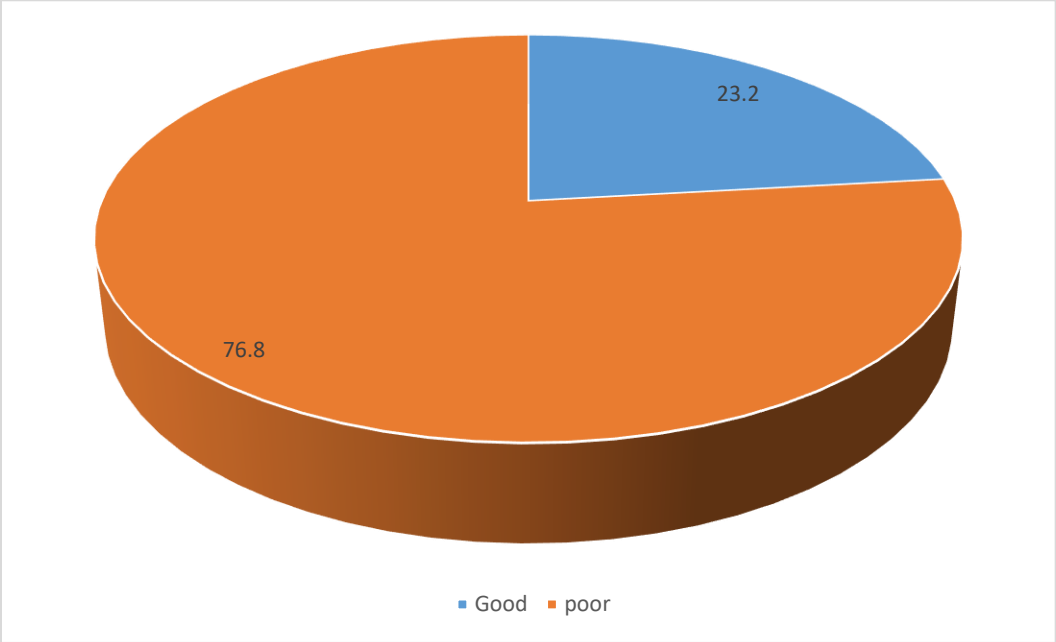


Figure 1: Level of glycaemic control among respondents

Table 1 a: Association Socio-demographic Characteristics and Glycaemic Control.

Variable	Glycaemic control (n =250)		Test statistics P- value
	Good glycaemic control n(%)	Poor glycaemic control n(%)	
Age category in years			
30-39	2 (11.8)	15 (88.2)	X^2=2.283
40-49	16 (23.9)	51 (76.1)	P =0.684
50-59	16 (20.80)	61 (79.2)	
60-69	19 (27.5)	50 (72.5)	
70 and above	5 (25.0)	15 (75.0)	
Gender			
Male	22 (21.0)	83 (79.0)	X^2=0.513
Female	36 (24.8)	109 (75.2)	P=0.474
Religion			
Islam	44 (21.4)	162 (78.6)	X^2=2.226
Christianity	14 (31.8)	30 (68.2)	P=0.136
Ethnicity			
Hausa	44 (21.8)	158 (78.2)	FE=3.196
Yoruba	4 (28.6)	10 (71.4)	P=0.358
Igbo	3 (18.8)	13 (81.3)	
Others	7 (38.9)	11 (61.1)	
Occupation			
Civil servant	26 (26.3)	73 (73.7)	FE= 2.238
Trader	17 (25.40)	50 (74.6)	P= 0.693
Farmer	2 (13.3)	13 (86.7)	
Retired	3 (14.3)	18 (85.7)	
Housewife/Artisan	10 (20.8)	38 (79.2)	

X^2= Pearson's Chi-square test, FE = Fisher's Exact test

Table 1 b: Association Socio-demographic Characteristics and Glycaemic Control.

Variable	Glycaemic control n= 250		Test statistics P-value
	Good glycaemic control n (%)	Poor glycaemic control n (%)	
Marital status			
Married	47 (23.3)	155 (76.7)	FE= 4.127
Single	1 (12.5)	7 (87.5)	P= 0.387
Divorced	1 (7.7)	12 (92.30)	
Widow/widower Separated	9 (34.6) 0(0.0%)	17 (65.40) 1 (100)	
Family type			
Monogamy	36 (25.0)	108 (75.0)	X^2= 0.618
Polygamy	22 (20.8)	84 (79.2)	P= 0.432
Highest level of education			
Primary	3 (20.0)	12 (80.0)	X^2= 2.129
Secondary	21 (24.4)	65 (75.6)	P= 0.712
Tertiary	22 (21.6)	80 (78.4)	
None	4 (17.4)	19 (82.60)	
Arabic	8 (33.3)		
Average income			
₦10,000-50,000	18 (21.4)	66 (78.6)	X^2= 3.416
₦51,000- 100,000	19 (20.9)	72 (79.1)	P= 0.491
₦101,000-150,000	6 (20.0)	24 (80.0)	
151,000-200,000	8 (30.8)	18 (69.2)	
>₦200,000	7 (36.8)	12 (63.2)	

Table 2 c: Clinical Characteristics by Glycaemic Control of the Respondents

Variable	Glycaemic control (n =250)		Test statistics P- value
	Good glycaemic control n (%)	Poor glycaemic control n (%)	
Clinical attendance			
Regular	57(27.0)	154(73.0)	X^2=11.04
Not regular	1 (2.6)	38 (97.4)	P = 0.01
Duration of Diabetes			
<5	18(26.9)	49(73.1)	X^2 =1.624
5-10 11-20 >20	21(21.6) 18(23.7) 1(10.0)	76(78.4) 58(76.3) 9(90.0)	P = 0.654
History of other Medical conditions			
Had history	21 (22.8)	71 (77.2)	X^2=0.011
No history	37 (23.4)	121 (76.6)	P=0.915
Blood pressure			
Normal BP	34(24.3)	106 (75.7)	X^2=0.211
Hypertensive	24 (21.8)	86 (78.2)	P=0.646
Body mass index			
Underweight	2 (16.7)	10 (83.3)	X^2=0.618
Normal weight	20 (22.5)	69 (77.5)	P=0.892
Overweight	19 (23.8)	61 (76.3)	
Obesity	16(26.2)	45 (73.8)	
Waist-hip ratio			
Normal	54 (25)	162(75.0)	X^2= 2.888
Abnormal	4 (11.80)	30 (88.2)	P= 0.089
Family history of			

Diabetes			
Had family history	34 (19.5)	140 (80.5)	X^2 =4.303
No family history	24 (31.6)	52 (68.4)	P=0.038

X^2= Pearson's Chi-square test, FE = Fisher's Exact test

Table 2 d: Clinical Characteristics by Glycaemic Control of the Respondents

Variable	Glycaemic control (n =250)		Test statistics P- value
	Good glycaemic control n (%)	Poor glycaemic control n (%)	
Types of treatment			
Pills	56(24.5)	173(75.5)	FX=2.213
Insulin	0 (0.001)	3 (100)	P = 0.87
Pills and insulin	2(12.5)	14 (87.5)	
Others	0 (0.001)	2(100)	

X^2= Pearson's Chi-square test, FE = Fisher's Exact

Table 3: Relationship between Medication Adherence, Lifestyle Modification and Glycaemic Control among Study Respondents

Variable	Glycaemic control=250		Test statistics
	Good glycaemic control n(%)	Poor glycaemic control n(%)	P-value
Medication adherence category			
High	5(50.0)	5(50.0)	$X^2 = 17.444$
Medium	21(41.2)	30(58.8)	P=0.01
Low	32(16.9)	157(83.1)	
Lifestyle modification category			
Healthy	43(27.6)	113(72.4)	$X^2 = 4.435$

Unhealthy	15(16.0)	79(84.0)	P=0.035

Table 4 a: Binary Logistics Regression to Determine Independent Predictors of Good Glycemic Control among Respondents

Variable	AOR	P-value	CI	
			Lower	Upper
Family history of diabetes				
No				
Yes*				
Clinical attendance	1.57	0.180	0.811	3.065
Non- regular				
Regular*				
Medication Adherence	0.09	0.017	0.011	0.645
Low	0.17	0.009	0.05	0.65
Medium	0.30	0.001	0.15	0.59
High*				
Lifestyle				
Unhealthy	0.54	0.52	0.29	1.01
Healthy*				

*=Reference category, AOR= Adjusted odds ratio, CI= Confidence interval

Discussion

This hospital-based cross-sectional study was designed to assess the effect of lifestyle modification and medication adherence on glycaemic control among outpatients with type-2 diabetes attending primary care setting in North Western Nigeria

The level of glycaemic control of this index study as seen in figure 1 shows that the proportion of the respondents with good glycaemic control in the index study was low (23.2%) while 76.8% had poor glycaemic control. Similar studies were carried out by Okoye and Ohenhen in southern Nigeria, where (27.2%) had good glycaemic control, and (70.8%) had poor glycemic control,[21] Alodhayani et al. reported that (23%) had good glycaemic control, and (77%) had poor glycaemic control in Saudi arabia.[22] In contrast, Alemu and colleagues in Ethiopia observed a lower proportion of respondents with good glycaemic control, with only (19.7%) in this category and (80.3%) with poor glycaemic control.[23] Their discovery suggests that more individuals with type 2 diabetes will have an elevated risk of diabetes-related complications and death. However, varying proportions were observed in different studies: David et al. reported (49.9%) with good control and (50.1%) with poor control in Nigeria.[24] Ufuoma and colleagues in Niger Delta found (45%) with good control and (55%) with poor control,[13] Similarly, Bukhsh et al. reported a lower prevalence in Pakistan, with only (7%) achieving good glycaemic control and (93%) having poor control.[25] The discrepancies in these findings may be attributed to differences in the study population,

methods of glycaemic control assessment, sample size, medication adherence, lifestyle education, knowledge, practices, and socio-demographic and clinical variables. Healthcare providers should encourage patients to adopt behaviours that promote better glycaemic control and educate them on avoiding actions that could lead to poor control, ultimately enhancing the quality of life for diabetic individuals.

The study found that none of the socio-demographic characteristics related to glycaemic control was statistically significant at the bivariate level. The proportion of study respondents 27.5% of respondents aged 60-69 years had good glycaemic control while the age group (30-39) had the lowest rate with good glycaemic control (11.8%). The explanation for this could be that those with increased age were likely to have retired or were on the verge of retirement. They had more time to practice lifestyle modification and adhere to their medication without distractions, unlike the respondents of lower ages, who were likely to be busy with their careers and might not have time to practice some lifestyle changes and to adhere to their medication. This is a concern, as many young diabetics might quickly develop complications from uncontrolled diabetes due to a lack of adherence to their medication and lifestyle changes. Therefore, physicians should emphasize counselling on the domains of medication adherence and lifestyle changes to their young diabetic patients during their routine clinic visits. This will improve their quality of life and reduce diabetes-associated morbidity and mortality. At the level of bivariate analysis, the relationship between the age of the study respondents and glycaemic control was not statistically significant. Similarly to studies conducted by Ibrahim and colleagues. in southern Nigeria,[26] and Yigazu et al. in Ethiopia.[27] Our study found that age was not significantly associated with glycaemic control. In contrast, other studies by Osuji et al. in southern Nigeria,[28] and Mamo et al. in Ethiopia,[29] did find a significant relationship between age and glycaemic control. The varying results could be attributed to differences in study populations, designs, and sample sizes.

About one-fourth of female study respondents with good glycaemic control was (24.8%) and (75.2%) were female study respondents with poor glycaemic control. The proportion of male respondents with good glycaemic control was (21%) and (79%) was the proportion of males with poor glycaemic control. The gender of the study respondents did not show a statistically significant relationship with glycaemic control at bivariate analysis. This finding was consistent with studies conducted by Ibrahim and colleagues in Nigeria,[26] and Alodhayani et al. in Saudi Arabia.[22] The similarities could be because the index study and studies done by Ibrahim and colleagues and Alodhayani et al. used cross-sectional study design and systematic random sampling. However Osuji et al. in Nigeria,[28] found a statistically significant relationship between gender and glycaemic control. The differences in results across studies may be attributed to the fact that osuji et al. used a study population of 316 and convenience sampling method.

Less than one-fourth (21.4%) of study respondents who reported being Muslim had good glycaemic control, while 78.6% had poor control. Among Christian participants, (31.8%) had good control and (68.2%) had poor control. However, bivariate analysis did not find a significant relationship between respondents' religion and their glycaemic control. A contrasting study conducted by How CB et al. in Malaysia,[30] where there was a statistically significant relationship between the religion of the respondents and their glycaemic control, our study did not find such a relationship. This difference may be attributed to varying sociocultural contexts, study population differences, and study methodology.

One-fifth of study respondents who practiced monogamy and had good glycaemic control was (25.0%), as against (75%) who had poor glycaemic control. Less than one-fifth of the respondents (20.8%) who practiced polygamy had good glycaemic control whereas (79.2%) of respondents who practiced polygamy had poor glycaemic control. At the level of bivariate analysis, the relationship between the family type of the study respondents and glycaemic control was not

statistically significant. This was similar to the findings by Ibrahim and colleagues,[26] and Osuji et al.,[28] both in Nigeria. The similarity is that both studies were conducted in the same geographical location and had the same study design.

The proportion of the study respondents who were Hausa and had good glycaemic control was (21.8%) as compared to (78.2%) who had poor glycaemic control. The proportion of respondents who were Yoruba and had good glycemic control was (28.6%) as against (71.4%) who had poor glycaemic control, and (18.8%) were study respondents who were Igbo and had good glycaemic control while (81.3%) had poor glycaemic control. At the level of bivariate analysis, this research and other research by Ibrahim and colleagues in Nigeria,[26] showed there is no statistical relationship between the ethnicity of the study respondents and glycaemic control. This was contrary to a study conducted by Alodhayani et al. in Nigeria,[22,] where there was a statistically significant relationship between ethnicity and glycaemic control. This variation may be because of differences in study design, sociocultural factors in the study population, and the influence of ethnicity on lifestyle modification and medication adherence.

About (26.3%) of the study respondents who were civil servants had good glycaemic control, while (73.7%) of civil servants did not have good glycaemic control. Among traders, (25.4%) had good glycaemic control, while (74.6%) did not. Farmers had a good glycaemic control rate of (13.3%), while (86.7%) did not. Retired individuals had a good glycaemic control rate of (14.3%), while (85.7%) did not. The relationship between occupation and glycaemic control was not found to be statistically significant in the bivariate analysis. Other studies have shown differing results, possibly due to variations in study design and socio-cultural factors among respondents.[7,22] Contrary study conducted by Emeka et al.,[31] have shown the association between occupation and glycaemic control to be statistically significant. The variation in these studies could be due to differences in study design, study population and sociocultural factors of the respondents.

About (23.3%) of married respondents had good glycaemic control, while (76.7%) did not. Among single respondents, (12.5%) had good glycaemic control, in comparison, (87.5%) did not, and (7.7%) of divorced respondents had good glycaemic control while (92.3%) of divorced respondents had poor glycaemic control. About (34.6%) of widows/widowers had good glycaemic control. Additionally, (65.4%) of widows/widowers had poor glycaemic control. At the level of bivariate analysis, this study, along with other studies by Osuji et al. in Nigeria,[28] Alodhayaniet al. in Saudi Arabia,[22]showed the relationships between the marital status of the study respondents and glycaemic control were not statistically significant. This contrasts with a study conducted by Omar et al. in Sudan.[32], where the relationship between the marital status of the respondent and glycaemic control was found to be significant. The reason for the variation may be because of the differences in sample size, sociodemographic factors, study design and level of education of the respondents.

Out of the respondents with primary certificates, (20.0%) had good glycaemic control and (80.0%) did not. Among those with secondary certificates, (24.4%) had good glycaemic control while (75.6%) did not. Among respondents with a tertiary level of education, (21.6%) had good glycaemic control in comparison, (78.4%) of respondents with a tertiary level of education did not have glycaemic control. However, based on bivariate analysis, the relationship between the higher level of education of the study respondents and glycaemic control was not found to be statistically significant. This finding was consistent with studies conducted by researchers in Nigeria.[28] On the other hand, studies in Sudan and Ethiopia found contrasting results.[29,32] The variation in these studies may be because of differences in study design and study population and may be due to the level of awareness of lifestyle practices and adherence to the medication.

About (21.4%) of the study respondents who had income sources between ₦10,000-50,000 had good glycaemic control, while (78.6%) did not as compared to (20.9%) of respondents with incomes between ₦51,000-100,000 had good glycaemic control, with (79.1%) not achieving glycaemic

control. Additionally, (20.0%) of participants with incomes between ₦101,000-150,000 had good glycaemic control, while (80.0%) did not. Furthermore, (30.8%) of respondents with incomes between ₦151,000-200,00 had good glycaemic control, while (69.2%) were the respondents with the same sources of income and had poor glycaemic control. Finally, the proportion of the respondents with average income >₦ 200,000 and had good glycaemic control were (36.8%) in contrast, (63.2%) were the respondents with the same sources of income and had poor glycaemic control. At the level of bivariate analysis, this study, along with other studies by Ibrahim and colleagues and Osuji et al. both in Nigeria,[26,28] showed a relationship between the study respondents' average income and their glycaemic control was not statistically significant. Contrary to this study by Emeka et al. in Nigeria,[31] where the relationship between study respondents' average income and glycaemic control was statistically significant. The difference in the association could be due to the different study populations, study design, sample sizes, and explored domains of medication adherence and lifestyle modification.

The study found that clinical characteristics such as clinical attendance and family history of diabetes were the only clinical parameters found to be significant. About one-fifths (27.0%) of the respondents with regular clinical attendance had good glycaemic control as against (73.0%) of respondents with regular clinical attendance had poor glycaemic control. Less than one-fifth of the respondents (2.6%) who were not regular with clinical attendance had good glycaemic control whereas more than one-third (97.4) of the respondents with non-regular clinical attendances have poor glycaemic control. This was slightly similar to a study conducted by Cedrick LM et. al.,[33] on prevalence and determinants of poor glycaemic control amongst patients with diabetes, where about (37.9%) of the respondent with regular clinical attendance have good glycaemic control and (7.3%) with regular clinical attendance have poor glycaemic control, whereas (62.1%) of the respondents with non-regular clinic attendance have good glycaemic control and (92.7%) with non-regular clinical attendance have poor glycaemic control even though the relation was not significant. The reason for these similarities might be that both studies use the same sample formula, (Fischer formula) and same study design (cross- sectional study).

About (19.5%) of the respondent with family history of diabetes had good glycaemic control and (80.5%) who have family history of diabetes had poor glycaemic control, contrary to this was the study carried out by Che M and colleagues[34] whereas (6.50%) who have family history of diabetes had good glycaemic control and (7.54%) with family history of diabetes had poor glycaemic control even though both studies were statistically significant, the later have p= <0.001. The difference between these two might be because the two studies were conducted from different geographical locations and the fact that Che M and colleagues used a much higher sample size (101,914), compared with the index study with sample size of 250. The study found that there was a statistically significant association between medication adherence (P=0.001), lifestyle modification (P=0.035) and glycaemic control among the study respondents, such that respondents who adhered to their medication and had healthy lifestyles had good glycaemic control than those with low medication adherence or unhealthy lifestyle. This was concurrent with studies by Eze et al.,[35] in Nigeria, and Sendekie et al. in Ethiopia,[22] This could be because the respondents may likely achieve control with good medication adherence. However, a study conducted by Pascal et al.,[10] yielded a contrasting result, possibly due to variations in sampling size and study design.

Furthermore, the effect of medication adherence on glycaemic control while controlling for lifestyle modification, family history of diabetes and clinical attendance was determined using a binary logistic regression; the logistic regression model was statistically significant (P=0.001), and the effect of lifestyle modification on glycaemic control while controlling for medication adherence, family history of diabetes and clinical attendance was not significant (p=0.52). In addition the effect of

clinical attendance on glycaemic control while controlling for medication adherence, lifestyle modification and family history of diabetes was significant (P=0.017). Furthermore, the effect of family history of diabetes on glycaemic control while controlling for medication adherence, lifestyle modification and clinical attendance was not significant (P=0.180). The independent predictor of good glycaemic control was medication adherence and clinical attendance. This study showed that respondents with low medication adherence were 83% less likely to have good glycaemic control than those with high medication adherence (AOR =0.17, 95%CI= 0.05-0.65). Conversely, the respondents with medium medication adherence are 70% less likely to have good glycaemic control than those with high medication adherence (AOR= 0.30, 95%CI= 0.15-0.59). In addition the respondents with no family history of diabetes were 57% more likely to have good glycaemic control than those with family history (AOR= 1.57, 95%CI= 0.811-3.065). Furthermore, the respondents with non-regular clinical attendance are 91% times less likely to have good glycaemic control than those with regular clinical attendance (AOR= 0.09, 95%CI= 0.011-0.645). This was concurrent with a study by Sendekie et al. in Ethiopia, [36] where respondents with a low level of medication adherence were 100% less likely to have good glycaemic control than those with higher medication adherence (AOR=0.003, 95% CI= 0.000-0.113). The respondents with unhealthy lifestyles were 46% less likely to have good glycaemic control than those with healthy lifestyles (AOR=0.54, 95%CI= 0.29-1.01). This study contradicts a study conducted by Che et al. in China,[34]where an unhealthy lifestyle was about 21% more likely to have good glycaemic control than a healthy lifestyle (AOR=1.21,95% CI=0.77-0.87). These results highlight the importance of maintaining a healthy lifestyle, regular clinic visits and adhering to medication regimens for optimal glycaemic control in diabetes management. Healthcare professionals should prioritize educating diabetes patients on the importance of medication adherence, lifestyle modifications and regular clinic visits for effective management of the condition

Conclusion

This study evaluated the effect of medication adherence and lifestyle modifications on glycaemic control among type 2 DM patients attending the General Outpatient Department of Usmanu Danfodiyo University Teaching Hospital, Sokoto State. This study revealed that most respondents had poor glycaemic control. The independent predictor of good glycaemic control in this study was medication adherence and clinical attendance. This study report will add to the body of knowledge and improved the glycaemic control among type 2 diabetes patients.

Recommendation

The following recommendations are made from the findings of this study:

Healthcare providers caring for diabetic patients should develop a protocol for diabetes lifestyle and adherence to medications as part of the overall care plan for diabetic patients. Furthermore, health care and other institutions should incorporate programmes that promote medication adherence, lifestyle modifications, and regular health talk sessions on diabetes management for their members, especially on recognised days like world diabetes day (every 14th of November).

The government should enact measures to lower the unemployment rate and the proportion of people lacking average education. Furthermore, interventional and other high-quality studies can be done to establish the causality of the independent predictors of glycaemic control.

Limitations

1. The study was a hospital-based cross-sectional study; it can only describe an association between the outcome and tested variables but cannot establish a causal relationship between them. However, the study could provide data for further research

2. The hospital-based study may not allow for a generalisation of the findings to the community

3. The Morisky medication adherence scale 8 (MMAS-8) used to collect data in this study might not allow comparison with similar studies where other instruments such as Brief Medication Questionnaire, Hill Bone compliance scale, Medication adherence questionnaire (MAQ), drugs attitude inventory questionnaire (DAI), Medication adherence rating scale (MARS), and adherence to refill and medications scale (ARMS), were used to classify medication adherence among T2DM patients. These different tools may give variations in medication adherence in the respective studies. Furthermore, the categorization of the lifestyle of the respondents in the index study may vary if methods for assessing lifestyles, such as health risk appraisal (HRA), lifestyle evaluation tools, healthy lifestyle and personal control questionnaire (HLPCQ), and lifestyle medicine assessment tool, are used instead of the simple lifestyle indicator questionnaire (SLQ).

4. Factors including haemoglobinopathies, iron or vitamin B12 deficiency-related anaemia can affect the level of glycated haemoglobin, which can lead to bias.

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Conflict of interest

There is no conflict of interest declared by the authors

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