The Impact of Information Technology on the Management of Diabetes – A Case Study of the Trust Hospital, Accra

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ABSTRACT
Diabetes is a chronic condition that causes serious, life-threatening complications like stroke, heart attack, amputation, impotence, and blindness. In Ghana, most Diabetic patients visit the health facility quarterly at which time their blood glucose levels are checked. This study therefore sought to ascertain the impact of Information Technology tools such as the glucometer, Mobile 'app' and the use of the phone on diabetic patients' self-management of the disease and how this is reflected in their blood glucose control. A randomized controlled trial was used for the study. Forty people diagnosed with type 1, type 2 or gestational diabetes participated. The study evaluated the impact of the glucometer, blood glucose tracker system and the mobile telephone in the treatment and management of diabetic patients. Two groups were involved in the study; those who used the intervention (experimental group) and those who did not use the intervention (control group) with 20 participants in each group. The experimental group had their blood glucose monitored constantly over a period of 12 weeks using a glucometer and a mobile 'app' and interventions given as and when needed. Glycated haemoglobin (HbA1c) values were estimated for all participants before and after the study period. Results were analyzed using paired t-test. The HbA1c final measurements showed significant improvement in the experimental group and none of them was diagnosed with additional Diabetic complications at the end of the period of study.

General Terms
Information and Communication Technology, mobile "Apps", Diabetes, blood glucose levels

Keywords
Information and Communication Technology tools and Diabetes, Diabetes Self-management, Glucose control

1. INTRODUCTION
The Ghana Diabetes Association has revealed that an estimated 4 million people are said to be living with diabetes; and 4,790 adult deaths due to diabetes occurred in 2015 whilst 266,200 new cases were also recorded (Ministry of Health Ghana., 2015). According to the International Diabetic Federation, an estimated 537 million persons between 20 and 79 years worldwide have diabetes, whilst 24 million adults in Africa have the disease, (IDF, Brussels., 2021). The disease is associated with comorbid conditions and requires multiple medications in its management.

HbA1c is an important indicator of long-term blood glucose control with the ability to reflect the cumulative glucose history of the previous two to three months. HbA1c not only provides a reliable measure of chronic hyperglycemia but also correlates well with the risk of long-term diabetes complications, (Sherwani et al., 2016). Some studies have shown that self-monitoring of blood glucose can have favourable effects on care and follow up using a guidance system based on Information Technology (IT). A study by Murata and others suggests that effective monitoring through the use of IT tools provides statistically significant results in decreasing HbA1c (Murata et al., 2003).

Understanding of how various IT applications support self-management interventions in patients in dealing with diabetes in everyday life is imperative for implementation of diabetes treatment aimed at improving and maintaining self-care activities. Self-management through IT application has grown to be very important for patients with diabetes, and health care provided via mobile applications (apps) has a great advantage when applied to patients with diabetes (Kaufman and Khurana, 2016). Also, the adherence to activities for the management of diabetes, such as regular medication and insulin injection, self-monitoring of blood glucose (SMBG), diet, and exercise, can be improved through mobile apps (Quinn et al., 2011). Today, self-management of diabetes has been impacted by the use of various technologies. These technologies have supplemented healthcare through the internet and mobile applications.

1.1 Research Objectives
1. To evaluate the effectiveness of the IT-based tools devised for diabetes management and treatment.
2. To determine if patient' self-management of the disease will improve diabetes short - term outcomes.

2. LITERATURE REVIEW
Patients with Diabetes have a high risk of developing other diseases. In developing countries, diabetes is now very common and has become an important cause of illness; prevalence is high among elderly people; younger adults in their productive ages also have their prevalence rates increasing. World Bank collection of development indicators has pegged the prevalence rate in Ghana at 2.6%, (tradingeconomics.com, 2021). If effective prevention and control programs are not put in place, more and more people will develop the disease. (International Diabetes Federation, Diabetes Atlas, 2021).

One of the major causes of adult ill health and deaths in Ghana is diabetes (de Graft Aikins et al., 2003); in 2019, 5,398 adult deaths reported in Ghana were due to diabetes (statista.com 2022). It was estimated in 2015 that about 2.2 million people had diabetes in Ghana with approximately 189,900 cases undiagnosed (National Diabetes Association). Diabetes is a chronic condition that causes serious, life-threatening complications like stroke, heart attack, amputation, impotence, and blindness. Basically, there are three types of diabetes mellitus: (1) type 1 diabetes (also known as juvenile diabetes); (2) type 2 diabetes (or adult-onset diabetes); and (3) gestational diabetes.

Information and Communication Technology (ICT) has advanced rapidly and can be used to improve health care especially in the management of diabetes. Using the internet and mobile devices such as phones could be beneficial in this field. These electronic components and devices can overcome time and location barriers through real-time and remote monitoring of data such as blood glucose levels so that insulin dosage can be adjusted on time as well as improve blood glucose control using dietary and or changes in physical activity. It can also facilitate communication between patients and Healthcare providers for timely interventions to be made when the need arises. Several investigations demonstrated how effective the telephone can be in Diabetes management because it serves as a means to reach patients who live far away and thus have difficulty in accessing healthcare facilities (Hayes et al., 2001.) A study conducted in which a low-income insured minority population with type 2 diabetes and poorly controlled blood glucose yielded moderate results with telephone intervention in one group compared to a printed intervention in another, there was statistically significant improvement in HbA1c ($p = 0.009$) between the two groups that were monitored after a year (Walker et al., 2011).

A study conducted by Montori and his colleagues in which participants with type 1 diabetes that was poorly controlled even though they were given intensive insulin treatment sent their blood glucose values to healthcare providers regularly over a period of six months by means of a modem. Telephone “feedback” from a nurse was sent within 24 hours of each relay, where insulin doses were adjusted appropriately. At the end of the study period, participants’ mean HbA1c levels decreased significantly ($p = 0.03$). In the control group there was reduction in mean HbA1c but this was thought to be related to a possible study effect (Montori et al., 2004). Obilor and her colleagues concluded in a study they conducted on using Information communication technology tools to prevent diabetic foot ulcers that these tools improved diabetic foot related outcomes, (Obilor et al., 2021)

The United Nations recognizes Diabetes as important because it is rated as a high cause of premature death and disability. It is one of four priority non-communicable diseases (NCDs) targeted by world leaders in the 2011 Political Declaration on the Prevention and Control of NCDs (United Nations General Assembly. New York: United Nations; 2011). The declaration indicated that the incidence and impacts of diabetes and other NCDs can be largely prevented or reduced using methods that include evidence-based, affordable, cost-effective, population wide and multi-sectorial interventions. These obligations were re-emphasized by the United Nations General Assembly when they adopted the 2030 Agenda for Sustainable Development. Having access to affordable treatment is critical in order to reduce mortality as well as improve outcomes of Diabetes. Patients in some countries and communities do not have access to Insulin and this continues to be a critical obstacle to successful treatment efforts. Oral medication for reducing blood glucose values cannot be easily obtained, and medication to reduce blood pressure and cholesterol levels is also a problem. Improving control of these diseases at the primary health care level with continuous support by community health workers can result in improved control of diabetes and fewer complications (New York: United Nations General Assembly; 2015). This is where the use of information technology can make an impact.

3. METHODOLOGY

A randomized controlled trial was used for the study. It involved 40 people diagnosed with diabetes type 1, type 2 or gestational diabetes. The study was to evaluate the impact of the Glucometer, Blood glucose tracker system and the mobile phone in the management of diabetic patients. The Trust Hospital in Accra was used as the study area and diabetic patients who attend Out Patient Clinic were used for the study.

A simple random sampling method was used to derive study respondents. Patients aged 20 years and above were recruited for the trial study. Diabetic patients visit the health facility to see the doctor once every three months or when they need to fill their prescriptions. Patients check their blood sugar values only when they visit the health facility. This study was carried out using two sets of participants; those who use glucometers (Experimental) and those who did not use glucometers (Control). There were 20 people in each group. A form was filled by each participant to gather information on their demographic factors as well as other information that is relevant such as weight, Glycated haemoglobin (HbA1c) values, initial fasting blood glucose levels and medications, form of exercises, foods taken in and whether they have any complications such as high cholesterol levels, cardiovascular disease, retinopathy, neuropathy and hypertension.

Participants in the control group were diabetic patients who did not have personal glucometers for checking their blood glucose at home. Participants in the Experimental group had personal glucometers which could be used for estimating their blood glucose at home. The initial blood glucose reading was estimated for each participant as well as their initial HbA1c values. Each participant in the Experimental group had an “app” known as the “blood glucose tracker” installed on their android mobile phones. The blood glucose readings from the glucometer were saved on the “app” after each test. Blood glucose readings were checked daily or twice a week depending on the doctors’ instructions and the type of diabetes the participant suffers from. Recordings were forwarded by WhatsApp or SMS to the researcher’s phone for review. Weekly and monthly averages were estimated from the recordings over a period of 12 weeks for each participant.

4. RESULT AND DISCUSSIONS

The data collected for each participant in the experimental group as well as any interventions done were noted and assessed. The average weekly readings were compared to see if there were improvements in the blood glucose values at the end of the research period. Glycated haemoglobin (HbA1c) values at the end of the research were recorded and compared to values at the beginning of the study.

4.1 Demographics of participants

Each participant filled a form for their demographic information at the beginning of the study.

4.1.1 Age and sex of participants

A total of 40 people participated in the study. Participants for both Experimental and Control groups comprised of twelve (12) females and eight (8) males in each group. For the

Control group, ages ranged between 21 and 85; the Experimental group ages ranged between 22 and 77. It is significant to note that forty percent (40%) of participants in both groups were aged between 51 and 60 years.

4.1.2 Type of Diabetes

One (1) person in the Control group had type 1 diabetes while nineteen (19) had type 2 diabetes. For the Experimental group, two (2) people had type 1 diabetes, two (2) had gestational diabetes and sixteen (16) had type 2 diabetes.

4.1.3 Current knowledge or use of ICT

All participants had current knowledge or use of the internet. For the Control group, ten (10) had personal computers, five (5) had access to computers but did not own them and five (5) had no access to computers; sixteen (16) had smart phones and seven (7) had personal glucometers. Thirteen (13) in the Experimental group had personal computers, four (4) had access to but did not own computers and three (3) did not have access to computers; seventeen (17) had smartphones and all twenty (20) had personal glucometers.

4.1.4 Disease complications

Five (5) people in the control had Hypertension, two (2) had cardiovascular disease, two (2) had neuropathy and six (6) had Dyslipidaemia (high cholesterol level) at the beginning of the study. The Experimental group had four (4) people with Hypertension, two (2) with cardiovascular disease and three (3) had Dyslipaedaemia at the beginning of the study.

Table 1: Age distribution for participants in the Control (C) and Experimental (E) Groups.

Age	(C)	% C	(E)	% E
21-30	1	5	1	5
31-40	1	5	3	15
41-50	6	30	4	20
51-60	8	40	8	40
61-70	1	5	2	10
71-80	1	5	2	10
81-90	2	10	0	0
Total	**20**	**100**	**20**	**100**

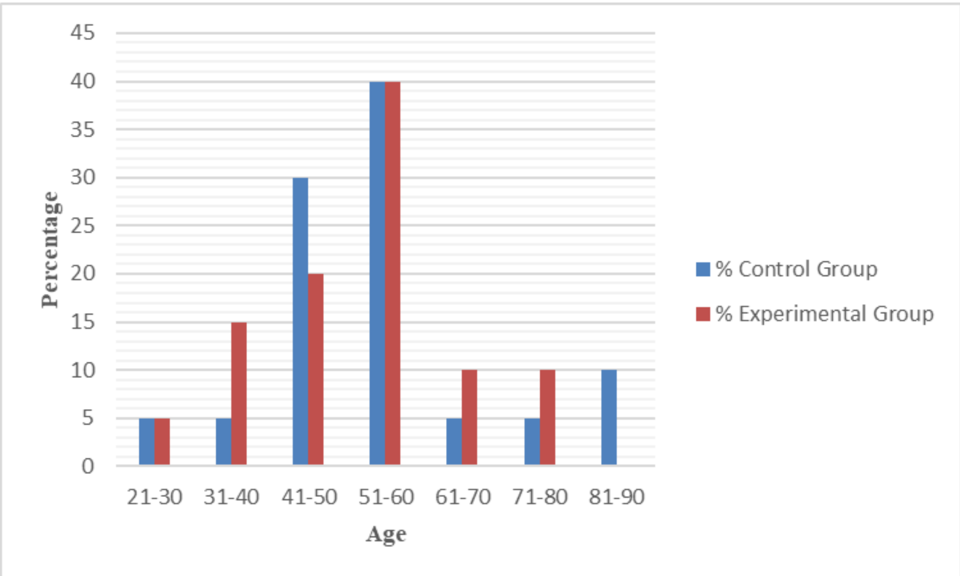

Figure 1: Age distributions in percentages for participants in the Control and Experimental groups

Table 2: Monthly average Glucose reading (mmol/l) for Control group (No ‘App’)

Participant Id	Age	Sex	Month 1	Month 2	Month 3
N1	55	M	6.4	7.2	7.8
N2	82	F	8.1	11.4	6.4
N3	59	F	9.5	9.9	9.5
N4	41	F	11.6	11.6	13.7
N5	85	M	11.4	14.1	11.8
N6	65	F	6.5	11.1	6.6
N7	48	F	12.8	8.0	9.8
N8	75	F	7.0	6.1	6.7
N9	46	F	14.9	11.0	9.6
N10	58	M	6.9	9.7	7.2
N11	40	M	7.8	7.2	6.4
N12	48	F	11.4	6.4	8.1
N13	56	F	14.1	11.4	11.4
N14	52	M	8.5	9.1	6.6
N15	21	M	11.6	9.2	9.8
N16	60	M	7.1	9.3	7.8
N17	62	F	7.1	6.0	7.2
N18	44	F	14.2	11.0	10.3
N19	51	M	6.2	9.7	7.9
N20	53	F	9.8	9.4	9.6

Table 3: Glycated Haemoglobin (HbA1C) for Control group (No App)

Participant Id	Age	Sex	Initial HbA1C %	Post HbA1C%
N1	55	M	6.4	7.6
N2	82	F	7.9	7.9
N3	59	F	8.3	10.6
N4	41	F	8.7	8.7
N5	85	M	8.8	9.8
N6	65	F	7.2	10.5
N7	48	F	10.5	11.1
N8	75	F	6.1	5.2
N9	46	F	13.3	13.4
N10	58	M	6.9	7.5
N11	40	M	6.6	7.2
N12	48	F	7.8	7.9
N13	56	F	12.8	13.6
N14	52	M	7.4	7.5
N15	21	M	9.8	10.5
N16	60	M	7.0	10.3
N17	62	F	5.9	5.4
N18	44	F	9.7	8.9
N19	51	M	7.9	10.0
N20	53	F	9.1	9.3

Table 4: Weekly (Wk) average fasting blood glucose reading for participants using glucometers and 'App' (Experimental)

ID	Age	Sex	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5	Wk 6	Wk 7	Wk 8	Wk 9	Wk 10	Wk 11	Wk 12
G1	42	F	6.0	5.8	5.2	5.3	5.3	4.2	4.7	4.9	4.6	4.1	5.4	5.1
G2	51	F	5.9	5.5	6.4	7.2	6.8	8.7	7.6	6.0	8.6	5.7	9.1	9.5
G3	51	M	12.7	8.2	7.7	6.2	6.6	5.7	6.2	6.1	5.1	5.1	6.0	5.0
G4	53	F	9.3	9.2	8.1	7.9	6.3	7.1	7.0	7.1	8.6	6.7	9.3	8.3
G5	33	F	5.5	5.7	5.7	6.9	5.1	5.1	6.8	5.3	5.9	5.6	6.0	5.4
G6	77	F	6.1	6.8	6.7	7.3	6.8	6.3	6.6	7.3	6.5	5.5	6.1	5.3
G7	60	M	6.9	8.3	6.9	6.3	7.5	6.6	7.0	6.4	6.3	6.6	5.4	5.4
G8	61	F	6.5	10.5	6.8	6.0	6.2	3.8	5.6	6.9	5.8	6.0	4.8	5.0
G9	53	M	6.0	7.1	7.3	6.3	7.1	8.2	7.9	8.3	8.0	7.7	8.3	8.1
G10	22	M	7.7	7.3	6.9	7.0	6.5	6.9	6.6	7.2	6.9	6.7	6.5	6.1
G11	45	M	6.8	10.2	6.9	6.0	6.1	5.6	6.9	5.8	4.0	6.0	4.8	4.8
G12	42	M	8.0	7.0	6.9	7.2	6.8	6.4	6.6	7.1	7.0	6.6	6.5	6.0
G13	49	F	6.0	5.8	6.1	6.0	7.0	6.8	8.5	7.6	6.2	8.4	6.0	9.0
G14	55	M	7.3	6.8	6.7	6.1	6.8	7.5	6.3	6.5	6.3	6.2	5.5	5.3
G15	62	F	9.5	9.0	8.3	7.7	7.2	7.0	7.1	6.3	9.3	8.6	8.3	6.7
G16	80	F	8.3	8.2	7.9	7.1	8.3	7.3	7.1	7.1	8.1	6.0	6.3	7.7
G17	38	F	5.8	6.0	5.5	5.0	5.3	4.9	4.7	4.2	5.1	5.4	4.6	4.1
G18	58	M	5.7	6.9	5.7	5.5	5.3	6.8	5.1	5.1	6.0	5.9	5.6	5.4
G19	56	F	13.0	8.7	7.0	6.1	6.4	6.3	6.1	5.7	6.2	5.0	5.0	5.0
G20	40	F	6.7	8.3	6.6	6.6	7.5	7.0	6.6	6.4	6.3	6.6	5.5	5.3

Table 5: Monthly average fasting blood glucose reading for participants using glucometers and 'App' (Experimental)

Participant ID	Age	Sex	Month 1	Month 2	Month 3
G1	42	F	5.9	4.9	4.7
G2	51	F	6.1	7.6	7.8
G3	51	M	9.5	6.2	5.7
G4	53	F	8.9	7.1	7.9
G5	33	F	5.6	6.0	5.0
G6	77	F	6.8	6.8	5.5
G7	60	M	7.1	6.9	6.2
G8	61	F	7.7	5.4	5.7
G9	53	M	6.7	7.9	8.0
G10	22	M	7.2	6.8	6.6
G11	45	M	7.5	6.1	4.9
G12	42	M	7.3	6.7	6.5
G13	49	F	6.0	7.5	8.2
G14	55	M	6.7	6.7	5.8
G15	62	F	8.5	6.9	8.2
G16	80	F	7.6	7.4	7.0
G17	38	F	5.6	4.8	4.8
G18	58	M	6.0	5.6	5.7
G19	56	F	8.7	6.1	5.3
G20	40	F	7.1	6.8	5.3

Table 6: Glycated haemoglobin (HbA1C) values for participants with blood glucose ‘App’ (Experimental)

Participant ID	Age	Sex	Initial HbA1C %	Post HbA1c %
G1	42	F	6.5	5.9
G2	51	F	9.3	7.2
G3	51	M	13.4	5.5
G4	53	F	10.3	7.4
G5	33	F	10.1	6.8
G6	77	F	10.5	6.1
G7	60	M	8.1	5.8
G8	61	F	6.1	5.7
G9	53	M	10.3	6.4
G10	22	M	11.2	6.3
G11	45	M	6.2	5.8
G12	42	M	11.3	6.2
G13	49	F	9.0	7.4
G14	55	M	10.2	6.6
G15	62	F	10.0	7.5
G16	80	F	10.4	6.4
G17	38	F	6.4	6.0
G18	58	M	8.3	6.5
G19	56	F	13.0	5.8
G20	40	F	8.5	6.0

4.2 Analysis of findings

The monthly average blood glucose values for the control group were mostly high with no significant change in values over the study period; 70% had their monthly averages greater than (>) 7mmol/l. 60% had their highest reading in the second month with a significant drop in the third month. This suggests that patients do not take measures such as medications, diets and exercises prescribed for them till they are about to pay the next visit to the health facility. The HbA1c values increased significantly for 60% of participants in the group that did not use the glucometer and 'app' at the end of the research period; it is an indication that the participants did not manage their disease properly. 90% of the participants had their HbA1c values greater than 7.0% which is the upper limit for Diabetic patients. At the end of the research period, one person in the control group had developed Dyslipidaemia (High blood cholesterol levels); another was referred to the eye clinic with eye problems; Eight of them were said to have uncontrolled or poorly controlled their blood glucose values because they did not comply to dietary advice or medication. One participant was newly diagnosed with Hypertension at the end the study period while three participants developed neuropathy. Two participants were also diagnosed with osteoarthritis. In all, ten out of twenty participants in the control group were diagnosed with some form of Diabetic complication at the end of the research period.

The values collected for each participant in the experimental group as well as any interventions done were noted and assessed.

These interventions include: A participant with gestational diabetes (42 years, female) had the 2 hours after meals glucose level increasing, she was advised to exercise after meals (walking) and the glucose level was normalized. A patient who had been newly diagnosed with diabetes type 2 (51 years, male) decided to use the "app" to record his blood pressure and it was consistently low; average of 75/50. His medications were changed when he reported this. Another participant with type 1 diabetes (34 years, female) who was pregnant had her morning insulin dosage increased from 30 units and 1000 mg metformin to 48 units insulin without metformin because her morning blood glucose values were high. A 77-year-old female with type 2 diabetes observed that her fasting blood glucose value was consistently high, her medication was changed. Most participants over time were able to identify foods that increased their glucose values and types of exercises that benefited them. Overall, monitoring the blood glucose values helped in keeping the blood glucose levels within normal limits.

The average weekly readings were compared to see if there were improvements in the blood glucose values at the end of the study period. HbA1c values at the end of the research were recorded and compared to values at the beginning of the study.

Participants were given a questionnaire to answer questions and rate the application and entire process at the end of the research period. There was a steady decrease in blood glucose values and by the fourth week, 80% of participants had their blood glucose values below 7.0mmol/l. At the end of the research, 70% of participants in the Experimental group had their weekly blood glucose values properly controlled (consistently within the normal range). The monthly blood glucose values for participants in the experimental group showed significant decrease for 70% of participants in the experimental group with values below 7.0mmol/l. The HbA1c values for the experimental group reduced significantly at the end of the study with 80% below 7.0%. None of the participants in the experimental group was diagnosed with any additional Diabetic complications during or at the end of the study period.

Statistical analysis was done using Paired t – tests for the experimental group using HbA1c values before and after the exercise and the control group using HbA1c values before and after the exercise.

Analysis was also done using independent t – test to compare the HbA1c values in both the experimental and control groups after the exercise.

4.3 Post Exercise Evaluation

Participants were given a questionnaire to answer questions and rate the application and entire process.

Table 7: Evaluating the usability, acceptance and effectiveness of the mobile 'App'

Participant ID	Ease of use of 'app'	Acceptance of 'app'	Effectiveness	Readings by
G1	No	Yes	Excellent	Sms
G2	No	No	Good	Whatsapp
G3	Yes	Yes	Excellent	App
G4	Yes	Yes	Excellent	App
G5	Yes	Yes	Excellent	App
G6	Yes	Yes	Excellent	App
G7	Yes	Yes	Excellent	Sms
G8	No	Yes	Good	Whatsapp
G9	Yes	Yes	Excellent	App
G10	Yes	Yes	Excellent	App
G11	Yes	Yes	Excellent	App
G12	Yes	Yes	Excellent	App
G13	Yes	Yes	Excellent	App
G14	Yes	Yes	Excellent	App
G15	No	Yes	Good	Sms
G16	No	No	Good	Sms
G17	Yes	Yes	Excellent	App
G18	Yes	Yes	Excellent	Whatsapp
G19	Yes	Yes	Excellent	Whatsapp
G20	Yes	Yes	Excellent	App

4.4 Statistical Analysis

Statistical analysis was done using Paired t – tests for the experimental group using HbA1c values before and after the exercise and the control group as well, using HbA1c values before and after the exercise. Analysis was also done using independent t – test to compare the HbA1c values in both the experimental and control groups after the exercise.

Table 8: Summary Statistics of the "Before" and "After" Measurements of HbA1c in both Control and Experimental Groups

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	"Before" for Experimental Group	9.5800	20	2.191803	0.693109
Experimental					

	"After" for Experimental Group	6.5527	20	0.905826	0.286447
Pair 2 Control	"Before" for Control Group	9.1550	20	2.293766	0.725352
	"After" for Control Group	8.4100	20	2.157905	0.682390

Table 9: Paired Test Results of the measurement of HbA1c in both Experimental and Control Groups

		Paired Differences			T	Df	Sig. (2-tailed)
		Std. Error Mean	95% Confidence Interval of the Difference				
			Lower	Upper			
Pair 1	"Before" for Experimental Group - "After" for Experimental Group	0.614405	-4.417181	-1.63741	-4.927	19	0.001
Pair 2	"Before" for Control Group - "After" for Control Group	0.341276	-1.517020	0.02702	-2.183	19	0.057

The p-value of 0.001 for the paired test between the "Before" and "After" measurements in the Experimental Group was below the $\alpha = 0.05$, this means there is enough evidence to reject the null hypothesis and conclude that the introduction of IT tools for monitoring the blood glucose levels of patients suggests a significant difference between the "Before" and "After" measurements of HbA1c values in the experimental group. However, the p-value of 0.057 for the paired test between the "Before" and "After" measurements in the Control Group, greater than $\alpha = 0.05$ helps conclude that there is not enough statistical evidence to suggest that there is a significant difference between the "Before" and "After" measurements of HbA1c in the control group. This shows that the use of the IT tools to manage blood glucose levels was significant in reducing the HbA1c values in the experimental group.

4.5 Discussion

The results from the findings show that using the IT tools in self-managing Diabetes can positively impact glycaemic control in the short term. The Ministry of Health (Ghana) standard treatment guideline states the fasting blood glucose levels for diabetics as 4.0 – 7.0 mmol/l and that of two-hours after meal glucose as 4.0 - 8.0mmol/l. The average monthly blood glucose for 70% of participants in the experimental group was below 7.0mmol/l by the end of the exercise, whilst the control group had 30% below 7.0mmol/l. Normal HbA1c values for diabetics as published by American Diabetes association is <7.0%. HbA1c for the experimental group after the exercise was below 7.00% for 80% of participants (table 6), whereas the control group had 10% of participants having HbA1c below 7.00% (table 3). Participants were able to identify certain foods and

activities that increased their blood glucose levels and made choices as to what to avoid and what to eat.

Montori and others in their study conducted in 2004 yielded similar results; participants with type 1 diabetes that was poorly controlled even though they were given intensive insulin treatment sent their blood glucose values to healthcare providers regularly over a period of six months by means of a modem. Telephone "feedback" from a nurse was sent within 24 hours of each relay. At the end of the study period, participants' mean HbA1c levels decreased significantly from a mean of 8.2% to 7.8%; ($p = 0.03$) (Montori et al., 2004). However, this same approach was used by Cho and others for patients with type 2 diabetes and there were statistically significant ($P < 0.01$) improvements in blood glucose values for participants. The Internet group had HbA1c levels reduced significantly from a mean of 7.6% to 6.9% for the and that of the phone group, from a mean of 8.3% to 7.1% (Cho et al., 2009). In another study by Takenga and colleagues, it was concluded that information technology is a suitable instrument to support health care providers to effectively manage diabetes and also assist in the prevention of diabetic complications. Results obtained at the end of the trial showed significant improvement in mean HbA1c values for the experimental group 8.67% at the beginning of the research to 6.89% at the end. (Takenga et al., 2014).

Recording the blood glucose values had an impact on making personal effort to keep the levels within limits, this reflected in the weekly average glucose values recorded for the experimental group. There was a significant drop in monthly blood glucose values by the third month within the experimental group with 70% of the values falling below 7.0mmol/l. This indicates a significant improvement in blood glucose as well as HbA1c values for participants in the experimental group as compared to those in the control group.

5. CONCLUSION

The findings have addressed the purpose of the study because there was a significant improvement in blood glucose and HbA1c levels for those who used the devices (Experimental Group) with $p<0.05$ ($p=0.001$) and mean values of 9.58% 'before' and 6.55% 'after' the study, and none of them was diagnosed with additional Diabetic complications at the end of the study period. With the group that did not use the tools (Control Group), the HbA1c final measurements did not show any significant improvement, $p>0.05$ ($p=0.057$) with mean HbA1c values 'before' at 9.15% and 'after' the study at 8.42%, and 50% were diagnosed with other Diabetic complications including hypertension, eye problems, neuropathy and dyslipidaemia by the end of the study period. Comparing the group that used the tools (Experimental Group) and the group that did not use the tools (Control Group), the HbA1c final measurement in the Experimental Group was significantly better (lower) than that of the Control Group. All participants were satisfied with the system used.

This shows that using IT based tools to assist in the management of diabetes is effective and gives short term positive outcomes in terms of controlling blood glucose levels. It also shows that diabetic patients can be monitored at home to help them achieve normal blood glucose levels, hence reduced emergency room visits and complications associated with diabetes as well as reducing the burden on Health professionals and Healthcare facilities.

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