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Application of Mobile Telephony to Improve Medication Adherence in Type 2 Diabetes Patients

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Abstract

Therapeutic failure, poor quality of life and high economic costs have been linked to poor adherence to medication in Type 2 diabetes (T2D) patients. This chapter aims to assess patients' glycemic control, knowledge of T2D and adherence to medications, and evaluate the impact of mobile telephone-based intervention on these indices. A one-year retrospective review of pharmacy refill records was followed by a 6-months' randomized controlled intervention conducted among 121 T2D patients in a secondary health care facility in Nigeria. Participants were assigned to control ($n = 60$) and intervention ($n = 61$) groups. The intervention comprised twice-weekly short message service (SMS) follow-up messaging to the intervention group alongside usual healthcare services. Control group received no SMS. Primary (HbA1c) and secondary (knowledge and adherence) outcome indicators were measured and compared pre- and post-intervention. The same copy of questionnaire was administered at baseline and post-intervention to both groups. Chi-square test was used to examine association of variables while two-sample t-test was conducted to compare mean pre- and post- intervention scores in both groups at $p<0.05$. The study revealed that intervention significantly improved glycemic control (HbA1c reduction) ($p = 0.01$). For the control group, mean pre- and post- intervention knowledge scores were 2.798 and 3.118 respectively ($t = 1.1368$, $p = 0.2705$) while intervention group recorded 2.714 and 4.193 respectively ($t = 5.6772$, $p<0.001$) on a 5-point Likert scale. Pre- and post- intervention adherence scores for control group were 3.804 and 4.013 respectively, ($t = 0.2343$, $p = 0.8182$) while intervention group had 3.430 and 6.859 respectively ($t = 6.3216$, $p>0.001$) on the 8-point Morisky Medication Adherence Scale (MMAS-8). The study concluded that patients initially had poor glycemic control, fair knowledge of T2D and low adherence to medications. SMS intervention significantly improved all three indices. Policy reforms in healthcare financing is recommended for sustainable provision of mhealth follow-up in diabetes care.

Keywords: *Type 2 diabetes; Medication adherence; mHealth; Health education; Follow-up.*

1.0. Introduction

Most adults with Type 2 diabetes are often given multiple medications to be used on a long-term basis. Many of these patients also live with other chronic non-communicable diseases such as hypertension and dyslipidemia. As a general rule, patients who take their medications strictly as directed by their health care providers (patients who exhibit high adherence) have been shown to achieve optimal treatment outcomes. Adherence here describes how much the patient correctly uses the medication, follows the diet, and executes lifestyle modifications in line with the recommendations of a health care provider (Asche *et al.*, 2011). Adherence also includes clinic attendance, self-directed physiotherapy exercises, correct use of medical appliances such as compression stockings, and chronic wound care, among others (Harande, 2011). Ensuring adherence to a medication plan is a responsibility that goes beyond patient compliance with physician's orders. It requires a positive and dynamic relationship among the physician, pharmacist, patient, and even care givers (Mouhtadi *et al.*, 2018). In diabetes management, health literacy has been shown to play an important role in patients' adherence to medication therapy regimes (Marciano *et al.*, 2019). Health literacy here may be defined as "the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions" (Caruso *et al.*, 2018). While health education improves health literacy, there is insufficient data on the level of knowledge of diabetes and its management among adults with type 2 diabetes in Nigeria and how this impacts treatment outcomes.

Patient evidence shows that adherence to antidiabetic medication is associated with reduced mortality (Hong & Kang, 2011), reduced overall cost of healthcare (Hansen *et al.*, 2010), reduced odds of hospitalization (Juarez *et al.*, 2013), and better control of risk factors (Fasamade & Dagogo-Jack, 2016). The World Health Organisation (WHO) says that an estimated half of individuals with chronic diseases for whom treatment regimens are prescribed do not follow the regimen or treatment schedule as directed, and that this contributes significantly to the human and economic burden of these diseases particularly in asthma, diabetes and hypertension (WHO, 2003). Some authors argue that adherence rates are over-estimated in medical literature as most of the analysis are based on data from typical clinical settings. In many developing health systems, including Nigeria, real life management of medication therapies for type-2 diabetes involves ambulatory, out-patient scenarios including community-based pharmacy settings (Kirkman *et al.*, 2015). Though scanty at the moment, out-patient adherence data remain critical in the planning and implementation of diabetes management plans in such environments.

Antidiabetic medications and patients' adherence to these drug therapies remain central to the quest to achieve effective glycemic control. All other interventions, at best, are complementary (Strom-Williams *et al.*, 2014). It is therefore understood why the various direct and indirect measures of medicines use adherence continue to command the on-going interest to health care professionals and researchers. The most common indirect measures include self-reports (using questionnaires and interviews), electronic drug monitoring (EDM), pill counts, and pharmacy refill methods, while the direct measures include detection of drugs or drug metabolites in the plasma and the directly observed therapy (Walker, 2013; Strom-Williams *et al.*, 2014). In practice, most researchers combine multiple methods in order to obtain a composite measure of medication adherence. Similarly, several interventions have been developed to improve medication adherence. These include measures aimed at reducing pill burden (such as using formulations with fixed-dose combinations and longer dosing intervals), using molecules with fewer adverse drug reactions (such as weight gain and hypoglycemia), health education and skills training interventions, and using mobile computing and communication technologies (M-Health) among others (Garcia-Perez, 2013).

Mobile health interventions come in various shapes but all depend on wireless digital telecommunication networks. In diabetes care, mobile health interventions are applicable in managing various health service programmes involving multidisciplinary teams working from far-flung locations. Examples include the use of mobile phones for short message services (SMS), voice calls and in social media messaging within closed-user groups (CUGs) to deliver health education, train on relevant self-care skills, drive behavioral changes, send dosing reminders, and facilitate real-time patient-provider communication, among others (Free *et al.*, 2010). mHealth interventions hold important promises to radically improve access to quality health care services in general and patient adherence to antidiabetic medications in particular seem greatest among developing health systems. In Nigeria, for an instance, recent reports revealed that the information and communications technology (ICT) sector (including mobile telephony) retained its position as the fastest-growing sector in the economy contributing 14.9% and 17.9% respectively to the nation's gross domestic product (GDP) in the first and second quarters of 2021 (National Bureau of Statistics, 2021). While mobile telephony has been studied as a tool to drive behavioural change for disease prevention and management in several developed (Ni *et al*., 2018), and developing health systems (Islam *et al.*, 2014), there is paucity of information regarding the Nigeria health system in this regard.

The technology acceptance model (TAM) appears the most appropriate among the various theoretical frameworks to guide the adoption of mobile phone – based follow up services for chronically-ill patients (Davis, 1989). TAM has enormous capacity to calibrate the level of fit between user tasks (service task) and technology (tool), and accurately predict possible use, individual decision to adopt a particular behavior and adopt a new technology. According to the Technology Acceptance Model, health care providers will embrace a new technology depending on how much they perceive it as useful to their tasks and how much they perceive it as easy to use. For this study, focus was on assessment of the level of glycemic control, knowledge of diabetes, and levels of adherence to diabetes medications. In addition, there was an evaluation of impact of an mHealth intervention on knowledge, adherence and glycemic control among type 2 diabetes patients in a secondary health care facility in Nigeria.

2.0 Methods

2.1 Study Design

The study was an experimental intervention study, structured into three stages. The first stage was a one-year retrospective review of medication charts and prescription refill records to establish a baseline adherence measurement as well as average monthly rate of new cases. The usual practice at the health centre involves scheduling follow up appointments once per month for every patient. Each patient is expected to make 12 clinic visits per year. For this study, pharmacy refill data (clinic attendance) were used as a surrogate measure for medication adherence as this has been shown to be a reliable method in similar studies elsewhere (Sangeda *et al.*, 2014). Patients who attended 11-12 such appointments were categorized as "high adherence", those who attended 9-10 appointments were categorized as "moderate adherence" while those who had below 9 attendances were categorized as "low adherence"

The second stage of the study was a cross sectional survey conducted using a structured questionnaire on all patients who were currently receiving diabetes care as outpatients of the medical center. The focus of the survey was to examine levels of knowledge of diabetes and self-reported adherence to medication and also assess patients' willingness to participate in a mobile telephone-based intervention.

In the third stage, consenting patients were randomly assigned to two equal groups, in which one group (control group) received the usual healthcare services while the intervention group received a mobile telephone-based short message service (SMS) intervention in addition to the regular care services. This prospective intervention lasted for a period of six months (25 weeks) after which outcome measures were assessed and compared between the two groups. Absolute reduction in HbA1C measurement was the primary outcome measure while changes in participants' scores on knowledge, self-reported adherence, and clinic attendance between Week 1 (baseline) and Week 25 (6 months) were adopted as the secondary outcome measures.

2.2 Study Context and Population

The study was conducted at the Medical and Health Center, Obafemi Awolowo University Ile-Ife Nigeria, a secondary healthcare facility that caters to the healthcare needs of members of the University community.

All patients diagnosed with type 2 diabetes at the Medical and Health Center were considered eligible to be included in the study subject to the inclusion and exclusion criteria.

2.3 Inclusion and Exclusion Criteria

The inclusion criteria consist of adults 18 years and above, diagnosed with Type 2 diabetes (based on WHO criteria) at the Obafemi Awolowo University Medical and Health Center, enrolled in the diabetes care programme, placed on medication therapy, willing to attend monthly clinic appointments for the next 6 months, using a mobile phone, and who have given a written informed consent to participate in the study. Patients below 18 years; diagnosed with other forms of diabetes (Type 1, gestational); enrolled in Type 2 diabetes care at other times beside the study period; with serious complications or comorbidities requiring hospitalization; without mobile phones; or otherwise failed to give written informed consent to participate were excluded from the study.

2.4 Sampling

For the baseline study, medication charts and prescription refill records of all cases (N = 510) diagnosed from January to December 2018, involving the prescription of one or more antidiabetic medications were retrospectively reviewed. Note was taken of comorbidities with hypertension and/or dyslipidemia. For the intervention phase, all patients on diabetes care were selected. A census review of all cases diagnosed between January and December, 2018 was conducted as well as a census survey of all patients (n = 133) enrolled in diabetes care as at study period (month of January, 2019).

A randomization software was then used to assign patients to either the control group (60 patients) or treatment group (61 patients).

2.5 Research Instruments

2.5.1. Development and validation of questionnaire

Sources of data for the study were the patient medical records and a structured questionnaire for patients. The questionnaire comprised three sections. Section 1 sought information on relevant demographic characteristics including age, sex, level of education and employment/income status, ownership/use of mobile phone. Section 2 comprised 10 items that explored patients' knowledge of nature, diagnosis, risk factors, prevention, and complications of diabetes. These items were drawn from detailed literature review. Levels of knowledge were measured on a 5-point Likert scale ranging from 1 – strongly disagree, 2 – disagree, 3 – cannot say, 4 – agree, to 5 – strongly agree

Section 3 contained 8 items that assessed patients' self-reported levels of adherence to their medications. This section was adapted from a standard instrument (Dias de Oliviera-Filho *et al.*, 2014), namely the 8-item Morisky Medication Adherence Scale (MMAS-8). This structured, self-reporting instrument comprises 7 items designed to elicit a "yes" or "no" response and an 8th item designed on a 5-point Likert scale. For this study, the wording of items 4 and 5 were reversed to avoid a "yes-saying" bias (giving the same response to a series of questions irrespective of their content). For items 1, 2, 3, 6, and 7, every "no" response was scored "1" and every "yes" response was scored "0". For items 4 and 5, every "no" response was scored "0" while every "yes" response was scored "1". For item 8 the scores (0-4) on the 5-point Likert scale were standardized by dividing each by 4 to generate a summary value. Hence the responses were scored as follows: "Never/Rarely" (1), "Once in a while" (0.75), "Sometimes" (0.5), "Usually" (0.25), and "All the time" (0). Total scores on the MMAS-8 range from 0-8. A score of 8 was categorized as "high adherence", 6 – 7 as "moderate adherence", while <6 was categorized as "low adherence". Permission to use the instrument was obtained from Donald E. Morisky, the copyright holder.

A draft of the questionnaire was reviewed by two senior faculty members who had expertise in diabetics care, one from the Department of Clinical Pharmacy and Pharmacy Administration, a second from the Department of Internal Medicine, Obafemi Awolowo University, Ile-Ife. Their expert scrutiny and comments were used to ensure correctness and validity of the instruments. Moreover, the questionnaire was subjected to the test-retest validation technique using 8 patients who were not part of the study. The Cronbach's alpha coefficient of Sections 2 and 3 of the questionnaire was computed to be α = .82 and .86 respectively, showing high internal consistency. It was observed that it took an average of 11 minutes for patients to fill the questionnaires.

2.5.2. Development and validation of SMS messages

For the intervention component of the study, short messaging service (SMS) messages were developed. A total of 30 messages were developed by the researchers based on the principles of the health beliefs model (Erdoğan & Araman, 2017). These health education messages were subjected to expert scrutiny by the same experts that reviewed the draft questionnaires.

Some examples of these messages include;

(a) Diabetes is a disease resulting from a defect in how the body handles glucose, but it can easily be controlled
(b) Please remember to take your medicines as prescribed by the physician
(c) Not taking your medicines as prescribed may worsen the disease; if in doubt please call the pharmacist on the numbers provided
(d) Regular exercises are important to help you regulate your blood glucose to normal levels
(e) A planned healthy diet is important to keep you healthy and avoid complications
(f) Remember to check your blood pressure and record the readings
(g) Medicines, healthy diet and exercise all work together to help you live happy and healthy

2.6 Data Collection and Analysis

2.6.1 Data collection

Two research assistants were recruited and trained for one day on data collection. The research assistants collated all patient files (physical) containing information of interest (prescriptions of antidiabetic medications and opened within the period from January to December, 2018). The researchers extracted and reviewed relevant information from these patient files. The entire document review process took one week. For the next 5 weeks, the research assistants were present in the hospital to identify eligible patients (every diabetes patient who came for clinic appointment, including newly diagnosed cases) and administer the questionnaire to them. Baseline HbA1C measurements were recorded for every newly diagnosed patient. A randomization exercise was carried out at the end of January 2019 among selected patients to assign them to one of the two study groups. For the next 6 months (February – July 2019) patients (n = 60) in the control group received no SMS, while those (n = 61) in the intervention group received two SMS per week. A randomization software was used to select one SMS for each patient per day. HbA1C measurements for all study participants were taken at their July 2019 clinic visit while the same questionnaires previously administered in January 2019 were repeated. Patients' drug refill records for the past 6 months were reviewed.

2.6.2 Data analysis

Descriptive statistics including frequency and percentages were used to analyse demographic and clinic attendance data of patients. Weighted mean scores were computed for respondents' knowledge of diabetes and their self- reported adherence on the Morisky scale. Two-sample t-test were conducted to compare mean pre- and post- intervention scores of patients in the control and intervention groups. Chi square test was conducted to examine association of demographic variables with adherence scores. Significance was fixed at $p < .05$. The IBM SPSS Statistics for Windows version 21 was used for data analysis.

3.0. Results

Out of 133 patients approached for questionnaire administration, 121 (91%) consented and filled the questionnaire. Table 1 presents the outcome of the document review exercise. Demographic characteristics of patients (n = 510) are presented in relation to their levels of adherence measured by the pharmacy refill method. Table 2 presents demographic data of participants (n = 121) in the prospective intervention. Table 3 shows knowledge scores of both control and intervention groups pre- and post-intervention while Table 4 contains data on self-rated medication adherence scores of the two groups pre- and post-intervention.

Post-intervention review of pharmacy refill records for the 6 months of the study revealed that in the control group, 31(51.7%) patients attended all 6 scheduled appointments (high adherence), 19 (31.7%) attended 5 times (moderate adherence); while 10 (16.7%) attended 4 times or less (low adherence). In the intervention group, 49 (80.3%) attended all 6 scheduled appointments (high adherence), 9 (14.8%) attended 5 times (moderate adherence), while 3 (4.9%) attended 4 times or less (low adherence).

HbA1c measurements for the control group at baseline showed that 29 (48.3%) had between 7.1-8.0%, 18 (30%) had 8.1- 9.0%, while 13 (21.7%) had 9.1-10.0%. The post intervention measurements for this group were 33 (55%) had 7.1- 8.0%, 18 (30%) had 8.1- 9.0%, while 9 (15%) had 9.1- 10.0%. The difference between the pre- and post-intervention readings was not statistically significant (p = 0.208). However, in the intervention group, the HbA1c measurements at baseline were as follows: 32 (52.5%) had 7.1-8.0%, 22 (36.1%) had 8.1-9.0%, while 7 (11.5%) had 9.1-10.0%. The post-intervention measurements of this group were 7 (11.5%) had 6.5- 7.0%, 35 (57.4%) had 7.1-8.0%, 18 (29.5%) had 8.1-9.0%, while 1 (1.6%) had 9.1-10.0%. The difference between the pre- and post-intervention measurements for this group was statistically significant (p= 0.01).

Pre- and Post- Intervention Knowledge Scores of Participants

From Table 3: For the Control group,
Week 1 – Pre-intervention – (Mean = 2.798, SD = .632)
Week 25 – Post- intervention – (Mean = 3.118, SD = .561)
Two-sample t-test (Comparison of means)
Ho (Null hypothesis): μA = μB
Ha (Alternative hypo): μA ≠ μB
mA = 2.798, mB = 3.118 df = 18
to = 1.136774, p = 0.270540 NS (2 tails)
→Ho was not rejected.

For the Intervention Group, Week 1- Pre-intervention - (Mean = 2.714, SD = .757)
Week 25 –Post-intervention - (Mean = 4.193, SD = .196)
Two-sample t-test (Comparison of means)
Ho (Null hypothesis): μA = μB
Ha (Alternative hypothesis): μA ≠ μB
mA = 2.714, mB = 4.193 df = 18
to = 5.677159, p = 0.000022 (2-tailed)
→ Ho was rejected. ==> Ha

Pre- and Post- intervention Adherence Scores

From Table 4, For the Control Group,
Week 1- Pre- intervention - (Mean = 3.804, SD = 1.574)
Week 25- Post – intervention - (Mean = 4.013, SD =1.755)

Table 1: Document Review Data on Adherence Status by Demographic Characteristics of Patients (N = 510)

Demographic Variable	High Adherence	Moderate Adherence	Low Adherence	Total
Total Patient population n (%)	362 (71.0)	102 (20.0)	46 (9.0)	510 (100)
Sex				
Male, n (%)	192 (53.1)	63 (61.6)	20 (43.5)	278 (54.5)
Female, n (%)	170 (46.9)	39 (38.4)	26 (56.5)	232 (45.5)
Age Group (Years), n (%)				
18-30	3 (0.8)	2 (2.0)	1 (2.2)	5 (1.0)
31-50	101 (27.9)	36 (35.3)	14 (30.4)	153 (30.0)
51-70	254 (70.2)	47 (46.1)	28 (60.9)	329 (64.5)
>70	4 (1.1)	17 (16.7)	3 (6.5)	23 (4.5)
Highest Level of Education n				
(%)	92 (25.4)	41 (39.8)	22 (47.8)	154 (30.2)
Ordinary Level or less	74 (20.5)	29 (28.7)	11 (23.9)	115 (22.6)
Diploma	129 (35.6)	18 (17.6)	8 (17.4)	155 (30.4)
Bachelor's degree	67 (18.4)	14 (14.0)	5 (10.9)	86 (16.8)
Higher Degrees				
Employment/Income Status n				
(%)	157 (43.5)	72 (70.6)	32 (69.6)	261 (51.1)
Unemployed/Self-Employed	118 (32.5)	13 (12.7)	7 (15.2)	137 (26.9)
Junior Staff	62 (17.0)	11 (10.8)	4 (8.7)	76 (14.9)
Middle Level Staff	25 (7.0)	6 (5.9)	3 (6.5)	36 (7.0)
Top-Level / Senior Staff				
Co-morbidities n (%)				
None	272 (75.2)	54 (52.7)	6 (13.0)	333 (65.2)
Hypertension only	40 (11.1)	22 (21.1)	13 (28.3)	75 (14.7)
Dyslipidemia only	21 (5.8)	11 (11.1)	6 (13.0)	38 (7.5)
Hypertension and Dyslipidemia	29 (7.9)	15 (15.1)	21 (45.7)	64 (12.6)
Enrollee in NHIS? N (%)				
Yes	84 (23.2)	14 (13.6)	7 (15.2)	105 (20.5)
No	278 (76.8)	88 (86.4)	39 (84.8)	405 (79.5)

Abbreviation: NHIS – National Health Insurance Scheme.

Two- sample t-test (Comparison of means)
Ho (Null hypothesis): $\mu A = \mu B$
Ha (Alternative hypothesis): $\mu A \neq \mu B$
mA = 3.80375, mB = 4.0125 df = 14
to = 0.23426887, p = 0.818163 NS (2 tails)
→ Ho was not rejected.

For the Intervention Group, Week 1 – Pre-intervention - (Mean = 3.43, SD = 1.124)
Week 25- Post-intervention - (Mean = 6.859, SD = 0.893)

Two-sample t-test (Comparison of means)
Ho (Null hypothesis): $\mu A = \mu B$
Ha (Alternative hypothesis): $\mu A \neq \mu B$
mA = 3.43, mB = 6.85875 df = 14
to = 6.321631, p = 0.000019 (2-tailed)
→ Ho was rejected. ==> Ha

Table 2: Demographic Characteristics of Participants in the Intervention Study (n = 121)

Demographic Variable	Frequency (%)
Sex	
Male	52 (43.0)
Female	69 (57.0)
Age Group (Years)	
18-30	1 (0.8)
31-50	30 (24.8)
51-70	62 (51.2)
>70	28 (23.1)
Highest Level of Education	
Ordinary Level or less	22 (18.2)
Diploma	31 (25.6)
Bachelor's degree	50 (41.3)
Higher Degrees	18 (14.9)
Employment/Income Status	
Unemployed/Self-Employed	60 (49.6)
Junior Staff	39 (32.2)
Middle Level Staff	13 (10.7)
Top-Level / Senior Staff	9 (7.4)
Co-morbidities	
None	70 (57.9)
Hypertension only	25 (20.7)
Dyslipidemia only	15 (12.4)
Hypertension and Dyslipidemia	11 (9.1)
Enrollee in NHIS?	
Yes	31 (25.6)
No	90 (74.4)

Association of Demographic Variables with Adherence

The chi square test revealed the following levels of association

Sex and adherence ($\chi2 = 13.625$, $p = .001$); Age and adherence ($\chi2 = 146.404$, $p < .001$); Education and adherence ($\chi2 = 74.327$, $p < .001$);

Employment status and adherence ($\chi2 = 88.323$, $p < .001$); NHIS enrolment and adherence ($\chi2 = 13.963$, $p < .001$); and

Co-morbidities and adherence ($\chi2 = 273.91$, $p <.001$)

4.0. Discussion

This study recruited all the subjects who were diagnosed of same condition (type 2 diabetes), enrolled in the care plan (diabetes care programme) and were receiving care at the same health care facility (University Medical and Health Centre, Obafemi Awolowo University, Ile-Ife). This was done to minimize the possibility of selection bias. The questionnaire used for data collection showed high reliability while the 91% response rate by patients suggests that they perceived participation in the study as beneficial to their treatment outcomes. The outpatient model was considered appropriate for the study because, like other chronic non communicable diseases, diabetes impacts the everyday lives of patients in their ambulatory states and interventions to reduce these impacts should therefore be tailored to fit the everyday life ecosystems of patients.

Table 3: Pre- and Post- Intervention Levels of Knowledge of Diabetes among Patients (N = 121)

S/N	Item	Control Group (n = 60)				Intervention Group (n = 61)			
		Week 1	Week 25	t	*p-value*	Week 1	Week 25	t	*p-value*
1	Diabetes is a disease arising from problem with how the body handles glucose	3.90	4.20	**1.1368**	**0.2705**	3.76	4.31	**5.6772**	**< 0.001**
2	Once diagnosed of diabetes, an individual will live with it all through life	3.31	3.74			2.48	3.98		
3	If one of your parents had type 2 diabetes, you have a high risk of having it too	2.41	3.33			3.03	4.47		
4	If you are obese or overweight, your chances of having diabetes are higher	2.93	3.02			2.89	4.46		
5	Exercising for 30 minutes for 5 days per week can lower your chances of developing diabetes	2.45	2.33			1.97	4.40		
6	Measurement of fasting plasma glucose can be used to diagnose diabetes	2.78	3.12			2.51	3.98		
7	Measuring plasma glucose 2 hours after a standard glucose meal can be used to diagnose diabetes	1.38	2.17			1.23	4.01		
8	If untreated, diabetes can lead to glaucoma and cataract in the eye	2.65	3.04			2.78	4.11		
9	If untreated, diabetes can cause feet wounds to become difficult to treat	3.20	3.07			3.98	4.23		
10	People with diabetes and hypertension stand a greater risk of complications	2.97	3.16			2.51	3.98		
	Mean	**2.798**	**3.118**			**2.714**	**4.193**		

Table 4: Pre- and Post- Intervention Performance of Patients on the Morisky Medication Adherence Scale (MMAS-8) (N = 121)

S/N	Item	Control Group (n = 60)				Intervention Group (n = 61)			
		Week 1	Week 25	t	*p-value*	Week 1	Week 25	t	*p-value*
1	Do you sometimes forget to take your medications?	1.79	2.33	**0.2343**	**0.8182**	2.36	6.98	**6.3216**	**< 0.001**
2	People sometimes miss taking their medications for reasons other than forgetting. Over the past 2 weeks, were there any days when you did not take your medication?	3.63	2.05			2.78	4.69		
3	Have you ever cut back or stopped taking your medication without telling your doctor because you felt worse when you took it?	3.05	4.65			3.41	7.21		
4	When you travel or leave home, do you always remember to bring your medication?	3.08	3.76			3.18	6.67		
5	Did you fail to take any of your medication yesterday?	3.25	2.98			2.95	7.65		
6	When you feel like your symptoms are under control, do you sometimes stop taking your medication?	2.95	3.45			2.65	7.12		
7.	Taking medication every day is a real inconvenience for some people. Do you ever feel hassled about sticking to your treatment plan?	5.73	4.97			3.97	6.80		
8.	How often do you have difficulty remembering to take all your medication?	6.95	7.91			6.14	7.75		
	Mean	**3.804**	**4.013**			**3.430**	**6.859**		

Data from the US Centers for Disease Control show that more American men are likely to be diagnosed of type 2 diabetes than women. This claim was supported by other Nigeria surveys (Ekpenyong *et al*., 2011; Uloko *et al*., 2018). In this study however, both the one-year document review (54% men: 46% women) and the census sampling of current patients on diabetes therapy (43% males: 57% females) failed to establish any significant difference in prevalence of type 2 diabetes between the sexes. The results clearly indicate that adherence is significantly influenced by various demographic characteristics of individuals including sex, age, education, income, employment, health financing mechanisms and co-morbidities. These findings are in line with expectations from extant literature regarding health literacy (Walker *et al*., 2013; Caruso *et al*., 2018; Marciano *et al*., 2019), age and sex (Boruett *et al*., 2013), and economic variables (Juarez *et al*., 2013; Kirkman *et al*., 2015). For optimal therapeutic outcomes, there is therefore the need for individualized therapies offered in culturally sensitive frameworks while health education must be sensitive to individual differences. While facility-level interventions have been shown to improve adherence in other chronic disease states (Boruett *et al*., 2016), interventions in type 2 diabetes must be designed to accompany patients in ambulatory care models if desired outcomes are to be achieved.

In this study, health insurance enrolment of 21% and 26% were found in the one-year retrospective review and one month enrolment data used for the prospective intervention respectively. These figures stand way above the national average and may be explained by the fact that the study setting was a tertiary health care facility where most public servants access care. Recent reports have put the overall prevalence rate for diabetes in Nigeria at 5.77% (95%, Cl 4.3-7.1) (Uloko *et al.*, 2018). With the United Nation's estimated population size of 206, 139,589, it means that 11.8m or 1 out of every 17 Nigerians has diabetes. Most of those on medication therapies pay out-of-pocket as the national health insurance penetration stands below 7% and mainly restricted to federal public servants. This study revealed that health care financing mechanisms played important roles in determining patient adherence to medications. Out of 286 patients who were enrolees in the National Health Insurance Scheme (NHIS), 229 (80%) showed high adherence to their medications. As seen in a cohort study in the United States (Hansen *et al*., 2010), economic aspects of managing medication therapies require system-wide reforms in order to improve access to, and outcomes of medication therapies in chronic disease states such as diabetes. There is therefore the need for policy reforms to expand health insurance coverage in developing as well as developed health systems

From the baseline scores, it can be seen that the patients generally had fair knowledge of diabetes and its sequelae as shown by the mean knowledge scores of both control (M = 2.798) and intervention (M = 2.714) groups on a scale of 1 to 5. The finding in the control group that improvement in knowledge scores post- intervention - (Mean = 3.118, SD = .561) compared to pre-intervention - (Mean = 2.798, SD = .632), was not statistically significant (t = 1.137, p = 0.2705) means that people will continue to perceive health services and their roles in managing their medication therapies in the same old ways unless they are exposed to new ideas about their conditions. This position is affirmed by data from intervention group whose knowledge scores post-intervention - (Mean = 4.193, SD = .196) compared to pre-intervention - (Mean = 2.714, SD = .757) showed significant improvement (t = 5.6772, $p < 0.001$). This is consistent with findings from an Indian study in which two follow-up communications at two monthly intervals resulted in increase of knowledge scores from 3.86 ± 0.93 to 10.28 ± 1.78 ($P = 0.004$) (Chawla *et al.*, 2019). There is therefore a clear nexus between patients' level of knowledge of the disease condition and its management, their adherence to medication regimens, and treatment outcomes (Hansen *et al.*, 2010; Hong & Kang, 2011; Juarez *et al.*, 2013; Marciano *et al.*, 2019). Health service reforms in the management of diabetes must exploit this nexus in order to improve value for assets employed and the overall cost effectiveness of interventions. The content and mode of delivery of health education in diabetes management must be built on the baseline health literacy of patients and must address gaps in knowledge, attitudes and practices necessary to empower individuals to play more meaningful roles in their therapies (Chawla *et al.*, 2019).

From the pharmacy refill records, a significantly higher proportion 49 (81.7%) of patients in the intervention group achieved high adherence compared to 31 (51.7%) in the control group. In addition, only 2 (3.3%) in the intervention group recorded poor adherence compared with 10 (16.7%) in similar category in the control group. This finding re-enforces the claim that mobile phone-based follow up strategies were successful in improving treatment outcomes in chronic disease states in general (Ni *et al.,* 2018) and in diabetes in particular (Chawla *et al.*, 2019).

The outcome measures chosen for the study were a combination of an objective laboratory index (HbA1c) and self- reported measures (MMAS-8 and knowledge scores) which have significant subjective components. The composite effect of these measures gives strength to the findings. In view of the primary outcome measure (HbA1c) this study adopted ≥ 6.5% (48mmol/mol) as diagnostic cut-off point and 7% (53mmol/mol) as target of glycemic control in line with the recommendation of the International Diabetes Federation (IDF, 2019). The finding that 6 (10%) patients in the intervention group achieved the set target for glycemic control affirms that the mHealth intervention was effective. Moreover, unlike the control group, the overall reduction in HbA1c levels in the intervention group was statistically significant ($p = 0.01$). This finding reflects similar outcomes in China (Ni *et al.,* 2018) and Bangladesh (Islam *et al.*, 2014).

MMAS-8 scores across control and intervention groups both at baseline and post-intervention reveal that the most common cause of non-adherence was forgetfulness. Patients wilfully stopping their medications when symptoms seem under control was another important contributor to non-adherence in the control group but this was clearly reversed by the health education messaging as shown in the exit data in the intervention group. Disruptive innovations in mHealth and telepharmacy, including dosing reminders are required to address the problem of forgetfulness. Targeted health education on the disease, medications, diet, exercise and related lifestyle modifications will improve the health literacy of patients thereby reducing the tendency to stop medications when symptoms seem under control. These follow up services can be conveniently offered via mobile telephones. With rapid growths in teledensity, more patients can gain access to the benefits of these follow up efforts particularly in resource constrained settings. However, expected improvements in adherence and treatment outcomes must be balanced against possible rise in overall cost of treatment due to additional cost of follow up interventions. Unlike the health systems of Finland, Canada, Australia, United States, among others where "cognitive pharmacy services (CPS)" and other "patient-based services" including follow-up are reimbursed from a federally funded pool (Houle *et al.*, 2014; Lavikainen *et al.*, 2020), the Nigeria scenario has no such reward system and health care financing reforms are needed in this regard.

Additional research is recommended to develop a framework to guide the provision of mobile telephone- based health education and follow up services in a sustainable manner to deliver optimum benefits to patients while minimizing downstream effects. Moreover, given the wide latitude for abuse in the information highway, research is required to develop ethical guidelines to protect both health care providers and patients.

5.0. Conclusion

Most diabetics in Nigeria have a fair knowledge of the disease condition, the risk factors, medications and complications. They generally exhibit low adherence to medications mainly due to forgetfulness and uninformed self-help. Mobile phone-based follow up and health education intervention significantly improved patients' glycemic control, knowledge of T2D, and adherence to medications. Policy reforms in health care financing are recommended to provide reimbursements for follow up services in the management of chronic disease states, including diabetes.

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