Android based Diabetic Manager to Enhance Compliance and to Control Blood Glucose Level among Type 2 Diabetic Patients in Magelang, Central Java, Indonesia

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Abstract

Android Based Diabetic Manager (ABDM) is an application used for diabetic patients to control their diet. This application is an easy way to remind them in consuming foods and giving them alert when its necessary calories have been achieved. This study was conducted in response to technological developments in the Era 4.0 to help people with Type 2 Diabetes Mellitus through diet control that can be done independently. This study was conducted in the city of Magelang aimed to evaluate whether using ABMD was effective to improve patients adherence in their diet and to control their blood glucose levels.

This experimental study was using pre test and post test with control group design. By using simple random sampling, 52 people suffering from Type 2 Diabetes Mellitus recruited in this study devided into two groups, ABDM group and control group.

The Pearson Chi-Square test result showed that there was significantly different between ABDM group and control group in the status of blood glucose control and patient adherence with *p* value was 0.048and 0.000 respectively (*p* value <0.05). This result indicated that H_0 was rejected and H_1 was accepted, which could be interpreted that *Android based Diabetic Manager*application influenced the status of blood sugar control and improved the patient adherence in managing their diet.

*Android based Diabetic Manager*application influenced the status of blood sugar control and improved the patient adherence in managing their diet.Recomendation was made to conduct future study in the wider Diabetes community by adding more complete types of menu list and its variations in the Android based Diabetic Manager.

Keywords

Android, Diabetes, Manager, Blood Glucose Level, Compliance.

Introduction

Diabetes Mellitus is a complex disorder and requires ongoing management to control blood glucose levels and prevent complications. Viswanatahan et. al. (2014) found that complications due to endocrine disorders include neuropathy, diabetic foot ulcers, eye complications and nephropathy. To control blood glucose levels, patient awareness is needed in the management of diabetes mellitus. Management of diabetes mellitus which includes 4 pillars including diet management, application of activities, control of blood glucose levels and education about diabetes must be carried out continuously. Rian, Kanittha and Paranee (2017) stated that continuous DM care required effective self-management education and was necesessarily supported by family members. However, diabetes self-management which is very complex is often constrained by patient non-compliance in carrying out the program. Al Mutairi (2015) classified the factors that influence the quality of diabetes care into two factors. They are patient factors and health worker factors. Patient factors include adherence, attitudes, beliefs, knowledge, financial resources and comorbidity factors. While health worker factors include trust, attitudes, knowledge, interactions between patients and health workers and communication.

Non-compliance is important in diabetes self-management. Adherence to medication, adherence to diet management and exercise play a large role in the success of diabetes management. Desroches, et al. (2013) identified several interventions used to improve adherence to diets in diabetic patients including education by increasing knowledge or understanding, inclusion, incentive, restriction, environment restructuring, such as changing the physical or social context, enablement, namely increasing meaning or decrease barrier to increase ability and combination of some of these interventions. Despite various interventions, diabetes control is still a problem for health workers. Santhanakrishnan, Lakshminarayanan and Sekhar (2014) conducted a study of factors affecting adherence to diabetes management of 135 diabetic patients found that adherence to medication (76%), diet modification (81.4%) and only 37% were compliant to do exercise. While knowledge related to risk factors (66%) and about complications (79%).

Furthermore, Desroches et al. (2013) who conducted a systematic review of diet adherence in diabetic patients found that adherence to the diet using interventions included telephone follow-up, video, contracts, feedback, nutritional tools and other complex interventions such as multiple interventions. However, these interventions did

not show differences in some dietary compliance outcomes compared to the control group. Most studies in the review reported that short-term adherence outcomes did not show a significant effect.

Other studies investigating interventions such as group sessions, individual sessions, reminders, restrictions and behavioral changes reported no significant difference in compliance outcomes. Meanwhile, Ali, Anderson and Kamaruddin (2007) conducted a qualitative study to evaluate diabetes control finding that patients see diabetes as a disease that comes alone and the duration of the illness is an obstacle for patients to adhere to treatment. Furthermore, Sohal, et al. (2015) who conducted a systematic review of barriers and facilitators in diabetes management found that the lack of understanding and misperception of patients towards diabetes management guidelines was a barrier for patients to follow the guidelines. It is also constrained because of language and communication in education about diabetes management provided by health workers.

Shantanakrishnan, Lakshaminarayanan and Kar (2014) said that optimal blood glucose control in diabetic patients depended on self-care in the form of adherence to dietary modification, medication, regular follow-up and physical activity. Non-compliance was believed to be the most common cause of failure in treatment (Nuesch et al., 2001). Disobedience will lead to reduced metabolic control which will contribute to the development and acceleration of diabetes complications.

Currently there are several android applications that have been developed to control calorie requirements. Researchers see that the application is used for the purpose of losing weight, maintaining weight, and increasing body weight with the determinants of caloric needs are gender, age, nutritional status, and activity. Because determining calorie requirements in diabetics has additional correction variables, namely pregnancy and metabolic stress (Sudoyo, Setiyohadi, Alwi, Simadibrata, & Setiati, 2010), an easy-to-use and easy to remember android application is offered to improve compliance with management diabetes. Android facility has become a tool that has been used by many people throughout the world including Indonesia. This condition provides an opportunity for smartphone users to take advantage of applications, especially in diabetes management through an application program called "Android Based Diabetes Manager". This application contains diet management and calorie count reminders, physical exercise reminders, documentation of blood glucose level examination results, use of anti-diabetic drugs, and health education through the information provided in this application. With this application, it is expected that patients can comply with diabetes management independently so that they can control their blood glucose levels.

Materials and Methods

This study was experimental study with pre-post test with control design. This study was to evaluate the use of Android Based Diabetes Manager (ABDM) application in blood gucose control in Type 2 Diabetic patients. The intervention group was given ABDM application. While the control group was given written information regarding dietary intake, activity, and oral hypoglycemic medication that was filled manually every day during the study period. Patients who are involved in this study were all type 2 Diabetec patients who had obtained information or prior knowledge about diabetes mellitus management either verbally or in writing through health education activities in Chronic Disease Management Program at the Primari Health Centre. The treatment in the two groups was given for 1 month and evaluated once a week by measuring the outcome in the form of blood glucose levels at a time. This study was conducted in the city of Magelang, Indonesia. This study was approved by Ethical review Comitte and all involved patients in this study were provided informed consent prior to enrollment. The sampling technique used was simple random sampling that met the inclusion and exclusion criteria. The inclusion creiteria included those who were able to use android smartphone, able to read and write, able to do daily activities and lived with other family members and those who had received information or knowledge about diabetes management both in writing, verbally, and through other information media. Respondents who had impaired vision and those who did not participate in the entire study activity were excluded from this study.

Study Procedure and Outcomes

Android Diabetic Manager Application was shared to the experimental group and explain how to use the ADBM application and distribute leaflets about the importance of diet, physical exercise, and the use of antidiabetic drugs in diabetes management to the control group after respondents signed the informed consent. Then, inviting respondents to carry out activities such as daily habits.

Conducting blood glucose levels while in the experimental group after one week using the ABDM application for measurement I and continued measurements in weeks II, III, and IV. Wilst, examining blood glucose levels when in the control group after one week of providing explanations and leaflets about the importance of diet, physical exercise, and the use of antidiabetic drugs in diabetes management for measurement I and continued measurements in weeks II, III, and IV, and repeating explain the importance of diet, physical exercise, and taking the recommended antidiabetic medication. A briefing as a

termination to the two groups conducted at the time of blood glucose measurement in the week IV.

Data Assessment and Statistical Evaluation

The data obtained was analyzed using univariate and bivariate. Univariate analysis was used to describe the distribution and percentage of blood glucose levels obtained each week contained tothe respondents then presented in the form of a frequency distribution table. Bivariate analysis was carried out on two variables to compare the stability of blood glucose levels between the treatment group and the control group using Chi-Square test.

A. Results and Discussion

The results of this study included 60 respondents who were divided into 2 groups. In the research process, 4 respondents experienced dropouts in each group because they did not fill out the application or did not fill in the daily calorie consumption sheet. Thus, the respondents in each group are 26 or the total number of respondents is 52. The results of the full study are explained below.

1. Characteristics of respondents

Characteristics of respondents in this study include the age and gender of the respondents as follows:

Table 1 Characteristics of respondents based on age and gender

Characteristic		Intervention Group		Control Group	
		Frequency	Percentage	Frequency	Percentage
Age	35 – 44	1	3.8	0	0
	45 – 54	2	7.8	2	7.8
	55– 64	13	50	14	53.8
	65– 74	6	23	7	26.9
	≥ 75	4	15.4	3	11.5
Gender	Male	14	53.8	3	11.5
	Female	12	56.2	23	88.5
	Total	26	100	26	100

Based on Table 1 above noted that the majority of respondents aged between 55-64 years with a total of 13 (50%) in the intervention group and 14 (53.8%) in the control group. Meanwhile, based on gender, male and female respondents in the intervention group were almost the same namely 14 and 12. Meanwhile, male respondents in the control group

only recorded 3 respondents and the remaining 23 respondents were women. Overall, based on gender, there were more women who participated in this study, as many as 35 respondents were compared with male respondents, namely 17.

2. Blood glucose level among respondents

Blood glucose level among respondents between two groups described in Tabel 2 and Tabel 3 as follows.

Table 2 Blood glucose level among intervention group during four weeks

Number of Respondent	Blood Glucose Level (mg/dl) / Week				Mean	Status
	1	2	3	4		
1	238	124	167	110	159,75	Controlled
2	350	262	320	224	289	Uncontrolled
3	135	145	199	197	169	Controlled
4	141	131	181	179	158	Controlled
5	175	232	153	145	176,25	Controlled
6	112	108	111	141	118	Controlled
7	178	182	138	201	174,75	Controlled
8	137	105	107	121	117,5	Controlled
9	278	138	193	175	196	Controlled
10	178	141	201	141	165,25	Controlled
11	140	226	211	132	177,25	Uncontrolled
12	215	257	148	232	213	Uncontrolled
13	255	262	264	197	244,5	Uncontrolled
14	205	284	192	110	197,75	Uncontrolled
15	230	305	171	180	221,5	Uncontrolled
16	318	459	284	403	366	Uncontrolled
17	142	201	127	141	152,75	Controlled
18	113	135	151	110	127,25	Controlled
19	251	248	207	222	232	Uncontrolled
20	354	229	327	315	306,25	Uncontrolled
21	112	107	97	135	112,75	Controlled
22	183	196	105	171	163,75	Controlled
23	251	284	267	257	264,75	Uncontrolled
24	220	215	163	231	207,25	Uncontrolled
25	205	215	317	323	265	Uncontrolled
26	296	292	283	167	259,5	Uncontrolled

Table 2 above shown that blood glucose level among respondents in the intervention group who controlled their blood glucose level were 14 and 12 were uncontrolled.

However, there were 6 respondents who controlled their blood glucose level had more than 200 mg/dl during four weeks.

Table 3 Blood glucose level among control group during four weeks

Number of Respondent	Blood Glucose Level (mg/dl) / Week				Mean	Status
	1	2	3	4		
1	205	243	198	233	219,75	Uncontrolled
2	234	209	187	205	208,75	Uncontrolled
3	178	205	235	198	204	Uncontrolled
4	205	186	209	205	201,25	Uncontrolled
5	198	216	201	199	201,5	Uncontrolled
6	234	278	223	205	235	Uncontrolled
7	232	221	198	207	214,5	Uncontrolled
8	175	179	179	170	175,75	Controlled
9	215	266	193	183	214,25	Uncontrolled
10	185	102	110	94	122,75	Controlled
11	190	272	180	282	231	Uncontrolled
12	232	179	175	222	202	Uncontrolled
13	134	180	121	175	152,5	Controlled
14	174	124	102	100	125	Controlled
15	139	127	104	188	139,5	Controlled
16	126	125	167	151	142,25	Controlled
17	237	184	238	145	201	Uncontrolled
18	171	245	184	261	215,25	Uncontrolled
19	135	100	116	120	117,75	Controlled
20	216	269	258	155	224,5	Uncontrolled
21	196	245	254	268	240,75	Uncontrolled
22	228	187	205	189	202,25	Uncontrolled
23	198	208	187	219	203	Uncontrolled
24	208	213	245	223	222,25	Uncontrolled
25	204	221	245	213	220,75	Uncontrolled
26	224	345	321	321	302,75	Uncontrolled

Based on Table 3 above noted that respondents in the control group who controlled their blood glucose level were 7 and 19 were uncontrolled. Table 3 also mentioned that all respondents who controlled their blood glucose level (n = 7) had result of blood glucose test under 200 mg/dl during four weeks.

3. Analisa Bivariat

Table 4 Blood glucose status in the intervention and control groups

		Blood Glucose Status		Total
		Controlled	Uncontrolled	
Group	Group of Diabetes Manager	14	12	26
	Control Group	7	19	26
Total		21	31	52

Based on Table 4, above shows that the status of controlled blood glucose is more in the control group which is 14. While only 7 respondents with the status of controlled blood glucose in the treatment group.

Table 5 Chi-square test results for Blood Sugar Status and ABDM

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	3,914[a]	1	.048		
Continuity Correction[b]	2,876	1	.090		
Likelihood Ratio	3,973	1	.046		
Fisher's Exact Test				.089	.044
N of Valid Cases	52				

Based on the results of the Chi-square test in Table 5, it is known that the asymp value. Sig. (2-sided) in the Pearson Chi-Square test is 0.048 or smaller than 0.05 so it can be concluded that Ho is rejected and H1 is accepted. Thus it can be interpreted that Android based Diabetic Manager influences the status of blood glucose control.

Table 6 Compliance of respondents in regulating their diet onGroup of Diabetes Manager and Control Group

		Compliance		Total
		Obey	Not Obey	
Group	Group of Diabetes Manager	23	3	26
	Control Group	10	16	26
Total		33	19	52

Based on Table 6 above shows that the compliance of respondents in managing their diet using the ABDM application is very much as many as 23 respondents. While only 3 respondents did not comply with their diet. Furthermore, in the control group, most respondents did not comply with the diets recorded as many as 16 respondents.

Table 7 Chi-Square Test Results Compliance with ABDM

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	14,016[a]	1	,000		
Continuity Correction[b]	11,943	1	,001		
Likelihood Ratio	15,028	1	,000		
Fisher's Exact Test				,000	,000
N of Valid Cases	52				
Based on the results of the Chi-square test in Table 7, it is known that the asymp value. Sig. (2-sided) in the Pearson Chi-Square test is 0,000 or smaller than 0.05 so it can be concluded that Ho is rejected and H1 is accepted. Thus it can be interpreted that ABDM affects the compliance in managing their diet.					

B. Discussion

The results of this study indicate that patients with type 2 diabetes are found in people between the ages of 55 - 64 years. This is consistent with the results of the 2018 Basic Health Research of Indonesia which noted that the age of most diabetic patients was 56 - 64 years-old. Diabetes is a degenerative disease where the function of the pancreas to produce insulin is reduced or insulin experiences resistance.

Several factors influence the development of type 2 diabetes. Sarasaswati (2009) states that the causes of type 2 diabetes are multifactorial. Genetic factors and environmental influences contribute greatly to causing diabetes mellitus such as obesity, a high-fat and low-fiber diet and a sedentary lifestyle or exercise. Wu, Ding, Tanaka & Zhang (2014) also explained that type 2 diabetes is a result of complex interactions between heredity and the environment together with risk factors such as obesity and sedentary lifestyle. Other risk factors include smoking (Hu, Manson, Stampfer & Colditz, 2001) and alcohol consumption (Manson, Ajani & Liu, 2000). In addition, diet is also a modifiable risk factor for type 2 diabetes. Liu, Manson, Stampfer & Hu (2000) found that a low-fiber diet with a high glycemic index was positively associated with risk factors for type 2 diabetes.

Meanwhile, the results of this study indicate that overall respondents were more female. The results of Riskesdas 2018 also found that in the category of non-communicable diseases due to diabetes mellitus, women accounted for 1.8% while for men it was 1.2%. Kautzky-Willer, Harreiter & Pacini (2016) mentioned that due to gender differences, type 2 diabetes is often diagnosed in young men and body mass index. However, most risk factors namely obesity are more often found in women. In general, the different ratios

between men and women with type 2 diabetes vary between countries. Diversity in biology, culture, lifestyle, environment and social and economic status affects the predisposition, development and clinical presentation factors between men and women.

The treatment of diabetes mellitus continuously requires effective self-management and is supported by family members. Braunwald (2005) mentioned that diabetes care diabetes health education and comprehensive self-management of diabetes is very important. Nevertheless, patient compliance is an important factor in self-management of diabetes mellitus. Al Mutairi (2015) states that there are patient factors and health staff factors that influence the quality of diabetes care. Including patient factors including adherence. Compliance in diabetes mellitus management includes adhering to diets, monitoring blood sugar levels, exercise and adherence to drug therapy. However, compliance in self management is often constrained by many factors. According to Kanarsih (2012) factors that can affect compliance include situation factors such as family support for patients, understanding factors, disease conditions and recall. Non-compliance is believed to be the most common cause of failure in treatment (Nuesch, et al., 2001).

Shantanakrishnan, Lakshaminarayanan and Kar (2014) stated that adherence to diet, medication, follow-up care and physical activity affected the control of patients' blood sugar levels. Disobedience will lead to reduced metabolic control which will contribute to the development and acceleration of diabetes complications. Kassahun, Gase & Rike (2016) who researched adherence in the treatment of diabetes found that only patient adherence to medication only 31, 2%. One of the causes of the non-compliance is the treatment complex and failure to remember. Meanwhile, Hariri, Daud, Almaiman & Saghir (2017) in their study related to adherence to diet and exercise in patients with type 2 diabetes found that patient compliance was still very low at 21% for diet and 15% for exercise.

Smartphones are mobile devices that are easily carried everywhere - so users can easily access information and use it in various applications. In this study shows that the use of Android-based smartphone diabetes manager application increases compliance with diabetic patient's diet management. Kerr, Hopper & Axelrod (2017) mentioned that there were several applications related to diabetes management to monitor blood glucose, diet and exercise.

As mentioned by Kassahun, Gase & Rike (2016) that one of the failures in diabetes management is adherence caused by failure to remember. The use of applications in Android will make it easy for users to remember how many calories they have consumed

and also find out the results of blood glucose levels beforehand. Jo, et al. (2017) mentioned that mobile applications have great benefits when applied to patients with diabetes; adherence to diabetes self management can be improved through the application. However, not all applications are suitable for all patients. In that study, Jo, et al. (2017) found that the percentage of patients who achieved the HbA1c treatment goal was significantly higher in the application user intervention group compared to the control group.

Conclusion and Recomendation

Based on the results of this study it can be concluded that most patients in this study were women who were 55-64 years-old. In this study, the use of a diabetes manager application can increase the compliance in managing their diet and show a positive impact in controlling blood glucose level.

The use of a diabetes manager application with a smartphone has a huge advantage.It reminds them on their diet management and monitors the results of blood glucose test. So, that is expected to be able to control their blood glucose levels. Further study recommendations are expected to include the wider Diabetes community by adding a more complete menu list of types and variations in the Diabetes Manager Application.

Data Availability

The data of this study can be accesed through the research authors.

Conflicts of Interest

All authors are lecturers at Health Polytechnic Semarang, Indonesia and have no conflict of interest from this study.

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