ORIGINAL ARTICLE

Factor Associated with Long-Term Control Blood Glucose Based on HbA1c Level in Type 2 Diabetes Mellitus Patients

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ABSTRACT

Introduction: Degenerative diseases are a double burden in developing countries, including type 2 Diabetes Mellitus (T2DM). The prevalence of DM in Indonesia based on the results of Fundamental Health Research 2018 is 2%. This study aims to determine factor associated with long-term control of blood glucose based on HbA1c level in Type 2 Diabetes Mellitus Patients. **Methods:** The research design used the cross-sectional approach. The samples in this study were 40 patients with T2DM. The sampling technique used was purposive sampling. Variables of social demographics, knowledge, attitudes, practice, physical activity and medical treatment of DM were measured using a questionnaire. Obesity and blood pressure were measured using the BMI and sphygmomanometer, respectively. Dietary energy adequacy, carbohydrates, protein, and fat measurements used the Food Frequency Questionnaire. HbA1c levels, using secondary data obtained from the results of examinations in T2DM patients using a Glycohemoglobin Analyzer. Data was analyzed using univariable, bivariable, and multivariable, while the magnitude of risk factor used the odds ratio (OR) and 95% Confidence Interval (CI). **Results:** Uncontrolled blood glucose level in patients T2DM reached as high as 75%. The factors associated with HbA1c level in patient with T2DM are: employment (p-value= 0.011; OR= 9.33; 95%CI= 1.38-63.2), medical treatment of DM (p-value= 0.015, OR= 0.08; 95%CI=0.007-0.89); dietary energy adequacy (p-value=0.025; OR=9; 95%CI= 1.01-80.13). **Conclusion:** T2DM patients can control blood glucose level by taking medical treatment of DM regularly and maintaining nutritional intake, especially dietary adequacy intake.

Keywords: T2DM, HbA1c, Medical treatment, Dietary energy adequacy

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INTRODUCTION

Diabetes Mellitus is a major lifestyle disorder. The International Diabetic Federation estimated that the prevalence of Type 2 Diabetes Mellitus (T2DM) is expected to double in the number worldwide in the next two decades, from 382 million in the year 2013 to 592 million people in 2035. The escalation of cases is more pronounced in Asian countries, where it has been reported that approximately 60% of the cases reside (1). The prevalence of DM in Indonesia, based on the results of Fundamental Health Research in 2018, showed approximately 2% of those diagnosed by medical professionals (2).

DM is a metabolic syndrome caused by an increase in blood glucose levels in patients. This is due to decreased insulin produced by beta cells of the pancreas or the occurrence of insulin resistance. Insulin is a hormone that is released by the pancreas which is responsible for maintaining the normal level of blood sugar. Insulin supplies glucose into cells for energy production or storage (3,4).

There are five pillars and the main principles of DM management are education, healthy eating pattern or dietary planning, physical activity, medication with pharmacotherapy, and checking blood glucose levels regularly (5–7). Diabetes Mellitus is a chronic illness, so those involved in treatment include not only doctors, nurses, and nutritionists, but also the patient and their family. A number of ways of gaining comprehension are through providing education, establishing DM awareness groups, monitoring appropriate food consumption of the patients, and creating physical activities that will improve DM management (8).

Patients with T2DM should have controlled diabetes, meaning that if they suffer from diabetes, they are required to be able to control blood sugar levels through regular examinations and monitoring, and are expected

to avoid various complications due to diabetes. One method for controlling blood sugar levels is by examining Glycated Hemoglobin (HbA1c) (9). In patients with T2DM, HbA1c is used as a biomarker to monitor blood glucose levels. Glycated Hemoglobin (HbA1c) was initially identified as hemoglobin bound to glucose in the blood in patients with T2DM. HbA1c is an important indicator for long-term glycemic control with the ability to reflect an individual's average blood plasma glucose levels over the preceding 2–3 months. (10,11). This study aims to determine factors associated with long-term control of blood glucose based on HbA1c levels in Type 2 Diabetes Mellitus patients.

MATERIALS AND METHODS

Study design
This study was an observational analytic study with a cross-sectional design.

Participants and setting
The samples in this study were patients with T2DM who were registered in the Chronic Disease Management Program at Cimahi Tengah Public Health Center, Padasuka Public Health Center and Kasih Bunda Health Clinic. The sample size in this study was 40 patients with TD2M who had their HbA1c levels checked. This study was conducted from March to December 2019. The sampling technique used is purposive sampling.

Ethical considerations
This research was approved by the Ethics Committee in Stikes Jenderal Achmad Yani Cimahi with number registration: 25/KEPK/IV/2019.

Variable and Data Collection
Independent variables in this research consisted of social demographic (age, gender, marital status, employment status and family history for T2DM) were measured using a questionnaire. The age variable was categorized into <59 years old (adult) and ≥ 60 years old (elderly). The gender variable was divided into male and female, and marital status was divided into single and married. The employment variable was categorized into formally employed and self-employed. Respondents were asked whether their family had ever had diabetes mellitus.

Medical treatment of DM was measured using a questionnaire. Physical activity was carried out by respondents every 24 hours and expressed in their physical activity level. Physical activity was categorized as low and moderate. Obesity was measured based on body mass index (BMI). Obesity was defined as a BMI of > 30. A blood pressure of 140/90 mmHg or higher was considered hypertension. Blood pressure was measured with a sphygmomanometer. Dietary adequacy energy, carbohydrates, protein, and fat measurements employed the Food Frequency Questionnaire. Dietary adequacy was categorized into excess (≥110%) and sufficient (<110%). Variable HbA1c levels used the secondary data obtained from the results of examinations in T2DM patients using a Glycohemoglobin Analyzer.

Data Analysis
Data analysis used univariable to explore each variable separately, bivariable analysis used the chi-square test, and multivariable analysis with multiple logistic regression. The significant test used a p-value with a significance level of 95%. The magnitude of the risk factor is determined by the Odds Ratio (OR) and 95% Confidence Interval (CI).

RESULTS

HbA1c level
HbA1C is the preferred test for assessing glycemic control in T2DM with long-term diabetes complications, and it is used for T2DM monitoring and chronic management. HbA1c reflected the average blood glucose level over the previous 2–3 months. A HbA1c level of 6.5% is recommended as the cut-off point for diagnosing Diabetes Mellitus. This research showed that HbA1c level >6.5% amounted to 25%, with an average HbA1c level of 5.64%. Meanwhile, patients T2DM with HbA1c levels of 8% to 47.5% outperformed subjects with an average HbA1c of 9.7% (Table I).

Table I: HbA1C level in patient with Type 2 Diabetes Mellitus (n= 40)

HBA1c	Total	Persentage (%)	Mean (min-max)
< 6,5%	10	25	5.64 (4.3 – 6.4)
6,5% - 8%	11	27.5	7.3 (6.7-7.8)
≥ 8%	19	47.5	9.7 (8-14.6)

Social Demographic Data
Characteristics of patients with T2DM in this research were obtained from social demographic data, consisting of age, gender, marital status, employment and family history of DM. Table II shows the social demographic data from patients with T2DM. Diabetes patients with uncontrolled HbA1c levels were found in as many as 14 people (84.4%) among the elderly, 23 people (76.7%) among females, and 4 people (100%) among those with a single marital status. Respondents with formally employed with HbA1c uncontrolled were as many as 28 people (82.4%) and T2DM patients with uncontrolled HbA1c who have a family history of DM were as many as 12 people (85.7%)

Physical Activity, Medical Treatment of DM, Obesity and Hypertension with HbA1c level in T2DM Patient
As shown in table III, T2DM patients with uncontrolled HbA1c and low physical activity are as many as 24 people (75%). As many as 29 people (80.6%) are receiving medical treatment for Diabetes Mellitus as a result of an HbA1c level examination in the uncontrolled group. Patients with T2DM who are included in the category of being obese with uncontrolled HbA1c levels

Table II: Frequency distribution HbA1c level based on characteristic of respondents (n= 40)

Variable/Category	HbA1c	
	Uncontrolled (> 6.5%)	controlled (≤ 6.5%)
Age		
Elderly	14 (82.4%)	3 (17.6%)
Adult	16 (69.6%)	7 (30.4%)
Gender		
Female	23 (76.7%)	7 (23.3%)
Male	7 (70%)	3 (30%)
Marital Status		
Single	4 (100%)	0 (0%)
Marriage	26 (72.2%)	10 (27.8%)
Employment		
Formally Employed	28 (82.4%)	6 (17.6%)
Self Employed	2 (33.3%)	4 (66.7%)
Family History of DM		
Yes	12 (85.7%)	2 (14.3%)
No	18 (69.2%)	8 (30.8%)

Table III: Frequency distribution HbA1c level based on physical activity, medical treatment of dm, obesity, hypertension (n=40)

Variable/Category	HbA1c	
	Uncontrolled (> 6.5%)	controlled (≤ 6.5%)
Physical Activity		
Low	24 (75%)	8 (25%)
Moderate	6 (75%)	2 (75%)
Medical treatment of DM		
Yes	29 (80.6%)	7 (19.4%)
No	1 (25%)	3 (75%)
Obesity		
Yes	13 (76.5%)	4 (23.5%)
No	17 (73.9%)	6 (26.1%)
Hypertension		
Yes	14 (82.4%)	3 (17.6%)
No	16 (69.6%)	7 (30.4%)
Dietary Adequacy Energy		
Excess	15 (93.8%)	1 (6.2%)
Sufficient	15 (62.5%)	9 (37.5%)
Dietary Adequacy Carbohydrate		
Excess	2 (100%)	0 (0%)
Sufficient	28 (73.7%)	10 (26.3%)
Dietary Adequacy Protein		
Excess	5 (83.3%)	1 (16.7%)
Sufficient	25 (73.5%)	9 (26.5%)
Dietary Adequacy Fat		
Excess	7 (87.5%)	1 (12.5%)
Sufficient	23 (71.9%)	9 (28.1%)

are 13 people (76.5%) and 14 people have hypertension (82.4%). Nutritional adequacy is assessed based on dietary energy adequacy, carbohydrates, protein, and dietary fat adequacy. Respondents with excess energy intake with uncontrolled HbA1c levels were 15 people (93.8%). All respondents who had excess carbohydrate intake had uncontrolled HbA1c levels (100%). T2DM patients with uncontrolled HBA1c levels and excess protein intake amounted to 5 people (83.3%), and excess fat intake amounted to 7 people (87.5%).

Factor Associated with HbA1c level in patient with DM

Employment was discovered to be a risk factor for uncontrolled HbA1c levels in T2DM patients (p-value = 0.011), with a magnitude of risk factor for uncontrolled HbA1c level of 9.33 (95% CI = 1.38-63.2). Medical treatment for diabetes is a factor associated with HbA1c level (p-value= 0.015; OR= 0.08; 95% CI= 0.007-0.89), indicating that despite receiving medical treatment, T2DM patients' blood glucose level has remained uncontrolled over the last two months. Dietary energy adequacy is a risk factor for HbA1c (p-value= 0.025; OR= 9; 95% CI=1.01-80.13). As shown in table IV, the multiple logistic regression test revealed that DM medical treatment was the most important factor influencing HbA1c levels in T2DM patients (p-value= 0.037; OR= 0.046; 95% CI= 0.003-0.833).

Table IV: Factor associated with HbA1c level in patient with Type 2 DM

Variable/Category	p-value	OR (95%CI)
Employment	0.011*	9.33 (1.38 – 63.2)
	0.082**	7.4 (0.07-71.61)
Medical treatment of DM	0.015*	0.08 (0,007 – 0.89)
	0.037**	0.046 (0.003-0.833)
Dietary Adequacy Energy	0.025*	9 (1.01 – 80.13)
	0.11**	8.25 (0.58-116,4)

* Chi Square test
** Multiple Regression Logistic

DISCUSSION

In patients with T2DM, glycated hemoglobin (HbA1C) in the blood is used as a standard for testing and monitoring blood glucose levels. HbA1c provides an average blood glucose level over the previous eight to twelve weeks. HbA1c is used for periodic monitoring of medical care for patients with T2DM along with exercise, physical activity, and diet (10–12). Controlling and maintaining blood glucose levels is important for people with T2DM because it helps prevent micro- and macrovascular complications, and HBA1c levels should be less than 6.5%. (11). HbA1c level >8% indicates uncontrolled blood glucose levels and a high risk of several complications (3). The higher HbA1C level in subjects who have T2DM has been identified with an increase in the occurrence of long-term specific effects of diabetes such as retinopathy, nephropathy, neuropathy and macrovascular complications such as heart attack, stroke, and cerebrovascular disease (10,12). Based on the research by Kurniawan (2018), it was found that the relationship between T2DM risk level and cardiovascular disease is causal. It means that the higher risk factor for T2DM will be caused by the higher risk factor for cardiovascular disease (13).

The result of the research showed that the majority of patients with T2DM have an HbA1c level of > 6.5%. It means that they have low control and maintenance of blood glucose levels. The high level of HbA1c reflects the non-adherence of patients undergoing integrated care for DM. It is related to medical treatment of DM and nutritional adequation. In a study by Hartini (2016), it was found that higher HbA1c levels (6.4-10%) in outpatients at Abdul Wahab Syahranie Hospital Samarinda were 44% (12). The Research by Badedi (2016), found that respondents with poor glycemic control (HbA1c >7%) amounted to 75% (14), and the median of HbA1c for the study was 8.7% (15).

This study showed that social demography was not significantly related to HbA1c level in patients with T2DM, but it was found that respondents aged ≥ 60 years old (elderly), female, and having a family history of DM were reported to have a more uncontrolled HbA1c level. Results of the research by Ngamal (2021) showed that patients with T2DM were dominated by females (63%). It shows that the prevalence of T2DM is higher in women (3). Uncontrolled HbA1c levels are significantly associated with formal employment.

In this research, it was found that obesity based on BMI (Body Mass Index) is not significantly associated with HbA1c level in patients with T2DM. The majority of respondents with a BMI of 30 kg/m3 or more have uncontrolled HbA1c. This study, according to Karimah et al (2019), found that respondents who were overweight and had an uncontrolled HbA1c level were 30% (16), and according to Fareedh (2020), the study found a positive correlation between BMI and HbA1c in T2DM. This means that the higher BMI is accompanied by increasing HbA1c (17). Obesity is often associated with insulin resistance, which affects insulin production and causes an increased blood glucose level (17).

In this study, medical treatment of DM is a factor associated with HbA1c level. Patients with T2DM require medical treatment to control blood glucose levels with oral antidiabetic drugs (OADs), such as Metformin, Dipeptidyl Peptidase-4 Inhibitor, and Sulfonylurea. Oral antidiabetic drug therapy is used to achieve optimal glycemic control in patients with T2DM. Several studies have shown that drug efficacy for diabetes medications can be reduced in HbA1c levels by an average of one percent (18). In this study, most of the patients with T2DM were taking OADs such as Metformin, Glimepiride, and Acarbose.

Dietary intake has an essential role in integrated care management for T2DM, especially metabolic control for achieving optimal weight. The most important challenge of treatment for patients with T2DM is determining what to eat and developing an individualized eating plan. The beneficial consumption of fruits and vegetables can prevent and protect the development of T2DM because they are rich in nutrients, fiber, and antioxidants (5,19). Several studies have shown that dietary intake that affects blood glucose levels in T2DM patients are dietary energy adequacy, carbohydrate, protein, and fat (5). In this study, dietary energy adequacy is a factor associated with HbA1c level in patients with T2DM. Energy intake has been correlated with obesity, related to volume of food, composition, and quality of the diet. Consumption of red meat, sweets, and fried foods can increase the risk of insulin resistance and, as a result, the development of T2DM (19).

Patients with T2DM need challenges to be managed appropriately. This includes the patient having to take OADs medication regularly, medical nutrition therapy, and controlling dietary intake as an integrated part of diabetes management care to achieve optimal glycemic control (20,21). Patients with T2DM need to implement Diabetes Self-Management Education/Support, which is a self-care behavior in the management of DM. This is effective in improving healthy living habits and implementing a healthy diet and physical activity (22). Patients with T2DM who have good management of care of their disease, including dietary nutrition, medical treatment with OADs, physical exercise, glucose control, and treatment of T2MD, lead to a perceived higher quality of life. (5,21).

CONCLUSION

According to this study, factors associated with HbA1c levels in T2DM patients include employment status, DM medical treatments, and dietary adequacy. Patients with T2DM must implement integrated management care for DM, controlling blood glucose levels for the previous 2-3 months through HbA1c levels, so that they can control and monitor the progression of DM and prevent various complications. Controlling and maintaining blood glucose levels in T2DM patients over time is critical for diabetes management, particularly dietary adequacy.

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REFERENCES

1. Ramachandran A. Trends in prevalence of diabetes in Asian countries. World J Diabetes. 2012;3(6):110.
2. Kementerian Kesehatan RI. Diabetes mellitus. Jakarta; 2018.
3. Ngamal EM, Pramudianti MID, Prasetya E. Correlation between eosinophil to leukocyte ratio (ELR) and HbA1c in type 2 diabetes mellitus patients. Malaysian J Med Heal Sci. 2021;17(April):82–4.
4. Sari RN. Diabetes mellitus. Yogyakarta: Nuha Medika; 2012.
5. Koor B, Nakhaie M, Babaie S, Ranjbaran M. Dietary Intake Adequacy and Evaluation of Nutritional Value in Diabetic Patients. Br J Med Med Res. 2016;13(9):1–8.
6. Sukardji K. Penatalaksanaan Diabetes Mellitus Terpadu. In Jakarta: Balai Penerbit Fakultas Kedokteran Universitas Indonesia; 2007.
7. Suciana F, Arifianto D. Penatalaksanaan 5 Pilar Pengendalian Dm Terhadap Kualitas Hidup Pasien Dm Tipe 2. J Ilm Permas J Ilm STIKES Kendal.

2019;9(4):311–8.
8. Waspadji S. Penatalaksanaan Diabetes mellitus Terpadu. In Jakarta: Balai Penerbit Fakultas Kedokteran Universitas Indonesia;
9. Driyah S, Oemiati R, Riyadina W. Indikator HbA1c pada Responden DM pada Studi Kohor Faktor Risiko Penyakit Tidak Menular di Kota Bogor , Indonesia 2017: Korelasi kadar Glukosa Darah dan Kolesterol Total. J Biotek Medisiana Indones. 2020;9(2):81–9.
10. Sherwani SI, Khan HA, Ekhzaimy A, Masood A, Sakharkar MK. Significance of HbA1c test in diagnosis and prognosis of diabetic patients. Biomark Insights. 2016;11:95–104.
11. WHO. Use of Glycated Heomoglobin (HbA1c) in the Diagnosis of Diabetes Mellitus. Report of a WHO Consulation. 2011.
12. Hartini S. Hubungan HBA1c Terhadap Kadar Glukosa Darah Pada Penderita Diabetes Mellitus Di RSUD Abdul Wahab Syahranie Samarinda. J Husada Mahakam. 2016;4(3):171–80.
13. Kurniawan T, Afrimasari E, Hartati S. Type 2 Diabetes Mellitus Risk Level, Cardiovascular Diseases Risk Level, and Quality of Work Life among University Staffs; Correlational study. J Keperawatan Padjadjaran. 2018;6(2).
14. Restrepo BI. Diabetes and tuberculosis. Microbiol Spectr [Internet]. 2016 [cited 2019 Aug 16];4(6). Available from: http://www.ncbi.nlm.nih.gov/pubmed/28084206
15. Badedi M, Solan Y, Darraj H, Sabai A, Mahfouz M, Alamodi S, et al. Factors Associated with Long-Term Control of Type 2 Diabetes Mellitus. J Diabetes Res. 2016;2016.
16. Karimah HN, Habibah N, Sarihati IGAD. Gambaran Kadar HbA1C pada pasien Diabetes Mellitus tipe 2 di RSUD Wangaya. Meditory J Med Lab. 2019;6(2):88–98.
17. Fareedh R, K S, P M. Corelation between body mass index and glycated hemoglobin in type 2 diabetes mellitus patients. Drug Invent Today. 2020;08(3):623–8.
18. Kanatsuka A, Sato Y, Kawai K, Hirao K, Kobayashi M, Kashiwagi A, et al. Relationship between the efficacy of oral antidiabetic drugs and clinical features in type 2 diabetic patients (JDDM38). J Diabetes Investig. 2016;7(3):386–95.
19. Sami W, Ansari T, Butt NS, Rashid M, Hamid A. Effect Of Diet Counseling On Type 2 Diabetes Mellitus. Int J Sci Technol Res. 2015;4(8):112–8.
20. Lee ZY, Airini IN, Hamdy O, Barakatun-Nisak MY. Nutritional characteristics and clinical outcomes of critically ill patients with and without diabetes mellitus: A single-center prospective observational study in Malaysia. Malaysian J Med Heal Sci. 2020;16(16):116–21.
21. Winahyu KM, Anggita R, Widakdo G. Characteristics of Patients, Self-Efficacy and Quality of Life among Patients with Type 2 Diabetes Mellitus. J Keperawatan Padjadjaran. 2019;7(3):3–8.
22. Noviyanti LW, Suryanto, Rahman RT. Peningkatan Perilaku Perawatan Diri Pasien melalui Diabetes Self Management Education and Support. Media Karya Kesehat. 2021;4(1):67–77.