Glycemic Control Determinant of Diabetes Mellitus Patients

I Wayan Sukawana[1*], I Made Sukarja[2], Listina Ade Widya Ningtyas[3], Ni Luh Putu Yunianti Suntari[4], Ni Made Juniari[5]

[1] Nursing Department, Denpasar Health Polytechnic, Indonesia; wsukawanajkp@gmail.com (Corresponding Author)

ABSTRACT

Diabetes Mellitus (DM) is a chronic disease that cannot be cured. Complications in DM are the main cause of blindness, kidney failure, heart attacks, strokes, and amputations of the lower limbs. Various problems in DM can be prevented by controlling DM. DM control is influenced by individual factors and external factors. This study aims to determine the determinants of DM control on DM control parameters. The study was carried out with a cross-sectional design on 31 DM patients who were taken consecutively in July 2022 at the Ubud I Gianyar Health Center. The data collected in this study were HbA1c levels, blood glucose levels (fasting and 2 hours post-prandial), systolic and diastolic blood pressure. The results obtained are factors of age, gender, duration of DM, and dietary adherence together had a significant effect of 75.6% (p-value = 0.00) on HbA1c control. There is a significant contribution of 39.5% to systolic control. Has a significant effect (p-value omnibus test = 0.013) of 45.2% on controlling fasting glucose levels. The conclusion is that DM control by intervening modifiable factors such as emphasizing the importance of dietary adherence.

Keywords: glycemic control; HbA1C; diabetes mellitus

INTRODUCTION

Diabetes Mellitus (DM) is a chronic disease threatening global public health. The prevalence of DM continues to increase. In the last three decades, the number of DM has increased fourfold. In 1980 the number of DM worldwide was 108 million, increasing to 422 million in 2014 (WHO, 2022). The DM is estimated to reach 784 million in 2045 (International Diabetes Federation, 2021). The prevalence of DM has increased more rapidly in middle and low-income countries. Basic Health Research (Riskesdas) reports that within five years since 2013, there has been a significant increase in DM in Indonesia. In 2013 the number of DM in Indonesia was 6.9% of the total population, then increased to 8.5% in 2018. This number placed Indonesia in sixth place in the world with the highest number of DM patients (Kementerian Kesehatan RI, 2018). DM cases in Bali are ranked ninth among most patients seeking outpatient treatment at health service units (Dinas Kesehatan Provinsi Bali, 2018). What is more worrying is that DM ranked first in most cases in outpatient installations in Gianyar Regency in 2016, including the Ubud Health Center 1 (Dinas Kesehatan Kabupaten Gianyar, 2018). This number is expected to continue to increase.

DM is a metabolic disorder caused by the pancreas being unable to produce optimal insulin or due to insulin receptor resistance. Insufficient insulin production or the presence of insulin-receptor resistance results in chronic hyperglycemia. Chronic hyperglycemia results in hyperglycemia in some body tissues. Some body tissues such as hemoglobin, blood vessels, nerves, kidneys, retina, and heart muscle experience a flood of glucose. Glucose trapped in these tissues undergoes metabolism to form substrates that do not decompose. The accumulation of undecomposed substrates causes damage to the structure and function of the tissue. Damage to the structure and function of hemoglobin, blood vessels, and nerves is the forerunner of complications in the DM (Waspadji, 2014). Decreased function of blood vessels and nerves triggers a decrease in the function of organ systems, such as the motor system. Research conducted by Nistiandani, Rondhianto, & Rozsy (2021) on the description of motor nerve damage reported that 75.4% of DM patients experienced motor damage to the right leg muscles.

DM is a cause of blindness, kidney failure, heart attacks, strokes, and amputations of the lower limbs. Adults with DM have three times the risk of heart attack and stroke. Besides the complications, the death rate from DM also continues to increase. Between 2000 and 2019, the death rate from diabetes increased by 3%. In 2019 it is estimated that the number

of deaths due to DM will reach 2 million deaths (WHO, 2022). The International Diabetes Federation (IDF) reported 6.7 million deaths in 2021 related to DM (International Diabetes Federation, 2022).

Aside from being a cause of death, DM also creates a high economic burden for patients and the government. The IDF reported that the cost of handling DM reached 966 billion USD. These costs have increased by 316% in the last 15 years (International Diabetes Federation, 2021). The National Health Insurance administering agency (JKN) reports that funding for DM services in Indonesia reached 700.29 billion rupiahs in 2014. This amount continues to increase to 1.877 trillion rupiahs in 2017 (Kementerian Kesehatan RI, 2018).

DM is a chronic disease that cannot be cured. Various problems in DM can be prevented by controlling DM. The Indonesian Endocrinology Association (Perkeni) determines the parameters for DM control in Indonesia. These parameters include HbA1c less than 7%, LDL cholesterol less than 100 mg/dl, triglycerides less than 150 mg/dl, and HDL cholesterol for men more than 40 mg/dl and more than 50 mg/dl for women, body mass index 18.5-22.9, pre-prandial capillary blood glucose level 80-130 mg/dl, 2 hours postprandial capillary blood glucose level less than 180 mg/dl, blood pressure less than 140/90 mmHg. DM control in Indonesia has not been satisfactory due to various factors (Soelistijo et al., 2021). Research in Sumbersari, Jember Indonesia in 2021 found all subjects with glucose levels above normal limits (Kurdi, Abidin, Priyanti, & Kholis, 2021). Research in Depok found that the average glucose level of DM patients was 370.38 ± 87.309 (Savitri & Ratnawati, 2022).

Individual and external factors influence the control of DM. Individual factors include the duration of the disease, adherence to taking medication, adherence to diet, and activity. The external factor that influences DM control is the distance to healthcare facilities. It is estimated that only 66% of the total DM patients are undergoing treatment. Only 22% are well-controlled (Soelistijo et al., 2021). Thus, it is necessary to study other factors that influence DM control. Based on this, the determinants of age, gender, duration of DM, and dietary adherence were investigated against DM control parameters, namely, HbA1c, LDL, BMI, Systolic pressure, diastolic pressure, fasting blood glucose levels, and 2-hour postprandial glucose levels.

METHOD

This research was conducted in July 2022 with a cross-sectional design. The research sample was DM patients in Ubud I Health Center. The samples were taken using a consecutive sampling technique. Sample inclusion criteria: DM patients routinely controlled at Ubud I Gianyar Health Center, adhere to dosages and drug usage schedules, routinely carry out light activities, and live close to Ubud I Gianyar Health Center. Exclusion criteria were that there were co-morbidities, including; hypertension, stroke, kidney failure, heart problems, and physical disorders that could hinder communication. The number of samples studied was 31 DM patients. The data collected in this study were HbA1c levels, LDL (low-density lipids), blood glucose levels (fasting and 2 hours postprandial), nutritional status, and systolic and diastolic blood pressure. HBA1C data and LDL levels were examined in the clinical laboratory. Blood glucose levels (fasting and 2 hours postprandial) were measured with a glucometer. Tools for checking nutritional status are a digital meter and scales. Blood pressure was measured using a digital sphygmomanometer. Before use, each tool was calibrated. DM control factor determinants with DM control parameters were analyzed by binary regression. Ethical approval was obtained from the Denpasar Ministry of Health Poltekkes Ethics Commission with number LB.02.03/EA/KEPK/0452/2022. All research respondents have signed an informed consent.

RESULT

This research was conducted in July 2022 at the Ubud I Gianyar Health Center. The total sample was 31 DM patients consisting of 12 (38.71%) males and 19 (61.3%) females. Found 25.8% of patients aged 65 years or more. Most (67.74%) adhered to the diet regarding the schedule and the amount programmed by the health workers. More than half (51.61%) of the patients had uncontrolled HbA1c levels. Most (83.87%) had uncontrolled LDL levels. controlled, 74.19% % had excess body mass index. More than half, 61.29% with controlled blood pressure (<140 / < 90 mmHg). Most (58.1%) patients had uncontrolled fasting glucose levels, and 77.42% had uncontrolled 2-hour post-prandial glucose levels. A description of control factors and control parameters of DM is presented in Table 1.

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Table 1. Overview of Control Factors and Parameters for DM Control in DM Patients at the Ubud I Health Center

Variable	Minimum	Maximum	Average	Standard Deviation
Age (years)	35	80	59.53	10.66
DM duration (years)	0.33	20	5.79	0.5
HbA1c (%)	4.9	14.6	8.41	3.03
LDL (mg/dl)	70	215	136.87	41.00
BMI	19.27	32.45	26.04	3.58
Systolic Pressure (mmHg)	105	159	132.65	15.03
Diastolic Pressure (mmHg)	50	110	79.16	12.67
Fasting glucose (mg/dl)	100	328	190.48	57.21
Glucose 2 hours post-prandial (mg/dl)	111	370	234.65	70.59

The analysis results of the effect of age, gender, duration of DM, and dietary adherence to HbA1c control are presented in Table 2.

Table 2. Effect of Age, Gender, DM Duration, and Dietary Adherence to HbA1c Control of DM Patients at Ubud I Health Center

Variable	P Value Omnibus Test	Nagelkerke R-Square	Wald Test	P Value Wald Test	Exp (B)
Age	0.00	0.756	1.697	0.193	0.897
Gender			0.268	0.605	2.229
DM duration			4.552	0.033	0.607
Dietary adherence			4.225	0.40	0.020

Table 2 shows that the p-value of the omnibus test is 0.00, and the Nagelkerke R Square value is 0.756. Thus, it can be concluded that age, gender, duration of DM, and dietary adherence significantly affect 75.6% on HbA1c control. The P value of the Wald test for the duration of DM was 0.033, which stated that the duration of DM had a significant effect on HbA1c control. The value of Exp (B) for sex is 2.229, which means that women are at risk of 2.229 times having problems controlling HbA1c.

The results of the analysis of the effect of age, gender, duration of DM, and dietary adherence to HbA1c control are presented in Table 3.

Table 3. Effect of Age, Gender, DM Duration, and Dietary Adherence to LDL Control of DM Patients at Ubud I Health Center

Variable	P Value Omnibus Test	Nagelkerke R-Square	Wald Test	P Value Wald Test	Exp (B)
Age	0.415	0.203	2.047	0.153	1.122
Gender			0.613	0.434	0.375
DM duration			0.235	0.628	0.935
Dietary adherence			1.700	0.192	0.171

Table 3 shows the p-value of the omnibus test of 0.415. Thus, it can be concluded that age, gender, duration of DM, and dietary adherence together do not affect controlling LDL levels. The Exp value (B) of the age factor is 1.122, which means that an increase in age is 1.122 times the risk of having problems controlling LDL.

The results of the analysis of the effect of age, gender, duration of DM, and dietary adherence on controlling body mass index (BMI), are presented in Table 4.

Table 4. Effect of Age, Gender, DM Duration, and Dietary Adherence to BMI Control of DM Patients at Ubud I Health Center

Variable	P Value Omnibus Test	Nagelkerke R-Square	Wald Test	P Value Wald Test	Exp (B)
Age	0.518	0.146	0.869	0.351	0.944
Gender			0.398	0.528	0.532
DM duration			2.650	0.104	1.207
Dietary adherence			0.593	0.441	2.413

Table 4 shows that the p-value of the omnibus test is 0.518. Thus, it can be concluded that age, gender, duration of DM, and dietary adherence together do not affect BMI control. The Exp (B) value of the DM duration factor is 1.207, which means that an increase in DM duration is at risk of 1.207 times experiencing BMI control problems. The Exp value

(B) of the dietary strictness factor is 2.413, stating that patients who do not comply with the diet are at risk of 2.413 times experiencing problems controlling BMI.

The analysis results of the effect of age, gender, duration of DM, and dietary adherence to controlling systolic and diastolic blood pressure are presented in Table 5.

Table 5. Effect of Age, Gender, DM Duration, and Dietary Adherence to Systolic and Diastolic Pressure Control of DM Patients at Ubud I Health Center

Variable	P Value Omnibus Test	Nagelkerke R-Square	Wald Test	P Value Wald Test	Exp (B)
Age	0.033; 0.230	0.395; 0.265	0.016; 0.569	0.899; 0.451	0.992; 0.944
Gender			2.845; 3.177	0.092; 0.075	0.138; 0.128
DM duration			0.398; 0.265	0.528; 0.607	0.926; 1.062
Dietary adherence			4.734; 2.393	0.030; 0.122	20.708; 9.637

Nagelkerke R Square value is 0.395. Thus, it can be concluded that the factors of age, gender, duration of DM, and dietary adherence together have a significant effect of 39.5% on systolic control. The P value of the Wald test for adherence to a diet was 0.030, which stated that partial adherence to a diet had a significant effect on controlling systolic blood pressure. The Exp value (B) of the diet adherence factor to systolic pressure was 20.708, which means that patients who do not comply with the diet are at risk of 20.708 times having problems controlling systolic pressure. Meanwhile, the Exp (B) value of the diet adherence factor to diastolic pressure was 9.637, which means that patients who are not compliant with the diet are at risk of 9.637 experiencing problems controlling diastolic pressure.

The analysis results of the effect of age, gender, duration of DM, and dietary adherence on controlling fasting glucose levels are presented in Table 6.

Table 6. Effect of Age, Gender, DM Duration, and Dietary Adherence to Controlling Fasting and 2 Hours Postprandial Glucose Level of DM Patients at Ubud I Health Center

Variable	P Value Omnibus Test	Nagelkerke R-Square	Wald Test	P Value Wald Test	Exp (B)
Age	0.013; 0.021	0.452; 0.475	2.355; 3.569	0.125; 0.059	1.113; 1.216
Gender			0.177; 1.367	0.674; 0.201	0.664; 4.502
DM duration			6.623; 4.373	0.105; 0.037	0.795; 0.691
Dietary adherence			4.127; 0.775	0.042; 0.379	9.050; 3.547

Nagelkerke R Square value is 0.452. Thus, it can be concluded that age, gender, duration of DM, and dietary adherence together have a significant effect of 45.2% on controlling fasting glucose levels. Likewise, for glucose levels 2 hours post-prandial (Nagelkerke R Square of 0.475). The P value of the Wald factor test for adherence to a diet is 0.042, which means that partial adherence to a diet significantly affects fasting glucose levels. Meanwhile, glucose levels 2 hours post-prandial were significantly affected by the duration of DM (p-value = 0.021). The Exp value (B) of the diet adherence factor to fasting glucose levels was 9.050, which means that DM patients who do not adhere to the diet 9.050 times experience problems controlling fasting glucose levels. Meanwhile, the Exp (B) value of dietary adherence to 2-hour post-prandial glucose levels was 3.547, which means that DM patients who are not compliant with the diet have a risk of 3.547 times experiencing problem controlling glucose levels 2 hours post-prandial.

DISCUSSION

In this study, it was found that there were more female DM patients than male DM patients, namely 61.3% compared to 38.7%). Another study found the number of DM patients with female sex reached 66.7% (Hadi Kurniyawan, Nadziroh, Widayati, & Wantiyah, 2022). This proportion is in line with the results of the 2018 Riskesdas which found 59.53% of DM patients in Indonesia were female. The 2018 Riskesdas results also found that female DM patients experienced a slight increase (Pangribowo, 2020). The results of this study are also in line with the results of a study in the Karala district of India which found 58.5% of DM patients were female (Najeeb, Joy, Sreedevi, & Vijayakumar, 2022). Differences in the proportion of DM in men and women can be influenced by differences in body structure. It is easier for a woman's body to store fat in adipose tissue, causing obesity. The results of the study prove that the prevalence of obesity in women is significantly higher than that of men (Okati-Aliabad, Ansari-Moghaddam, Kargar, & Jabbari, 2022). Obesity causes insulin

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resistance in target tissues. Excess fat in adipose tissue also harms the function of pancreatic beta cells, resulting in decreased insulin production (Zhang et al., 2020).

It was found that 25.8% of DM patients were aged 65 years or more. This number is almost the same as the United States Centers for Disease Control and Prevention report which reports that around 26% of DM are aged 65 years or more. This number is expected to continue to increase in the next decade. (Centers for Disease Control and Prevention, 2015). DM at the age of 65 years or more has a higher risk of complications compared to those aged less than 65 years. At that age, various health problems that accompany DM are often found, such as; cognitive impairment, cardiovascular disease, and others (Endocrine Society, 2013). The complexity of DM problems at the age of 65 years or more requires a complex handling approach. diabetes education and management.

Most (67.74%) DM patients adhered to the diet both in terms of the schedule and the amount programmed by health workers. The results of this study were higher than the results of a study at the Sultan Agung Islamic Hospital in Semarang which found 54.5% of DM patients adhered to the recommended diet (Ramadhina, Sulistyaningsih, & Agung, 2022). Dietary management, physical activity, and drug administration are the main factors in managing DM (Soelistijo et al., 2021). Diet and physical activity settings are also very important carried out in conditions of impaired glucose tolerance. The results of the study prove that dietary adjustments combined with physical activity can reduce and delay the occurrence of type 2 DM in people who experience impaired glucose tolerance problems (Hemmingsen, Gimenez-Perez, Mauricio, Figuls, M. R. i, Metzendorf, & Richter, 2020).

More than half (51.61% of patients) had uncontrolled HbA1c levels. The mean HbA1c level was 8.41 ± 3.03. This average was slightly lower than the results of another study in the Kerala District of India state which found average levels -HbA1c average of 8.87 ± 1.8% (Najeeb et al., 2022). Research at the Kariadi Hospital in Semarang found an average HbA1c of 8.72 ± 1.73 (Driyah, BS, & DK, 2019). HbA1c is the glycated component of hemoglobin. Glycation or also called non-enzymatic glycosylation occurs due to covalent bonding between sugar and hemoglobin components. Generally, about 6% of hemoglobin will be glycated. The glycation of hemoglobin depends on glucose concentration with the age of the erythrocyte. The age of the erythrocyte is around 120 days, and every day it experiences. Therefore, only 50 of the HbA1c values represent the previous 30 days of glucose exposure, 40% represent the previous 31 – 90 days of glucose exposure, and 10% represent the previous 91 – 120 days of glucose exposure (Wang & Hang, 2021). HbA1c levels are an indicator of controlling blood glucose levels. HbA1c levels of more than 7.0% are significantly associated with micro and macrovascular complications (Kshanti et al., 2019).

The average LDL found in this study was 136.87 ± 41.00. The findings of this study are higher than the findings of other studies. Research at the Kariadi Hospital in Semarang found an average LDL of 110.64 ± 32.10 (Driyah et al., 2019). In said study, it was also found that most (83.87%) had uncontrolled LDL levels, LDL is a group of low-density lipoproteins of various sizes. LDL functions to transport triglycerides, cholesterol, and other fats from the liver to the tissues to be combined with the body's cells. LDL components consist of cholesterol esters (35-40%), triglycerides (8-12%), phospholipids (20-25%), free cholesterol (5-10%), and apolipoprotein B (20-24%). LDL particles, which are small and dense, are highly atherogenic because they are easily oxidized and difficult to clean (Hirano, 2018). Atrogenic is the ability of LDL to induce atherosclerosis. Atherosclerosis is the narrowing and hardening of the arteries as a result of plaque deposits in the blood vessels, thereby disrupting circulation.

Two-thirds (74.19%) of DM patients have an excess body mass index. The findings of this study are higher than the results of research in Kotapinang District, North Sumatra, which found 56.9% had excess BMI (Harahap, Ariati, & Siregar, 2020). Other studies have also found that DM patients are overweight with a BMI of 32.5 ± 5.7 (Mitri et al., 2022). Being overweight in DM is one of the supporting factors for the emergence of complications. Conversely, weight loss in DM with obesity can reduce the risk of complications. Weight loss of 5% of initial body weight in DM with obesity will improve glycemic control and reduce the need for diabetes medication. Weight loss of more than 5% will improve lipid control and blood pressure in DM with obesity (Sandouk & Lansang, 2017).

More than half (61.29%) of DM patients with controlled blood pressure (<140 / <90 mmHg). The findings in this study were higher than the results of other studies which found 54% of DM patients with controlled blood pressure (Grossman & Grossman, 2017). Another study reported that two-thirds of DM patients in the world have hypertension (Ele & Cushman, 2012). Research that took DM patient subjects in the agricultural area of Jember Regency found that 59.8% of DM patients experienced hypertension (Nistiandani et al., 2021). The global prevalence of DM and hypertension continues to increase. These two problems mutually contribute to micro and macro angiopathy (Yildiz, Esenboğa, & Oktay, 2020). Controlled blood pressure has been shown to have a lower mortality rate (Lastra, G., Syed, Kurukulasuriya, Manrique, & Sowers, 2014).

Most of the patients (58.1%) had uncontrolled fasting glucose levels, and 77.42% had uncontrolled 2-hour post-prandial glucose levels. The results of this study were higher than the results of a study conducted at the Medical Records

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Section of Sanglah Hospital, which found only 52% DM with uncontrolled post-prandial blood glucose levels (Sugandha & Lestari, 2015). Controlling blood glucose levels is a very important factor in the management of DM. Controlling blood glucose levels has been shown to reduce the risk of complications in DM. Post-prandial blood glucose levels are a strong risk factor for cardiovascular complications in DM. Controlling blood glucose levels in DM patients requires a holistic approach, such as education, physical activity, medical nutrition therapy, medication administration, and routine monitoring of blood glucose levels (Kshanti et al., 2019).

In this study, it was proven that age, gender, duration of DM, and dietary adherence together had a significant effect of 75.6% (p-value = 0.00) on HbA1c control. DM duration factor has a significant effect (p-value = 0.033) on HbA1c control. Based on the value of Exp (B) it is concluded that women are at risk of 2.229 times having problems controlling HbA1c. The results of this study are following the results of a study at the DM Clinic Federal Medical Center Gusau which concluded that glycemic control was significantly better in men and there was a positive relationship between duration and complications of DM. The study also found a positive relationship between dietary adherence and glycemic control. Complications that increased significantly after 5 years of suffering from DM were visual disturbances (p-value = 0.002) and erectile dysfunction (p-value 0.001) (Sada et al., 2021). Other studies also prove that the proportion of controlled HbA1c is higher in DM patients who adhere to a diet (Grahovac et al., 2021). The relationship between age and HbA1c is a result of the relationship between age and erythrocytes. Research proves that there is a negative relationship between age and the number of erythrocytes (Wu et al., 2017). HbA1c is a picture of blood glucose levels in the last three months. The higher of the blood glucose level in the last three months, the higher the HbA1c value. High blood glucose levels as a result of insulin deficiency or insulin receptor resistance. Insulin resistance is influenced by several factors, such as the presence of the hormone resistin which is produced by the body. Resistin is one of the 50 types of adipokine hormones produced by adipose tissue (Khanna, Welch, & Rehman, 2022). Compared to men, women's body structure contains more adipose tissue. HbA1c control in women is strongly influenced by adipose tissue. In the period before menopause, fat accumulation occurs in the gluteofemoral. After menopause, along with a decrease in estrogen, fat accumulation occurs in visceral tissue (Magueresse-Battistoni, 2022). This difference in adipose tissue results in women being at a higher risk of experiencing problems with uncontrolled HbA1c compared to men. Besides decreasing estrogen production, increasing age also has an impact on decreasing body structure and function. Therefore, the longer the DM durations, the more complex the DM problem.

In this study, there was no significant influence between age, gender, duration of diabetes mellitus, and diet adherence to controlling LDL levels. The Exp value (B) of the age factor is 2.229, which means that an increase in age is 1.122 times the risk of having problems controlling LDL. Previous research found the best results compared to this study, that increasing age is related to LDL levels, as evidenced by a p-value of 0.045 (Domanski et al., 2020). In theory, the factors that inhibit fat metabolism in patients with type 2 DM include insulin resistance, and/or relative insulin deficiency, adipocytokines, and hyperglycemia (Vergès, 2015). LDL is the lipoprotein that contains the most cholesterol. LDL is produced from the process of hydrolysis of Very Low-Density Lipoprotein (VLDL). VLDL is secreted by the liver as a result of the synthesis of triglycerides and cholesterol. Some LDL cholesterol will undergo oxidation. The more LDL in the plasma, the greater the amount of oxidized cholesterol. Oxidized cholesterol will be captured by macrophages and then settles in the blood vessels. This deposition triggers the process of atherosclerosis (Adam, 2014).

Analysis of the influence of age, gender, DM duration, and dietary adherence to BMI control found an Exp (B) value of DM duration factor of 1.207 and dietary strictness factor of 2.413. This shows that an increase in the duration of DM is at risk of 1.207 times experiencing problems controlling BMI. DM patients who are not compliant with their diet are at risk of 2.413 times experiencing problems controlling BMI. Diabetes is known to have a relationship with obesity, where a study found that there was a relationship between diabetes and obesity (p-value = 0.000) (Seclén, Nunez-Robles, Yovera-Aldana, & Arias- Chumpitaz, 2020). BMI is a simple indicator used to determine a person's nutritional status. Excess BMI (obesity) exacerbates DM problems. The results of the study prove that women are at a higher risk of experiencing obesity and DM. Sex hormones influence energy metabolism and body composition (Kautzky-Willer, Harreiter, & Pacini, 2016). Obesity occurs as a result of an accumulation of excess fat tissue. This accumulation occurs as the body responds to excess energy intake. Excess energy intake is converted into fatty acids. Fatty acids are then stored in the form of triglycerides in adipose tissue. In conditions where the body lacks energy, this fat tissue is used as an energy source. Fat tissue secretes peptides (resistin) that act like hormones. These peptides cause insulin resistance resulting in hyperglycemia (Soegondo, 2014). BMI has a positive correlation with resistin. The higher of BMI, make the higher resistin in the body. Research on experimental animals reported that resistin was proven to induce apoptosis of pancreatic beta cells. Pancreatic beta cell apoptosis is a biological mechanism that results in cell death. Damage to pancreatic beta cell results in decreased insulin production. Besides inducing pancreatic beta cell apoptosis, resistin was reported to decrease insulin receptor activity and stimulate hepatic glucose formation (Acquarone, Monacelli, Borghi, Nencioni, & Odetti, 2019).

Decreased insulin production due to pancreatic beta cell apoptosis, decreased insulin receptor activity, and increased hepatic glucose production resulted in increasingly severe hyperglycemia.

Factors of age, gender, duration of DM, and dietary adherence together had a significant effect (p-value omnibus test = 0.033) of 39.5% (Nagelkerke R Square = 0.395) on systolic control. The P value of the Wald test for adherence to a diet was 0.030, which stated that partial adherence to a diet had a significant effect on controlling systolic blood pressure. The Exp (B) value of the diet adherence factor was 20.708, which means that patients who do not comply with the diet are at risk of 20.708 times having problems controlling systolic blood pressure. Meanwhile, the Exp (B) value of the diet adherence factor to diastolic pressure was 9.637, which means that patients who are not compliant with the diet are at risk of 9.637 experiencing problems controlling diastolic pressure. The results of this study are under the results of other studies which conclude that diet has a significant effect on blood pressure (Dewi, Sugiyanto, & C. Wira, 2015). Research on dietary regulation of hypertension has long been encouraged. The study concluded that dietary adjustments significantly reduce blood pressure, especially in cases of hypertension. The diet's main aspect that needs to be regulated is the amount of sodium and potassium intake (Filippou et al., 2020). DM patients need support from their families so that patients can control their disease. Research proves that family support will improve diabetes management in DM patients (Trisnadewi & Suniyadewi, 2022). It is important to regulate the diet in DM by paying attention to the fat content of each type of food consumed. A decrease in the amount of insulin and insulin receptor resistance triggers the problem of dyslipidemia. Post-prandial dyslipidemia was reported to differ significantly in DM compared to non-DM. The duration and magnitude of post-prandial lipidemia are directly related to the pathogenesis and development of cardiovascular disease in DM (Chaha, Gupta, Chawla, & Grewal, 2021).

The factors of age, gender, duration of DM, and dietary adherence together have a significant effect (p-value omnibus test = 0.013) of 45.2% (Nagelkerke R Square of 0.452) on controlling fasting glucose levels. Likewise, on glucose levels 2 postprandial hours (Nagelkerke R Square of 0.475). The P value of the wald factor test for adherence to a diet was 0.042, meaning that partial adherence to a diet significantly affected fasting glucose levels. Meanwhile, glucose levels 2 hours postprandial were significantly affected by the duration of DM (p-value = 0.021), and the Exp value (B) of the diet adherence factor to fasting glucose levels is 9.050, which means that DM patients who do not comply with the diet 9.050 times experience problems controlling fasting glucose levels. on glucose levels 2 hours post-prandial of 3.547, DM patients who are disobedient to the diet are at risk of 3.547 times experiencing problems with diabetes control of glucose levels 2 hours post-prandial. Plasma glucose levels are also affected by age. After the age of 30 years, fasting glucose concentrations increase by 1-2 mg% per year, and two-hour postprandial glucose levels increase by 5.6-13 mg%. A decrease in the number and sensitivity of insulin receptors causes this increase in glucose levels. This results in a decrease in Glut-4 translocation resulting in hyperglycemia (Rochmah, 2014). Diet is a food regulation technique that contains essential nutrients to support body health. Food arrangements in DM patients are almost the same as the general public, namely balanced food according to caloric needs. Important aspects that must be followed, especially by DM patients who use insulin drugs or insulin triggers, are the regular schedule of meals, the accuracy of the number of calories eaten, and the accuracy of the types of food (Soelistijo et al., 2021). The regularity of the meal schedule and the number of meals is important to match the absorption of nutrients in the gastrointestinal system with the availability of insulin in the body.

The type of food is related to the glycemic index, which is the speed at which foods containing carbohydrates can increase blood glucose levels. Types of food have different glycemic indexes. Foods with a high glycemic index will increase blood glucose levels quickly. In contrast, foods with a low glycemic index will experience a longer digestion process, so the increase in blood glucose levels can occur slowly. The duration of DM affects the function of pancreatic beta cells. The higher the duration of DM, the function of the pancreatic beta cells in secreting insulin will decrease (Solis-Herrera, Triplitt, Cersosimo, & DeFronzo, n.d.).

CONCLUSION

Factors of age, gender, duration of DM, and dietary adherence significantly influence 75.6% against HbA1c control, 39.5% of systolic control, and 45.2% for controlling fasting glucose levels and 2-hour postprandial glucose levels. There was no significant influence between age, gender, duration of DM, and diet adherence to controlling LDL levels, BMI, and diastolic pressure. Thus, it is suggested that Officers holding the Non-Communicable Disease Program at the Health Center, who are responsible for DM services, intervene by emphasizing the importance of dietary adherence to patients in controlling DM.

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