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Impact of Pharmacist-Led Pharmaceutical Care Intervention on Clinical Outcomes of Type 2 Diabetes Mellitus Management: A Case Study of a Tertiary Hospital in Keffi, Nigeria

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ABSTRACT

The primary aim of this study was to evaluate the impact of pharmaceutical care intervention on clinical parameters as health outcomes in patients with type 2 diabetes in a tertiary hospital in Keffi. **Methods:** A randomized controlled study was conducted on 240 patients with type 2 diabetes accessing care in the diabetes clinic and general out-patient clinic of FMC Keffi. Patients were randomized into control and intervention groups. Participants in the intervention group received pharmaceutical care intervention administered through a non-pharmacological approach, from clinical pharmacists while the control group patients received normal care without any special training from the clinical pharmacists. FBS, HbA1c, HDL, LDL, TCh, TGl, SrCr, SBP, DBP, and BMI were assessed at baseline, 3rd month, 6th month, and 12th month and compared, with FBS, HbA1c, TCh, SBP and DBP as primary endpoints. **Results:** After a follow-up of twelve months, statistically, significant changes were achieved in all the clinical outcomes in the intervention group, without any of such changes in the control group. Based on the primary endpoints of the study (FBS, HbA1c, TCh, SBP, and DBP), good glycemic, lipid, and BP controls were achieved. **Conclusion:** The study has demonstrated and proved the effectiveness of pharmacist-led pharmaceutical care intervention in improving glycemic, lipid and BP controls with the resultant effect of reducing risks of microvascular and macrovascular complications in patients with Type 2 diabetes mellitus. As such, appropriate policies and guidelines should be advocated to make clinical pharmacists an integral part of medication therapy in diabetes mellitus and other chronic diseases.

INTRODUCTION

As early as 1500 BC, Egyptian physicians described a disease associated with the "passage of much urine". This was later, in 1674, identified to be Diabetes mellitus by a Greek physician named Willis. Diabetes mellitus (DM) is now defined as a group of metabolic disorders, largely characterized by hyperglycemia resulting from impaired insulin secretion with or without insulin resistance. This impaired insulin secretion can either be absolute or relative. The absolute impairment leads to type 1 diabetes mellitus (T1DM) while the relative impairment results in type 2 diabetes mellitus (T2DM). The impaired insulin secretion will lead to the inability of tissues to carry out routine metabolic functions on CHO, Fats, and Proteins. In other words, diabetes is a progressive, chronic metabolic disease characterized by hyperglycemia.[1]

Chronic hyperglycemia causes damage to the blood vessels and nerves. Damage to the large blood vessels affects the brain, heart, and lower limbs and this can lead to stroke, heart attack, and blockage of blood flow to the extremities particularly the leg. This is what is referred to as the macrovascular complication of diabetes mellitus (DM). On the other hand, damage to the small blood vessels affects the eyes, teeth/gums, kidneys, and nerves, while damage to the nerves affects the digestive system, sexual organs, and feet. This is referred to as the microvascular complication. By implication, this chronic hyperglycemia associated with diabetes can cause multi-organ damage resulting in ophthalmic, renal, neurologic, cardiovascular, and other significant complications. [2]

DM is considered to be a disease of clinical and public health significance, as it adversely affects personal health, health-related quality of life, and life expectancy and has significant implications on the health care system.

Globally, DM affected 463 million people in 2019 within the age range of 20-79 years[8] and 19 million are in Africa. [3] In Nigeria, the overall pooled prevalence of DM was 5.77% [4].

Diabetes mellitus may present with some characteristic symptoms such as polyuria, polyphagia, polydipsia, blurring of vision, and weight loss. In its most severe forms, ketoacidosis, or ketotic hyperosmolar state may develop and leads to stupor, coma, and in the absence of effective treatment, death.

The Diabetic Prevention Program (DPP), a major randomized clinical study has shown the prevention of delayed-type 2 diabetes in those with prediabetes through lifestyle changes of

diet control, regular exercise, and weight reduction. [5] The Diabetes Control and Complication Trial (DCCT), one of the largest studies of diabetes treatment ever undertaken showed that keeping blood glucose levels as close to normal as possible is extremely effective at reducing the complications of diabetes.[6]

DM is classified on the basis of its etiology, but by far the common types are Type 1 and Type 2 diabetes mellitus. In Type 1, the cause is the absolute deficiency of insulin secretion which is related to autoimmune destruction of β-cells of the pancreas mediated by T-cells. This Type 1, formerly called insulin-dependent diabetes mellitus (IDDM) or Juvenile onset diabetes mellitus is further subdivided into Type 1A and Type 1B which is idiopathic. [7] In Type 2 diabetes mellitus (T2DM), formally known as Non-Insulin Dependent Diabetes Mellitus (NIDDM) or Adult-onset diabetes mellitus, the cause is mainly a combination of insulin resistance and/or inadequate compensatory insulin secretory response. It is the much more prevalent form of DM.

In addition to a health burden, diabetes-related health expenditures incur heavy costs on individuals, health systems, and governments. The global health expenditure on diabetes was expected to total at least 376 billion USD in 2010 and 490 billion USD in 2030.[8]

Statement of the Problem

Diabetes is a global health problem with an increasing prevalence because, at the moment, one in ten adults have diabetes, one in three have prediabetes and even a greater number of people remained undiagnosed or are at the pre-diabetic stage. [9] Just as DM patients have a 2-4 times higher risk of developing coronary heart disease (CHD) and stroke than normal subjects[25] (Dal Canto et al., 2019), so also they have an increased risk of stroke and stroke-related dementia. [10] The myriad of complications associated with DM makes the patients have a 50% higher risk of death from any cause than adults without diabetes. [11] The nerve damage due to hyperglycemia causes autonomic neuropathy in DM patients, and this accounts for a high rate of erectile dysfunction in men [12] and also accounts for about 80% of amputations. [13]

Justification for the Study

Failure to adhere to therapy increases the risk of developing macrovascular complications such as coronary heart disease (CHD), stroke, and peripheral vascular disease. This coupled with the economic burden calls for concerted effort in an intensive intervention program to

reduce DM morbidity and monitor its progression with measurable outcomes. Such intervention is associated with reduced mortality, morbidity, and increased health-related quality of life (HRQoL)[14].

The study aims to evaluate the impact of pharmaceutical care intervention (PCI) on clinical parameters as health outcomes in patients with type 2 diabetes mellitus.

MATERIALS AND METHODS

Study setting

Patients were recruited from the endocrinology and outpatient clinics of Federal Medical Centre, (FMC) Keffi which is a Tertiary Health Institution with a 400-bed capacity, situated about 50 km away from Abuja, the capital city of Nigeria. It serves as a referral Centre for all the secondary healthcare facilities in Nasarawa state and also other healthcare facilities on the outskirts of Abuja.

The hospital, being a referral center for diabetes mellitus, has consultant diabetologists and qualified clinical pharmacists who render pharmaceutical care services to patients with chronic diseases.

Study design

The study is a randomized controlled, longitudinal, and two-arm parallel prospective one with a 12-month patient follow-up.

Study Participants

The study participants were patients with Type 2 DM who were 18 years and above, drawn from endocrinology and general out-patient clinics, and already on oral hypoglycemic agents' prescription (but not on insulin injection).

Ethical Approval

Ethical approval was obtained from the Health Research Ethics Committee of Federal Medical Centre, Keffi with reference number NHREC/ 21/12//2012, dated 12th September 2017.

Data collection

Sociodemographic data and clinical parameters of all the recruited participants from both the control and test groups were taken at baseline, at 3rd month, at 6th month, and 12th month. The clinical parameters in question were FBS, HbA1c, HDL, LDL, SrCr, SBP, DBP, and BMI.

Sample size

Published data on the variability of HbA1c in T2DM patients dictated that to detect an absolute difference of >1% in HbA1c (a clinical effect), with $\alpha = 0.05$ and a power of 0.90 (90%), a sample size of 104 patients in each of the control and intervention groups was required[15] Based on these data, to ensure sufficient statistical power and to account for 'drop-outs' during the study, a target sample size of 240 patients (120 control and 120 intervention) was used.

Randomization

Participants were recruited and randomized into the two groups using systematic randomization such that the first 2 participants were assigned to the control group (NCCG), and the next 2 were assigned to the test or intervention group (PCIG). This alternate randomization continued till the total sample size was reached.

Patients in the intervention group received pharmaceutical care interventions through the Structured Education Program (SEP) by clinical pharmacists while patients in the control group received only usual or normal care devoid of any special training session from the clinical pharmacists.

Clinical parameters such as FBS, HbA1c, HDL, LDL, SrCr, SBP, DBP, and BMI were measured at the baseline, at three months, at six months, and at 12 months intervals for both interventions and control groups.

Normal Care Process (NCP)

NCP defines the usual process through which patients with T2DM pass in FMC Keffi to assess health care. Firstly, patients go to Medical Records Department to activate their data in the electronic medical record (EMR). Secondly, they go to triage nurses for taking of vital signs, and thirdly, they go to the clinic for consultation and prescription by the physician.

And lastly, they go to the pharmacy for prescription filling. The patient normally spends an average of 8-10 minutes each with the physician and the pharmacist. The normal care received by patients from the physician usually does not go beyond prescription and an instruction to go to the pharmacy to access medication and information for a new date for the next appointment. For participants in the NCCG in this study, who served as the control, they received only this normal care without any special training in form of SEP by the clinical pharmacists.

Pharmaceutical Care Intervention Process (PCIP)

PCIP is the structured education program (SEP) on the disease and its complications, the medications and their side effects, lifestyle modifications in diet and physical exercise, cessation of smoking, and moderation of alcohol consumption, delivered to the participants by the pharmacists, in addition to NCP. In this study, participants in PCIG received SEP at enrolment, at the 2nd encounter (after one month), and at the 3rd encounter (after two months). There was also repeated counseling by the clinical pharmacists during every encounter with patients at each hospital visit on the components of the SEP.

The Structured Education Program (SEP)

At Enrolment

Participants were asked several questions on lifestyle modification, the disease, and the medication with the aim of identifying their education needs. The responses were documented as the identified educational needs of the participants**.**

Education Needs of the Participants

The following indices were identified as the education needs of the participants and they were appropriately addressed:

- Knowledge of the disease and its process
- Knowledge of the signs and symptoms
- Knowledge of the complications and their causes
- Knowledge of the medication and side effects
- Knowledge of how to monitor blood glucose

- Knowledge of exercise and its pattern.
- Knowledge of how to differentiate between hypoglycemia and hyperglycemia.

Diabetes and its complications

Participants were briefly educated on what diabetes is all about and were made to understand that it is the long-standing hyperglycemia that is responsible for the irreversible complications such as retinopathy (blindness), neuropathy (amputation), and nephropathy (kidney failure) usually associated with diabetes.

Diabetes medications and their side effects

Participants were briefly educated on the commonly used medications in the management of diabetes and their side effects so that they would be able to manage the unavoidable ones and avoid the ones that can be avoided.

They were discouraged from missing any dose of their medication and also encouraged to use family members' clocks or phone alarms to remind them of the time of taking their medication.

This point was re-emphasized to them at every encounter with the clinical pharmacists.

Lifestyle modifications

Participants were briefed on the significance of lifestyle modifications in diet and physical activities (exercise). They were encouraged to modify the types of food they eat and their quantities, avoid sedentary life and adopt one form of physical exercise to practice.

Self-monitoring of blood glucose (SMBG)

Participants were introduced to the concept of SMBG. They were educated on its importance in diabetes management and were encouraged to measure their sugar level at least three times a week.

Self-monitoring of the disease (SMD)

Participants were introduced to the concept of SMD through the identification of common signs and symptoms of DM. They were trained to differentiate between symptoms of hyperglycemia (extreme thirst, dry mouth, nausea, blurred vision, and shortness of breath)

and hypoglycemia (hunger, sweating, confusion, fast heartbeat, dizziness, and slurred speech).

Second Encounter (after 1 month)

Participants were carried through:

- Advanced discussions on complications and how to avoid them
- Advanced discussions on medications and their side-effects
- Advanced discussion on adherence to medication
- Advanced discussion on lifestyle modification

Participants were encouraged to reduce their intake of saturated fats and increase the intake of mono and polyunsaturated fats such as olive oil, as dietary control. The saturated fats to reduce include butter, fatty red meat, fast foods, etc.

They were educated on foods with a high glycemic index (GI) > 70 and were advised to reduce or moderate them. Foods with a high glycemic index (GI) > 70 include maize, white rice, cassava, etc. But they were advised to increase their intake of foods with low GI such as beans and carrots.

Participants were advised to engage in aerobic exercise such as brisk walking for about 90-150 minutes per week.

Third Encounter (after 2 months)

Sharing experiences

Participants were subjected to an interactive session to share the difficulties experienced and how to overcome them on the challenges of:

- Lifestyle modification
- Adherence to medication
- Target setting to achieve good glycemic controls and other clinical parameters used in monitoring diabetes
- Self-monitoring of blood glucose

Skin, Foot, and Dental Care

Participants were educated on the need to observe skin, foot, and dental care. They were encouraged to minimize the contact of hard objects with such parts to avoid causing injuries as healing of injuries is always in DM. They were encouraged to use a soft toothbrush and room slippers to avoid being injured.

Follow Up and Appointments

Participants were counseled and encouraged not to miss their clinic appointments for proper review and monitoring, and they were equally counseled to make sure they see their clinical pharmacists on each hospital visit so that they receive pharmaceutical care education.

All these counseling points as they relate to lifestyle modification, medication adherence, and self-monitoring of glucose were repeatedly mentioned to the participants in PCIG at every encounter with the clinical pharmacists. In this RCT, all the clinical parameters in the question of the participants were assessed at baseline, 3rd, 6th, and 12th month.

Materials used

- Diabetes Diaries
- Blood samples
- One-Touch Ultra 2 Blood Glucose Meter, Europe
- Training Manuals for Research assistants
- Data Collection Booklets for documenting:

- Patients' Demographic Data
- Patients' Clinical Parameters

Outcome Measures

The changes from baseline to 3rd, 6^{th,} and 12th month in clinical parameters of participants in the groups were measured with particular focus on FBS, HbA1c, TCh, SBP, and DBP as primary endpoints.

Data Analysis

IBM SPSS Statistics for Windows Version 25 (IBM Corp., Armonk, N. Y., USA) was used for the Statistical analysis. While Categorical data were reported in proportions, Quantitative data were summarized as Mean and Standard deviation,

Socio-demographic data of the participants in both the control and intervention groups were generated, analyzed, and compared.

Clinical characteristics of the participants in both the control and intervention groups were assessed, analyzed, and compared at baseline, at 3rd month, at 6th month, and 12th month. Statistical analysis performed using the IBM Repeated Measure Analysis of Variance was used at a 95% Confidence Interval. Two–sample comparisons were made using Independent and Paired Samples T-tests as appropriate. Comparison of frequencies and proportions was carried out using the Chi-squared test (X^2), Fisher's exact, and z-test.

Bivariate analysis was used to examine the impact of interventions on treatment outcomes. Chi-square ($\chi 2$) test was used for variables at the nominal level of measurement. McNemar $\chi 2$ test was used for nominal level variables. A priori significance level of P <0.05 was used throughout.

RESULTS

Of the 240 study participants randomized into intervention (120) and control (120) groups, 4 and 2 participants were lost to follow-up in the intervention (n=116) and control (n=118) groups respectively.

Tables 1 and 2 represent sociodemographic characteristics of the study participants which revealed that the majority of the participants were females (54.2%); a good majority had their diabetes duration falling within the age range of 1-5 years (65.8%); the majority of participants were within the age range of 40-59 years (62.9%); the majority of them had a strong family history of diabetes (84.2%), were married (78.3%) and neither smoke cigarette (93.8%) nor take alcohol (95.8%). A good number of them were either unemployed (40.4%) or had retired (5.4%) from active public service, and a good number of them had no formal education (21.2%) or had only primary education (19.2%); the mean age of the control and the intervention groups are 50.73±11.95 and 53.98±11.73 respectively. Statistical analysis of

the sociodemographic characteristics of the study participants revealed similarities, as the little differences observed, were not statistically significant.

Table 1. Socio-demographic Characteristics of the Study Participants

Variables	NCCG (120)	PCIG (120)	**Total (240)**		**p-value**
Age (years)					**0.075**
20 – 39	17 (14.1)	12 (10.9)	20 (12.6)		
40 – 59	82 (68.4)	69 (57.4)	151 (62.8)		
60 – 79	19 (15.8)	36 (30.0)	55 (22.9)		
Above 79	2 (1.7)	2 (1.7)	4 (1.7)		
Mean ±SD	**50.73 ±11.95**	**53.98 ±11.73**	**52.36 ±11.93**		
Gender					**0.092**
Female	58 (48.3)	71 (59.2)	129 (53.8)		
Male	62 (51.7)	49 (40.8)	111 (46.3)		
Duration of diabetes (yrs.)					**0.134**
</=5	87 (72.5)	71 (59.1)	158 (65.8)		
6 – 15	26 (21.7)	35 (29.2)	61 (25.4)		
16 – 25	6 (5.0)	8 (6.7)	14 (5.9)		
26 – 35	1 (0.8)	4 (3.3)	5 (2.1)		
36 – 40	0 (0.0)	2 (1.7)	2 (0.8)		
Mean ±SD	**4.73 ±2.84**	**5.25 ±3.24**	**4.99 ±3.05**		
Educational status					**0.080**
None	23 (19.2)	28 (23.3)	51 (21.2)		
Primary	25 (20.8)	21 (17.5)	46 (19.2)		
Secondary	42 (35.0)	27 (22.5)	69 (28.8)		
Tertiary	30 (25.0)	44 (36.7)	74 (30.8)		
Occupation					**0.111**
Employed	57 (47.5)	73 (60.8)	130 (54.2)		
Retired	8 (6.7)	5 (4.2)	13 (5.4)		
Unemployed	55 (45.8)	42 (35.0)	97 (40.4)		
Marital status					**0.342**
Divorced	6 (5.0)	2 (1.7)	8 (3.3)		
Married	94 (78.3)	94 (78.3)	188 (78.3)		
Single	7 (5.8)	10 (8.3)	17 (7.1)		
Widowed	13 (10.9)	14 (11.7)	27 (11.3)		

Table 2. Family History and Social Habits of the Study Participants

Variables	NCCG (120)	PCIG (120)	**Total (240)**		**p-value**
Family history of diabetes					**0.563**
Yes	104 (86.7)	98 (81.7)	202 (84.2)		
No	12 (10.0)	16 (13.3)	28 (11.7)		
Don't know	4 (3.3)	6 (5.0)	10 (4.2)		
Smoking					**0.790**
Yes	7 (5.8)	8 (6.7)	15 (6.2)		
No	113 (94.2)	112 (93.3)	225 (93.8)		
Alcohol consumption					**0.197**
Yes	3 (2.5)	7 (5.8)	10 (4.2)		
No	117 (97.5)	113 (94.2)	230 (95.8)		

On the other hand, baseline data of clinical outcomes of the study participants in both the control and intervention groups revealed comparable results with no statistically significant differences in all the clinical indices: FBS (p-value 0.147), HbA1c (p-value 0.389), HDL (p-value 0.812), LDL (p-value 0.563), TCh (p-value 0.180), TGL (p-value 0.303), SrCr (p-value 0.566), SBP (p-value 0.121), DBP (p-value 0.765) and BMI (p-value 0.653). Table 3.

Table 3. Baseline Clinical Characteristics of Participants

Parameters	**Normal range**	**PCIG**	**NCCG**	**Diff.**	**P-value**
FBS	3.5-6.9mmol	7.56 ±2.16	7.19 ±1.76	0.37	0.147
HbA1c	<7%	7.03 ±0.80	6.93 ±1.03	0.1	0.389
HDL	(M=0.9-1.4,F=1.2-1.7) mmol/L	1.49 ±0.37	1.50 ±0.44	-0.1	0.812
LDL	(1.6-4.7) mmol/L	4.02 ±1.07	3.94 ±1.07	0.08	0.563
Tch	(0.5-5.2) mmol/L	4.52 ±0.97	4.35 ±1.00	0.17	0.180
TGL	(M=0.6-1.4,F=0.4-1.6) mmol/L	1.89 ±0.76	1.51 ±0.38	-0.08	0.303
SrCr	M=80-133,F=62-107µmol/L	104.28 ±22.75	102.62 ±21.96	1.66	0.566
SBP	120-140mmHg	142.38 ±9.70	140.18 ±12.05	2.2	0.121
DBP	80-90mmHg	92.28 ±7.25	91.98±8.24	-0.30	0.765
BMI	18.5-24kg/m^2	23.30 ±3.80	23.07 ±4.09	0.23	0.653

NCCG=Normal care control group, PCIG=Pharmaceutical care intervention group, FBS= Fasting blood sugar, HbA1c=Glycated hemoglobin, HDL=High density lipoprotein LDL=Low density lipoprotein, Tch=, TGL=Triglyceride
SrCr= Serum creatinine, SBP=Systemic blood pressure, DBP=Diastolic blood pressure. BMI=Body mass index

After 3 months of intervention, all biochemical indices in the intervention group improved better than in the control group except HDL (p-value 0.4320) and SrCr (p-value 0.744). The changes observed in the other parameters were statistically significant with p-values of <0.005 in each of them. Table 4.

Table 4. Clinical Outcomes between Groups of Participants at 3rd Month

Parameters	Normal range	PCIG	NCCG	Diff	P-value
FBS	3.5-6.9mmol	5.59 ±0.88	6.29 ±1.19	-0.7	0.001
HbA1c	<7%	6.03 ±0.74	6.73 ±0.88	-0.7	0.001
HDL	(M=0.9-1.4,F=1.2-1.7) mmol/L	2.22 ±0.24	1.48 ±0.31	0.74	0.432
LDL	(1.6-4.7) mmol/L	3.12 ±0.94	3.79 ±1.05	-0.67	0.001
Tch	(0.5-5.2) mmol/L	3.88 ±0.88	4.37 ±0.98	-0.49	0.001
TGL	(M=0.6-1.4,F=0.4-1.6) mmol/L	1.37 ±0.27	1.59 ±0.37	-0.22	0.001
SrCr	M=80-133,F=62-107µmol/L	103.23 ±19.32	104.08 ±21.01	-0.85	0.744
SBP	120-140mmhg	140.64 ±8.14	144.63 ±8.71	-3.98	0.001
DBP	80-90mmhg	90.93 ±6.19	93.71 ±7.38	-2.78	0.002
BMI	18.5-24kg/m^3	21.53 ±3.04	23.17 ±4.15	-1.64	0.001

NCCG=Normal care control group, PCIG=Pharmaceutical care intervention group, FBS= Fasting blood
LDL=Low density lipoprotein, Tch=, TGL=Triglyceride, SrCr= Serum creatinine, SBP=Systemic Blood pressure, DBP=Diastolic blood pressure. BMI=Body mass index

Again, six months of intervention demonstrated greater changes of all the clinical parameters in the intervention group than the control group with statistical significance, except SrCr (p-value 0.129). The difference in clinical outcomes with statistical significance includes FBS (p-value 0.001), HbA1c (p-value 0.001), HDL (p-value 0.047), LDL (p-value 0.001), TCh (p-value 0.001), SBP (p-value 0.001), DBP (p-value 0.001) table 5.

Table 5. Clinical Outcomes of the Study Participants at 6th month

Parameters	Normal range	PCIG	NCCG	Diff	P-value
FBS	3.5-6.9mmol	5.04 ±0.71	6.32 ±1.03	-1.28	0.001
HbA1c	<7%	5.23 ±0.56	6.77 ±0.88	-1.54	0.001
HDL	(M=0.9-1.4,F=1.2-1.7) mmol/L	1.15 ±0.13	1.22 ±0.38	-0.07	0.047
LDL	(1.6-4.7) mmol/L	2.69 ±0.78	3.79 ±1.04	-1.1	0.001
Tch	(0.5-5.2) mmol/L	3.38 ±0.70	4.36 ±1.03	-0.98	0.001
TGL	(M=0.6-1.4,F=0.4-1.6) mmol/L	1.15 ±0.19	1.68 ±0.41	-0.52	0.001
SrCr	M=80-133,F=62-107µmol/L	98.10 ±16.39	101.87 ±21.31	-3.78	0.129
SBP	120-140mmHg	135.91 ±7.10	144.85 ±7.42	-8.94	0.001
DBP	80-90mmHg	87.49 ±4.93	93.63 ±6.84	-6.14	0.001
BMI	18.5-24kg/m^3	20.32 ±2.42	23.85 ±10.01	-3.53	0.001
NCCG=Normal care control group, PCIG=Pharmaceutical care intervention group, FBS= Fasting blood					
LDL=Low density lipoprotein, Tch=, TGL=Triglyceride, SrCr= Serum creatinine, SBP=Systemic blood pressure, DBP=Diastolic blood pressure. BMI=Body mass index					

Furthermore, 12 months of intervention in the study produced better improvements in all the clinical parameters in the intervention group than in the control group. All the changes were statistically significant with p-values of < 0.05 in each of the outcomes. Table 6.

Table 6. Clinical Outcomes Among the Study Participants in the 12th Month

Parameters	Normal range	PICG	NCCG	Diff.	P-value
FBS	3.5-6.9mmol	4.40 ±0.76	7.10 ±0.68	-2.7	0.001
HbA1c	<7%	3.17 ±1.23	8.08 ±4.07	-4.91	0.001
HDL	male=.9-1.4,F=1.2-1.7mmol/L	1.23 ±0.22	1.42 ±0.83	-0.19	0.017
LDL	1.6-4.7mmol/L	2.27 ±0.60	5.10 ±1.97	-2.83	0.001
Tch	0.5-5.2mmol/L	1.42 ±1.06	4.73 ±1.75	-3.31	0.001
TGL	M=0.6-,F-5.2mmol/L	0.77 ±0.29	3.31 ±1.83	-2.54	0.001
SrCr	M=80-133,F=62-107µmol/L	81.46 ±13.41	117.21 ±31.38	-35.75	0.001
SBP	120-140mmHg	129.97 ±7.43	144.96 ±6.91	-14.98	0.001
DBP	80-90mmHg	83.26 ±4.90	94.00 ±7.93	-10.74	0.001
BMI	18.5-24kg/m2	20.10 ±1.99	29.29 ±12.14	-9.19	0.001

NCCG=Normal care control group, PCIG=Pharmaceutical care intervention group, FBS= Fasting blood, LDL=Low density lipoprotein, Tch=Total cholesterol, TGL= Triglyceride, SrCr= Serum createnin,SBP=Systemic blood pressure,DBP=Diastolic blood pressure.BMI=Body mass index

Tables 7 and 8 described the changes achieved in the mean values of clinical outcomes at the end of the study period of 12 months compared to the baseline, in both the intervention and the control groups. While in the intervention group (Table 8), FBS and HbA1c reduced by 3.2 mmol/L and 3.9% respectively, FBS reduced only by 0.102 mmol/L, and HbA1c increased by as much as 1.148% in the control group (Table 7). Again, in the intervention group, there were reductions in TCh, SBP, DBP, and BMI by 3.1 mmol/L, 12.5 mmHg, 9.02 mmHg, and 3.2 kg/m^2 respectively, while on the other hand, the same clinical outcomes increased in the control group by 0.38 mmol/L, 4.72 mmHg, 4.24 mmHg and 6.22 kg/m^2 respectively. Furthermore, there were reductions in the mean values of HDL, LDL, TGL, and SrCr in the intervention group by 0.26 mmol/L, 1.77 mmol/L, 1,10 mmol/L, and 23.39 respectively, all of these increased in the control group except HDL which minimally decreased by 0.08 mmol/L.

Table 7. Intra-group Comparison of Mean Differences Among Study Participants at Baseline and 12th Month in Normal Care Control Group (NCCG)

S/N	Clinical parameter	Mean at Baseline	Mean at 12th Month	Mean Difference	P-value
1	FBS	7.2	7.098	0.102	1.000
2	HbAIc	6.936	8.085	-1.148	0.210
3	HDL	1.498	1.425	0.074	1.000
4	LDL	3.936	5.097	-1.161	<0.001
5	TCh	4.346	4.729	-0.383	0.242
6	TGL	1.517	4.729	-3.212	<0.001
7	SrCr	102.822	117.212	-14.39	0.001
8	SBP	140.237	144.958	-4.72	<0.001
9	DBP	89.763	94	-4.237	<0.001
10	BMI	23.075	29.291	-6.216	<0.001

NCCG=Normal care control group, PCIG=Pharmaceutical care intervention group, FBS= Fasting blood, LDL=Low density lipoprotein, Tch=Total cholesterol, TGL= Triglyceride, SrCr= Serum creatinine, SBP=Systemic blood pressure, DBP=Diastolic blood pressure. BMI=Body mass index

Table 8. Intra-group Comparison of Mean Differences Among Study Participants at Baseline and 12th Month in Pharmaceutical Care Intervention Group (PCIG)

S/N	Clinical Parameter	Mean at Baseline	Mean at 12th month	Mean Difference	P-value
1	FBS	7.594	4.399	3.195	<0.001
2	HbAIc	7.052	3.172	3.88	<0.001
3	HDL	1.497	1-233	0.264	<0.001
4	LDL	4.041	2.271	1.77	<0.001
5	TCh	4.516	1.417	3.099	<0.001
6	TGL	1.862	0.772	1.091	<0.001
7	SrCr	104.853	81.457	23.396	<0.001
8	SBP	142.509	129.974	12.535	<0.001
9	DBP	92.276	83.259	9.017	<0.001
10	BMI	23.284	20.099	3.185	<0.001

NCCG=Normal care control group, PCIG=Pharmaceutical care intervention group, FBS= Fasting blood, LDL=Low density lipoprotein, Tch=Total cholesterol, TGL= Triglyceride, SrCr= Serucreatenin, SBP=Systemic blood pressure, DBP=Diastolic blood pressure. BMI=Body mass index

DISCUSSION

The study participants in the control and intervention groups have similarities in sociodemographic profiles as the mean differences in their sociodemographic characteristics were not statistically significant at baseline, as depicted in tables 1 and 2. The findings in the study were also consistent with the findings of [16] which reported that the majority of the patients with T2DM were female (64.29%) and the mean age of the participants was 52.07 years which is relatively comparable to 52.36 years of this study (Table 1). They also have similarities in clinical characteristics at baseline, as the mean differences of their clinical indices were not statistically significant (Table 3). This lack of statistically significant differences in the mean values of clinical data in all the study participants of the two groups at baseline implies that the impact of the normal care process was the same on all the study participants before intervention. On the other hand, the consistently improved reductions in clinical mean values noticed in the 3rd, 6^{th,} and 12th months in the intervention group, compared to the baseline, proved the positive impact of the pharmacist-led pharmaceutical care intervention (PCI). On a general note, the participants in the intervention group achieved statistically significant changes in all the clinical outcomes at the end of the study period.

The primary endpoints of particular interest in this pharmacist-led intervention study were FBS, HbA1c, TCh, SBP, and DBP, and the study revealed a trend of continuous improvement with statistically significant reductions in their mean values for participants in the intervention group, without any of such trends and reductions in the control group (tables 7 and 8). On the contrary, the mean values of such biochemical indices consistently increased in the control group except for FBS which was slightly reduced by 0.09 mmol/L. The statistically significant reductions noticed in FBS and HbA1c signify improved glycemic control resulting from the focused patient education on the disease and its complications, lifestyle modifications on diet and exercise, and the repeated counseling on medication use as it relates to timing and consistency, delivered to the participants in the intervention group, by the clinical pharmacists, times and again, as detailed in the structured education program (SEP). This consistent bonding of clinical pharmacists with the patients over a period of 12

months, could have led to the development of a strong patient-pharmacist professional relationship. This also could have improved the problem-solving skills of the pharmacists and might have increased the confidence of patients, which would result in enhanced medication compliance and improved glycemic control. Similar findings where significant changes were noticed in the intervention group and not in the control group, were reported by[17].

In this study, pharmacist involvement indirect patient care through individualized self-management education that involves adherence to support and lifestyle modification produced a reduction of 3.68% in HbA1c at the end of the study period. This agrees with the finding of an RCT by [19] which reported a reduction of 2.1% [19] also reported a reduction of at least 1% HbA1c in an RCT conducted through pharmacist collaborative practice. The UKPDS study has proved that every 1% reduction of mean HbA1c is associated with a 21% risk reduction for any endpoint related to diabetes and a 37% risk reduction for microvascular complications[20]. HbA1c in this study was reduced by 3.68%.

This study achieved a reduction of 3.10 mmol/L in TCh in the intervention group at the end of the study period. This corroborates the findings of [21] which reported a statistically significant change (p-value -0.001). This good lipid control achieved by this pharmacist-led intervention implies a reduction of atherosclerosis risk factors that can lead to minimizing cardiovascular events and kidney diseases.

The reduction in the mean values of SBP and DBP (12.41 mmHg and 9.02 mmHg respectively), demonstrated by this pharmacist-led intervention study conforms to the findings of[17]. which reported a decrease of 10.47 mmHg and 4.04 mmHg in SBP and DBP respectively. In another isolated study as reported by [22] a reduction of 19.6 mmHg with a statistical significance (p-value 0.001) was achieved in SBP after the intervention. Again, [23] reported a reduction of 7.1 mmHg in DBP with a statistical significance (p-value 0.026) after pharmaceutical care intervention. These reductions in SBP and DBP also imply a significant reduction in cardiovascular risks. On a general note, our findings in terms of BP control and glycemic control in this pharmacist-led intervention, are consistent with the report of[43] Mino-Leon et al., 2015 which states that “patients counseled by the pharmacist were at least 55% more likely to achieve BP control and 13% to achieve glycemic control when compared to the control group (usual care)”.

All these achievements of glycemic, lipid, and BP control in this pharmacist-led pharmaceutical care intervention study, are products of the structured education program

(SEP), delivered by the clinical pharmacists to the intervention group which focused on diabetes and its complications, medications, and their side effects, medication adherence and lifestyle modifications on diet and exercise.

CONCLUSION

The findings of this study revealed that pharmacist-led pharmaceutical care intervention is effective in improving glycemic, lipid, and BP controls in patients with type 2 diabetes mellitus. These three outcomes resulting from clinical pharmacists' professional involvement in direct patient care are indicators that incorporating pharmaceutical care intervention into the healthcare process within healthcare institutions will optimize treatment goals and outcomes.

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