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The Behavior of Patients with Type 2 Diabetes Mellitus in Monitoring Blood Glucose Levels and Foot Care: A Cross-sectional, Community-Based Study

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ABSTRACT. Hyperglycemia in patients with Diabetes Mellitus (DM) can lead to complications such as diabetic foot ulcers. Therefore, efforts are needed to prevent this chronic complication through proper foot care. This study aimed to determine the behavior of patients with type 2 diabetes mellitus (T2DM) in performing blood glucose monitoring and correct foot care. This study is a descriptive cross-sectional study, with a sample size of 125 patients with T2DM from the Community Health Center in Surabaya Indonesia. Data was collected with the use of a self-made questionnaire from May to October 2018. The variables of the study were patient characteristics, random blood glucose levels, blood glucose monitoring and foot care skills. The data analysis used was Spearman rho to determine the factors associated with foot care behaviors. Fifty-six percent (56%) of the participants have poor behavior on foot care, 36 % have moderate and only 7.2% have good. Factors that were significantly associated with foot care behavior were signs and symptoms ($p = 0.023$), blood glucose monitoring ($p = .000$), and random blood glucose levels ($p = 0.040$). The behaviors of patients with T2DM in blood glucose monitoring and foot care need to be improved to prevent complications from diabetic foot ulcers. Nurses must provide health education about the importance of regular foot care to patients and their families. The results of this study can be used to further improve the programs and services to prevent DM and delay the progression of chronic complications like diabetic foot ulcers at the community level.

INDEX TERMS blood glucose; diabetic foot; diabetes mellitus.

I. INTRODUCTION

Diabetes Mellitus (DM) is a significant health problem that is one of the four priority non-communicable diseases that requires urgent action among world leaders. The number of cases and the prevalence of patients with DM has continued to increase over the last few decades [1], [2]. The number of patients with DM aged 20-79 years in Indonesia in 2017 ranks sixth in the world and is estimated to decline to seventh in 2045 [3]. DM is a metabolic disease characterized by increased blood glucose levels. Patients with Type 2 Diabetes Mellitus (DMT2) must carry out long-term management to control their blood glucose levels. Diabetes self-care management includes a healthy diet, physical activity, blood

glucose monitoring, proper medication, excellent problem-solving attitude, good adaptability, and risk reduction. These seven self-care practices are associated with good glycemic control, reducing problems, and improved quality of life. Patients with DM tend to be unable to control their blood glucose levels. This behavior can lead to complications in patients with T2DM, one of which is Diabetic Foot Ulcer (DFU) [4]. Undeniably, these complications of DFU can lead to an increased disease burden and much higher medical costs than patients without complications. Therefore, foot care is a significant behavior to prevent DFU complications for patients with DM [5]. While, for patients with DM, monitoring glucose

is the key to achieving glycemic targets that can lead to prevention and delay of chronic complications like DFU [6].

Self-monitoring of blood glucose (SMBG) refers to the testing and record-keeping of blood glucose levels by patients and/or caregivers, at home or in the hospital, at different times of the day. Obtained blood glucose levels help patients and physicians to make appropriate adjustments in diet, exercise, and medication settings [5]. Continuous glucose monitoring (CGM) also has a significant role to play in assessing the effectiveness and safety of treatment in many patients with type 1 diabetes mellitus (T1DM), and it can also help patients with type 2 diabetes mellitus (T2DM) to prevent and delay complications.

DFU as a complication of patients with DM is associated with mortality, morbidity, and high-cost care that can be prevented by education, treatment, and early diagnosis. The most important risk factors for DFU are peripheral neuropathy, Peripheral Arterial Disease (PAD), leg deformities, previous leg ulceration, and amputation [7]–[9]. This complication is closely related to uncontrolled blood glucose levels of DM patients. In low and middle-income countries, patients with DM who walk barefoot, have low awareness, and are late in seeking treatment, are common factors that exacerbate DFU [10].

The foot examination is an easy method as a screening to specifically identify loss of protective sensation caused by peripheral neuropathy and for signs or symptoms of PAD [8]. Regular foot care as a component of self-care is needed to maintain health status and prevent complications of foot amputation in patients with DM due to diabetic ulcers. Statistically, more than 60% of non-traumatic lower-limb amputations occur in patients with DM [11]. Foot screening and assessment to identify high-risk feet aim to prevent significant complications from ulceration and amputation [7].

Existing studies show predictors that significantly influence foot care behavior, namely: gender, history of a foot injury, nephropathy, perception of disease, and health beliefs [12]. Other studies with significant predictors associated with the risk of developing diabetic foot ulcers in DM patients include neuropathy, history of ulceration, history of smoking, callus, range of motion of the foot, duration of diabetes, blood glucose levels, and foot abnormalities [13].

This study aimed to determine the behavior of patients with T2DM in monitoring blood glucose levels and performing regular foot care, which are components of effective self-care management. This study explored the behavior of patients with T2DM through the use of self-made questionnaire. These can help patients improve their abilities by developing self-care management skills specifically on monitoring blood glucose levels and performing proper foot care. This management program focuses on preventing foot complications through patient and family education, regular foot examination, identifying at-risk feet, using appropriate footwear, and treating signs of injury, reducing the occurrence of lower extremity amputations, and improving the patient's

quality of life. Health care costs of this chronic disease are increasing and greatly affecting the economic status of the patient [14] [15].

II. MATERIALS AND METHOD

The study utilized a descriptive correlational research design with a cross-sectional approach. One hundred twenty-five patients with T2DM were included in the study. They were patients visiting the Community Health Center (Pukesmas) in Surabaya such as Pucangsewu, Tambak Rejo, and Tanah Kali Kedinding, Surabaya, East Java, Indonesia. The inclusion criteria of the study were patients with T2DM, 30-70 years of age, duration of DM more than one year, and have a stable condition (e.g. vital signs within normal limits).

The variables of the study were patient characteristics, random blood glucose levels, skills on blood glucose monitoring, and foot care. The data was collected through a self-made questionnaire that underwent content validity and reliability testing. Characteristics of the patients include age, sex, education, duration of DM, signs, and symptoms, family history, presence of complications, random blood glucose levels, and blood glucose monitoring skills. The questionnaire for assessing the skills on blood glucose monitoring consists of 3 questions [16] which are measured using a Likert scale with the following options: always (4), often (3), rarely (2), and never (1). The total score for this section is in the range of 3-12, with higher scores indicating a higher skill level, then categorizing into good (3), moderate (2), and poor (1). This questionnaire has a Cronbach value of 0.734 with a calculated r -value of more than r table (sequentially: 0.796, 0.904, 0.714). On the other hand, the questionnaire for assessing skills on foot care consist of 7 questions developed from foot care tips in patients with DM [10] that are measured using a Likert scale with the following options: always (4), often (3), rarely (2), and never (1). The total score for this section is in the range 7-28, with higher scores indicating a higher level of skill, then categorized as good ($M+1SD < X < M+1SD$), moderate ($M-1SD < X < M+1SD$), and poor ($X < M-1SD$). The Cronbach value of this questionnaire is 0.764 with a calculated r -value of more than the r table (sequentially: 0.679, 0.795, 0.494, 0.676, 0.505, 0.544, 0.800).

Data was collected from May to October 2018. The researcher first explained the research objectives, benefits, and rights of the respondents. In addition, the researcher asked respondents to sign the informed consent before they answered the questionnaire. Descriptive statistics like frequency, percentage, mean, and standard deviation were used to describe the characteristics of the patients, blood glucose monitoring and foot care skills. Spearman's rho was used to determine the relationship between the characteristics of patients with T2DM and foot care, and a p value of < 0.05 was considered significant.

This study has received ethical approval from the Ethics Commission of Politenik Kesehatan Kementerian Kesehatan Surabaya with No. 228/S/KEPK/VI/2018.

III. RESULTS

The results of this study are about the characteristics of patients with T2DM, random blood glucose levels, blood glucose monitoring skills, and foot care behavior. Tables 1 and 2 show the complete data of this study. Table 1 shows that most of the patients belong to 51-60 years of age, female, elementary graduates, and have less than five years duration of DM. Moreover, the majority of the patients (65%) have experienced more than one signs and symptoms. Some of the signs and symptoms experienced by patients with T2DM in this study were feeling weak, feeling shaky, unable to sleep

at night, tingling legs, numb feet, frequent urination, skin itchiness, stiff legs, cold sweats, chest palpitations or pain, and headaches or body aches. Majority had a family history of DM (56.8%) but had no complications of DM (56%) and many of the patients have abnormal levels of random blood glucose (64%).

Furthermore, Table 1 shows patients have a moderate (46.4%) skill in blood glucose monitoring, while others have poor (35.2%) and good (18.4%). Data on foot care behavior mostly have poor behavior (56%), moderate (36.8%), and

TABEL 1
Characteristics of patients with T2DM and the relationship of the variables (n = 125)

Characteristics	n (%)	Foot Care			r	p
		Poor n (%)	Moderate n (%)	Good n (%)		
Age (years)					-0.006	0.943
30 – 40	3(2.4)	2(1.6)	1(0.8)	0(0)		
41 – 50	18(14.4)	10(8.0)	7(5.6)	1(0.8)		
51 – 60	98(78.4)	54(43.2)	36(28.8)	8(6.4)		
61 – 70	6(4.8)	4(3.2)	2(1.6)	0(0)		
Sex					-0.041	0.653
Male	8(6.4)	4(3.2)	3(2.4)	1(0.8)		
Female	117(93.6)	66(52.8)	43(34.4)	8(6.4)		
Education					-0.056	0.535
No	32(25.6)	16(12.8)	12(9.6)	4(3.2)		
Elementary	59(47.2)	35(28.0)	21(16.8)	3(2.4)		
Secondary	28(22.4)	16(12.8)	10(8.0)	2(1.6)		
University	6(4.8)	3(2.4)	3(2.4)	0(0)		
Duration of DM (years)					0.087	0.337
> 10	16(12.8)	8(6.4)	6(4.8)	2(1.6)		
6-10	39(31.2)	27(21.6)	10(8.0)	2(1.6)		
1 – 5	70(56.0)	32(25.6)	30(24)	5(4.0)		
Signs and symptoms					0.203*	0.023
None	43(34.4)	27(21.6)	15(12.0)	1(0.8)		
1-3	45(36.0)	28(22.2)	15(12.0)	2(1.6)		
4-7	37(29.6)	15(12.0)	16(12.8)	6(4.8)		
Family history					0.098	0.275
No	54(43.2)	36(28.8)	9(7.2)	9(7.2)		
Yes	71(56.8)	34(27.2)	37(29.6)	0(0)		
Complication					0.128	0.155
No	70(56)	44(35.2)	20(16.0)	6(4.8)		
Yes	55(44)	26(20.8)	26(20.8)	3(2.4)		
Random blood glucose levels					0.184*	0.040
Abnormal	80(64)	50(40.0)	26(20.8)	4(3.2)		
Normal	45(36)	20(16.0)	20(16.0)	5(4.0)		
Blood glucose monitoring					0.719**	0.000
Poor						
Moderate	44(35.2)	43(34.4)	1(0.8)	0(0)		
Good	58(46.4)	27(21.6)	29(23.2)	2(1.6)		
	23(18.4)	0(0)	16(12.8)	7(5.6)		

** Correlation is significant at the 0.01 level; * Correlation is significant at the 0.05 level;
r: Spearman correlation coefficient; p: significant.

TABLE 2
Score and question items for blood glucose monitoring and foot care

No.	Item	Scale				Mean	SD
		Always n(%)	Often n(%)	Rare n(%)	Never n(%)		
Blood glucose monitoring							
1.	Checking blood sugar levels independently	9(7.2)	54(43.2)	34(27.2)	28(22.4)	2.34	0.90
2.	Understanding the meaning of the value of blood sugar levels	20(16.0)	48(38.4)	25(20)	32(25.6)	2.54	1.00
3.	Documenting the value of blood sugar levels	15(12.0)	28(22.4)	21(16.8)	61(48.8)	1.98	1.10
Foot care							
1.	Drying the feet after washing the feet	8(6.4)	55(44.0)	37(29.6)	25(20)	2.37	0.88
2.	Apply lotion to the feet	19(15.2)	30(24.0)	40(32.0)	36(28.8)	2.26	1.04
3.	Using footwear when going out	77(61.6)	36(28.8)	10(8.0)	2(1.6)	3.50	0.71
4.	Checking always the footwear (shoes or sandals) when it will be used	18(14.4)	66(52.8)	24(19.2)	17(13.6)	2.68	0.89
5.	Cutting nails properly	13(10.4)	62(49.6)	42(33.6)	8(6.4)	2.64	0.76
6.	Periodically check the condition of the feet	2(1.6)	34(27.2)	49(39.2)	40(32.0)	1.98	0.81
7.	Doing regular leg exercises	5(4.0)	6(4.8)	39(31.2)	75(60.0)	2.37	0.88

only a few have good (7.2%). Table 1 shows the cross-tabulation between patient characteristics, random blood glucose levels, and blood glucose monitoring skills, and foot care behavior. Table 1 also shows a significant relationship between signs and symptoms, random blood glucose levels, and skills on blood glucose monitoring with foot care behavior, with significance values of $p = 0.023$, $p = 0.040$, and $p = 0.000$ respectively. Table 2 shows the scores and specific questions on blood glucose monitoring and foot care in patients with T2DM. In this study, 48.8% of the patients never documented the value of their blood glucose levels ($x=1.98$). In addition, 39.2% of the T2DM patients rarely checked their feet periodically ($x = 1.98$), 32% rarely used lotion ($x = 2.26$) 60% never did regular leg exercises and 44% often dried their feet after washing ($x=2.37$). However, 61.6% of patients with T2DM always used footwear when going out ($x = 3.50$).

IV. DISCUSSION

Self-care is an activity in which people use their knowledge, skills, and strengths as resources to establish, maintain health and prevent and treat disease. This is a significant factor in reducing disease prevalence, improving health, and ultimately improving quality of life [17]. Patients with DM need to monitor their blood glucose levels independently and regularly. Independent blood glucose level monitoring is a periodic blood glucose check carried out using a glucose meter by the person and/or their family. Appropriate blood glucose control is a significant factor in reducing the risk of complications in patients with T1DM and T2DM. The frequency and timing of SMBG are determined individually

through discussions and agreements between doctors / trained health workers and people with DM. Several things that need attention in implementing SMBG are the type of DM, treatment pattern, clinical condition, family and financial ability/support, educational and behavioral factors. If the patient with DM can achieve the blood glucose target, they can reduce the frequency of carrying out SMBG. Patients need to record the results and time of SMBG in a blood glucose diary book or digitally [18], [19]. For a patient with DM, there are other means to lower blood glucose levels, such as using herbal medicine. They have the belief that herbs can effectively lower blood glucose levels [20][21].

In patients with DM, blood glucose control is one of the most important factors to prevent and delay the onset of chronic complications associated with DM. Inadequate blood glucose control is the priority cause of DFU [22] [3]. The results of the study showed that the results of random blood glucose levels and the monitoring of blood glucose levels had a strong relationship with foot care behavior (Table 1). Diabetic patients with complications should monitor their blood glucose levels more often than patients without complications. Patients with longer disease duration may experience more complications, so they must pay more attention to their blood glucose monitoring (Raoufi et al., 2018).

This study has shown that the majority of patients with T2DM have not performed regular foot care (Table 2). The patients have not had regular foot examinations and have not done leg exercises. In addition, drying the feet after washing and applying lotions were not regularly performed. These

behaviors can be a risk of developing DFU. Usually, The causes of DFU are repeated stress over an area of intense pressure or shear in patients with peripheral neuropathy [24]. Diabetes is also a cause of Charcot's arthropathy, which is the progressive deterioration of bones, joints, soft tissues, and most often occurs in the ankles and feet. A neuropathic condition accompanied by abnormal loads on the limbs, repetitive trauma, and abnormalities in the bones, causing inflammation, osteolysis, fractures, dislocations, and deformities [10], [25]. The preventions of DFU are by controlling blood glucose levels, regular foot examinations, use of appropriate footwear, patient and family education, and early referral if there are lesions on the feet [10], [26]. The family has a significant role in managing DM. Family involvement in mentoring, provide patient input and reminders to comply with DM management [27]–[29].

Significant predictors associated with the risk of diabetic foot ulcers in patients with DM include neuropathy, history of ulceration, history of smoking, presence of callus, range of motion of the ankle joints, duration of DM, blood glucose levels, and abnormalities in the feet [13]. Foot care is a part of DM patient self-care behavior that aims to prevent diabetic foot ulcers. The predictors that were significantly associated with foot care were family members or friends who had diabetic foot ulcers, length of time of diabetes mellitus, knowledge of foot care, consequences, treatment control, and local beliefs [30]. Other studies showed several predictors that significantly influence foot care behavior, namely gender, history of foot wounds, nephropathy, disease perception, and health beliefs [12].

Patient education plays a significant role in the prevention of diabetic foot problems. It aims to increase knowledge, awareness, and self-care behavior to increase motivation, skills, and adherence to foot care behavior. Nurses can be part of the preparation and implementation of training programs to change patient behavior and improve patient quality of life. Nurses must have sufficient knowledge about foot care and provide accurate information to patients with DM about preventing the formation of diabetic foot and treating diabetic foot ulcers [7], [15].

Some tips about diabetic foot care that can be taught to patients with DM are (1) check the feet and the area between the toes every day, (2) wash your feet daily with room temperature water, with careful drying, especially between the toes, (3) use a moisturizer for dry skin, but not between the toes, (4) cut nails straight, (5) do not remove warts and calluses using chemicals or plaster at home, be handled by trained staff, (6) wear socks when wearing shoes and check the inside of the shoes for foreign objects, (7) always wear footwear when walking, (8) check feet regularly at health care, and (9) immediately visit the health service if blisters, cuts, scratches, or pain occur [10].

Several factors that triggered the occurrence of DFU in this study were more signs and symptoms, abnormal random blood glucose levels, and moderate level of blood glucose monitoring skills. These factors can be improved by proper health education to improve patient's behavior

towards foot care. The family has an important role by providing support to patient in all facets of DM management. Family support is needed to help T2DM patients in monitoring blood glucose levels and performing regular foot care. T2DM patients require family involvement in mentoring, providing patient input and reminders to comply with DM management. Patient will more receptive to receiving information, if the information is supported by other family members. Another factor that needs to be considered by patients in improving foot care skills is a strong motivation and intention to prevent DFU complications.

A limitation of the study is that all data on the behavior of monitoring blood glucose levels and foot care among patients with T2DM are based on the responses of the patients, not based on observations of the researchers. This study also has not explored patient knowledge and capabilities of monitoring blood glucose levels and foot care. The results of this study will be a source of information to create programs focusing on the prevention of diabetic foot ulcers as one of the common chronic complications of DM at the community level.

V. CONCLUSION

This study aimed to determine the behavior of patients with T2DM in monitoring blood glucose levels and performing foot care, which are critical components of diabetes self-care. The behavior of monitoring blood glucose levels, most of the patients with DM still needs to be improves, especially in terms of recording the value of their blood glucose levels. Performing regular assessment of feet, applying lotion to the feet, doing leg exercises and drying of feet need to be improved. These behaviors can lead to complications of diabetic foot ulcers. Health professionals, particularly nurses, have critical role in improving the behavior of patients with DM towards blood glucose monitoring and foot care through effective health education. Researchers recommend conducting further research on foot care intervention methods that are effective in preventing DFU and other predictors associated to increase incidence of DFU.

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