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Self-care of chronic illness prevents the risk of diabetic foot ulcers in patients with diabetes: a cross-sectional study

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ABSTRACT

Introduction: Diabetic foot ulcer (DFU) is a serious and chronic complication of diabetes mellitus (DM). This study aims to explain a model of self-care of chronic illness on the prevention of DFU risk in patients with DM, including foot self-care of maintenance, monitoring, and management.

Methods: This study was an analytical study with a cross-sectional approach, with 300 patients randomly selected from six Public Health Centers in Surabaya, Indonesia, from June to August 2022. The inclusion criteria were individuals with DM and aged more than 26 years. Exclusion criteria were reading disabilities or having cognitive impairments Data were collected using a questionnaire. The correlation between variables was analyzed using the statistical method of Partial Least Squares.

Results: The risk of DFU in patients with DM was 40% with low risk, 38% with moderate risk, 8% with high risk, 5% remission, and 10% with DFU. This research shows that there is a significant correlation between foot self-care management and the risk of DFU, where the p-value = 0.000, while the indicators of foot self-care maintenance and self-care monitoring do not have a significant correlation with the risk of DFU, where the p-value is respectively equal to 0.350 and 0.844.

Conclusions: Foot self-care management was a factor that directly correlates with the risk of DFU. Autonomous self-care management behaviors still needed to be improved, because most patients still had these inadequate behaviors. Further research is needed to improve the behavior quality of patients with DM in managing foot care independently.

Keywords: diabetes mellitus, diabetic foot, self-care

Introduction

Chronic hyperglycemia in diabetes in the long term can cause microvascular complications affecting the eyes, kidneys, and nerves and an increased risk of cardiovascular disease (Canadian Diabetes Association Clinical Practice Guidelines Expert Committee, 2013). Long-term complications of diabetes can be present at diagnosis in people with type 2 diabetes and can appear earlier (around five years) after the onset of type 1 diabetes (Federation International Diabetes., 2019).

Peripheral neuropathy is the most common form of neuropathy associated with diabetes. It affects the distal nerves of the limbs, especially those on their feet. It primarily alters the symmetrical sensory function causing the abnormal feeling and progressive numbness. This condition facilitates the development of foot ulcers, referred to as diabetic foot. DFU is one of the most severe and chronic complications of diabetes mellitus, including deep tissue lesions with peripheral vascular disease (PVD) of the lower extremities and peripheral neuropathy. Often patients with DM who

have diabetic foot ulcers require amputation of that part of the body and bear medical costs five times higher than patients without foot ulcers (Federation International Diabetes., 2019 ; Elkashif, Mahdy and Elgazzar, 2021; Thotad, Bharamagoudar and Anami, 2023). Patients with DFU will experience limited life and require strong efforts to adapt to their conditions (Alfaqih, Kusnanto and Padoli, 2020).

In chronic disease, self-management refers to carrying out daily activities that serve to maintain or restore health and well-being, prevent complications, and manage chronic disease (Song, 2010; Costa, Tregunno and Camargo-Plazas, 2021. In patients with chronic disease, it may be necessary to organize and adapt self-care during the illness, for example, with an exacerbation of the disease, if comorbid occurs, or if continued treatment is required. Self-care of chronic illness is a construct built from three main concepts: self-care of maintenance, monitoring, and management, which are closely interrelated. Therefore adequate self-care performance must cover all three of these behaviors ; Ausili, Rebora and Valsecchi, 2020).

Regarding DFU prevention, one of the many ways is to involve patients in day-to-day self-management, which is a patient-centered approach to care. The results of qualitative research show that patients with DM who experience DFU have a passive role in foot care and they do not realize the importance of foot care (Costa, Tregunno and Camargo-Plazas, 2021). The results revealed that out of 100 patients with DM, 79% suffered from burning or tingling in the limbs; 74% complained of redness of the lower extremities, leg or leg pain during exertion, and loss of lower extremity sensation; and 80% had skin discoloration or skin lesions. Most of them had low knowledge and inadequate foot care behavior before the intervention. Self-care practices of diabetics are important to maintain and reduce diabetic foot complications, but commitment to self-care practices is still inadequate (Elkashif, Mahdy and Elgazzar, 2021).

DM sufferers must have proper self-care skills to prevent DFU from occurring or developing foot ulcers. These skills are necessary for individuals with DFU, who usually must apply daily self-management and be on top of their ulcer care to prevent the poor outcome of lower limb amputation. Many self-management models have been developed for patients with chronic disease, especially for patients with DM to prevent DFU. Poor diabetic foot self-care practices are identified as a factor in the occurrence of DFU and a high risk of amputation. However, until now, there has been no research that explains how self-care of chronic illness is implemented which consists of three components in daily self-management practices in patients with DM who continue to do diabetic foot self-care.

This study aims to explain a model of self-care of chronic illness on the prevention of DFU risk in patients with DM. Self-care of chronic illness in this study consists of three components, namely foot self-care maintenance, monitoring, and management hereinafter referred to as latent variability. The risk of DFU is a health outcome of this model, hereinafter referred to as manifest variables.

Materials and Methods

Study Design

This research was analytical study with a cross-sectional approach. This study determined the correlation between latent variables, namely foot self-care maintenance, monitoring, and management behavior and risk of DFU as manifest variable, and also explained the relationship between latent variables. In addition, this study also measured indicators or constructs that make up each latent variable. There were three indicators that make up the latent foot self-care maintenance variables were (a) Disease prevention behaviors, (b) Health promoting behaviors, and (c) Illness-related behaviors. There were two indicators that make up the latent foot self-care monitoring variable, namely (a) Body listening, (b) Symptom recognition. There were two indicators that make up foot self-care management, namely (a) Autonomous self-care management behaviors and (b). Consultative self-care management behaviors.

Population, Samples, and Sampling

The population in this study was patients with DM who visited six Primary Health Centers (PHC) in East Surabaya, East Java, namely Pucang Sewu, Tambak Rejo, Pacar Keling, Keputih, Medoka Ayu, and Tenggilis located in East Surabaya. The sample size was 300 adult patients with DM calculated using the rule of thumb formula and recruited using the simple random sampling technique. The inclusion criteria were individuals with DM and aged more than 26 years. Exclusion criteria were reading disabilities or having cognitive impairments. This study was approved by the heads of institutions participating and by all enrolled and willing patients by signing a consent form.

Data Collection

The research was conducted from June to August 2022 at six PHC in Surabaya, East Java, Indonesia. All eligible participants had to fill out a self-administered questionnaire on characteristics and foot self-care of chronic illness, consisting of foot self-care maintenance, monitoring, and management, all of which were written in Indonesian. Researchers distributed questionnaires to patients who visited the PHC face to face with them. Eight nursing students were involved as enumerators, where they had previously received training in filling out questionnaires. Before data collection, the researcher explained the purpose of the study to the patients and ensured that they had obtained written informed consent. Patient participation was voluntary. In addition, patients as participants could choose to remain anonymous and had the option to refuse or not fill out the survey questionnaire.

Measurements

Data collection used a questionnaire consisting of characteristic data, including age, gender, marital status, smoking history, Body Mass Index (BMI), duration of DM, family history, type of medication, co-morbidity, and random blood glucose levels. BMI categories are Underweight: < 18.5, Normal: 18.5 - 25.0, Overweight: 25 – 27, and Obese > 27 (Menteri Kesehatan RI (Indonesian Minister of Health), 2014). The instrument used to measure foot self-care maintenance, foot self-care monitoring, and foot care management was a modified and combined questionnaire from the Self-Care of Diabetes Inventory (SCODI) (Ausili *et al.*, 2017) and Diabetic Foot Management (García-Inzunza *et al.*, 2015; Kaya and Karaca, 2018; Schaper *et al.*, 2019 (Kaya and Karaca, 2018)).

The foot self-care questionnaire consists of three parts, namely (1) maintenance of foot care (13 questions) spread over three indicators, namely: (a) Disease prevention behavior (5 items), (b) Health promotion behavior (4 items), (c) Disease-related behavior (4 items). (2) monitoring foot care (15 questions) spread over two indicators, namely: (a) Body listening (11 items), (b) Symptom recognition (4 items). (3) Foot Self-Care Management (30 questions) which is spread over two indicators, namely: (a) Autonomous self-care management behavior (26 items) and (b). Consultative self-care management behaviors (4 items). The scoring of foot self-care maintenance and monitoring uses a Likert scale with the categories strongly agree, agree, and disagree, where the higher the value, the better the behavior. The scoring of foot self-care management used a Likert scale with the categories always, often, sometimes, rarely, and never, where the higher the value, the better the behavior. Meanwhile, the development of risk category questions from DFU comes from the Diabetic Foot Model of Care with a score range of 1-5, where the higher the score, the more risky (National Clinical Programme for Diabetes, 2021). Score 1 is mild risk, score 2 is moderate risk, 3 is high risk, 4 is remission, and 5 is active ulcer.

Because this research has used Partial Least Squares (PLS) analysis, the validity and reliability test values use structural model testing, namely convergent validity, construct validity, and discriminant validity), and reliability (composite reliability).

Data Analysis

The descriptive statistics used to describe patient characteristics are frequency, percentage, mean, and standard deviation. The PLS determined the relationship between foot self-care of chronic illness variables and the risk of DFU as a health outcome. This research uses data analysis methods using PLS (*Partial Least Squares*) which can simultaneously test measurement models (outer model) and structural model testing (inner model). Measurement models are used to test validity (convergent validity, construct validity, and discriminant validity), and reliability (*composite reliability).* The result of convergent validity can be seen from the value of the loading factor and the calculated t value. The factor loading value is said to be valid if it is more than 0.5, while the result of t count can be said to be valid if it is more than 1.96. Construct validity measured by looking at AVE values greater than 0.5 indicates the adequacy of good validity for latent variables. The validity of the description can be measured using the cross- loading value. If the high cross loading value is 0.5 in the dimension of a particular variable compared to the dimension value of another variable then the constructive validity of the latent variable is good. Construct reliability is measured by the value *of composite reliability* and *reliable construct;* if the value of composite reliability is above 0.70 then the indicator is called consistent in measuring its latent variable. Structural models are used to test causality (hypothesis testing with predictive models). Testing was carried out using the t test. A variable was said to have correlation if the calculated t value was greater than the table t value. The t table value in this study was 1.96 (Latan and Ghozali, 2012).

Ethical Approval

Ethical approval was obtained from the Poltekkes Ethics Institute of the Ministry of Health Surabaya: No.EA/ 901/KEPK-Poltekkes_Sby/V/2022, and administrative was obtained from the Surabaya Health Office for each selected CHC before data collection.

Results

Description of Characteristics

The mean age of the participants in this study was 59.03 ± 9.78 years, 69% were aged between 46 and 65, 55% were female, 37% were high school seniors, 55% were unemployed, and 75% were married. Clinical characteristics data indicate that 86% were not smokers, and 53% had overweight. The mean Duration of DM was 7.31 ± 6.52, 55% had a family history, 87% used oral drugs, and 65% had co-morbidities. The average random blood sugar level at the time was 207.18 ± 78.44, 45% ≥ 200 mg/d (table 1). The risk of DFU in patients with DM was 40% with low risk, 38% with moderate risk, 8% with high risk, 5% remission, and 10% with DFU (Table 2).

Table 1 Description of characteristics of patients with DM (n=300)

Characteristics	Frequency n	%
Age (years) (Mean 59,03 ± 9.78)		
26-35	3	1
36-45	19	6
46-55	89	30
56-65	118	39
> 65	71	24
Sex		
Male	134	45
Female	166	55
Marital Status		
Yes	224	75
No	27	9
Widowed	49	16
Smoking		
No	258	86
Yes	42	14
BMI (kg/m2) (Mean 24.46 ± 4.04)		
Underweight	10	3
Normal	107	36
Overweight	159	53
Obesity	24	8
Duration of DM (years) (Mean 7.31 ± 6.52)		
1-5	162	54
6-10	80	27
>10	58	19
Family history of DM		
Yes	164	55
No	136	45
Type of medication		
Oral	261	87
Injection	15	5
Combination	24	8
Co-morbidities		
Yes	197	66
No	103	34
Random blood sugar level (Mean 207.18 ± 78.44)		
<200	166	55
≥ 200	134	45

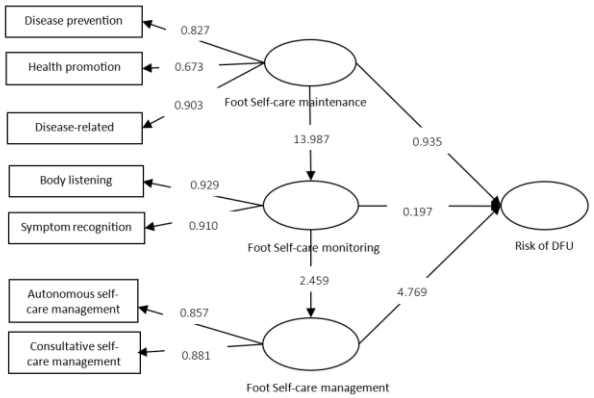

Figure 1 *The factor loading value of indicator and t-value of correlation between variables*

Description of Foot Self-care Maintenance, Monitoring, and Management

Variable foot self-care management has shown that of the three indicators, the highest proportion (47%) is indicated by inadequate disease prevention behavior. Variable the foot self-care monitoring showed that 64% of the patients had body listening and 59% had adequate symptom recognition. On the variable foot self-care management, the majority of patients (76%) had inadequate autonomous self-care management behavior, but 60% had adequate consultative self-care management behavior (Table 3).

The results of testing the structural model on each indicator for each latent variable can be seen in Table 2 and Figure 1. The convergent validity value of each indicator can be seen from the loading factor value, namely (a) Disease prevention behavior was 0.827, (b) Health promotion behavior item was 0.673, (c) Disease-related behavior is 0.903, (d) Body listening was 0.929, (e) Symptom recognition was 0.910, (f) Autonomous self-care management was 0.857, and (g) Consultative self-care management behaviors was 0.881. The convergent validity value was valid, because it was more than 0.5. The construct validity value could be seen from the AVE value, where the AVE value of this research is > 0.5. Sequentially the AVE values were 0.651, 0.846, and 0.756, so it could be stated that this indicator had a good validity value. The construct reliability value of each variable was expressed as a composite reliability value, where the value was declared reliable if the value was

Table 2 Description of risk of Diabetic Foot Ulcers (n=300)

Characteristics	Frequency n	%
Risk of DFU		
Low	119	40
Moderate	114	38
High	23	8
Remission	14	5
Active ulcer	30	10

Table 3 Description of foot self-care maintenance, monitoring, and management (n=300)

Indicator	Adequate		Fairly adequate		Inadequate		Factor Loading	Composite Reliability	Average Variance Extracted (AVE)
	n	%	n	%	n	%			
Foot Self-care Maintenance								0.847	0.651
Disease prevention behaviors	45	15	115	38	140	47	0.827		
Health-promoting behaviors	159	53	132	44	9	3	0.673		
Illness related behaviors	98	33	160	53	42	14	0.903		
Foot Self-care Monitoring								0.916	0.846
Body Listening	93	31	192	64	15	5	0.929		
Symptom recognition	84	28	178	59	38	13	0.910		
Foot Self-care Management								0.861	0.756
Autonomous self-care management behaviors	21	7	52	17	227	76	0.857		
Consultative self-care management behaviors	180	60	41	14	79	26	0.881		

above 0.70. These values were respectively 0.847, 0.916, and 0.86 so that these indicators could be declared consistent in measuring latent variables (Table 3). Variable foot self-care management has shown that of the three indicators, the highest proportion (47%) is indicated by inadequate disease prevention behavior. Variable the foot self-care monitoring showed that 64% of the patients had body listening and 59% had adequate symptom recognition. On the variable foot self-care management, the majority of patients (76%) had inadequate autonomous self-care management behavior, but 60% had adequate consultative self-care management behavior (Table 3).

The Correlation between Foot Self-care Maintenance, Foot Self-care Monitoring, Foot Self-care Management and Risk of DFU

To determine the correlation between variables, a structural model (inner model) was tested. Testing was carried out using the t-test. A variable is said to have influence if the calculated t value is greater than the table t value. The t table value in this study is 1.96. This research shows that there is a significant correlation between foot self-care management and the risk of DFU, where the p value = 0.000, while the variable of foot self-care maintenance and self-care monitoring do not have a significant correlation with the risk of DFU, where the p value is respectively equal to 0.350 and 0.844 (Table 3). Based on these data, we conclude that foot self-care management is a variable that has a direct correlation to DFU risk, while foot care maintenance and monitoring is an indicator that correlates with self-care management.

Table 4 The value of the correlation between foot self-care maintenance, foot self-care monitoring, foot self-care management and risk of DFU

Correlation	Original Sample (O)	T Statistics (|O/STDEV|)	*P*-Values
Foot Self-Care Maintenance -> Risk of DFU	0.073	0.935	0.350
Foot Self-Care Maintenance -> Foot Self-Care Monitoring	0.650	13.987	0.000
Foot Self-Care Monitoring -> Risk of DFU	-0.017	0.197	0.844
Foot Self-Care Monitoring -> Foot Self-Care Management	0.197	2.459	0.014
Foot Self-Care Management -> Risk of DFU	0.296	4.769	0.000

Discussions

This research explains the correlation between foot self-care and the risk of DFU through the self-care of chronic illness model. We use the theory of self-care of chronic illness to analyze foot care abilities in patients with DM. The components of self-care of chronic illness consist of Foot Self-care Maintenance, Foot Self-care Monitoring, and Foot Self-care Management, which are the variables in this study. Based on research results, it shows that foot self-care management has a direct correlation with the risk of DFU. Meanwhile, foot self-care maintenance and monitoring have an indirect correlation with the risk of DFU. Treatment of foot ulcers is challenging behavior because the causes are multifactorial, become a burden for the patient, involve the healthcare system, and society. Meanwhile, for foot ulcers that have successfully healed, the risk of recurrence is still high (Netten *et al.*, 2020). Self-care practice is one of the most significant parts of self-management for preventing diabetic foot ulcers (Mekonen and Demssie, 2022)..

The risks of DFU discussed in this study are low, moderate, high, remission, and ulcer. The majority of participants had a low to moderate risk of DFU. However, based on data on foot self-care management it shows that the majority of patients with DM had low autonomous self-care management behaviors. This condition can be a risk for developing diabetic foot ulcers. Diabetic foot ulcers are usually caused by repeated stress on areas subjected to high vertical or shear forces in patients with peripheral neuropathy (Armstrong, Boulton and Bus, 2017). Diabetes can also involve Charcot's neuroarthropathy, which involves the progressive destruction of bones, joints, and soft tissue, most commonly in the ankles and feet. The combination of neuropathy, abnormal foot loading, repetitive micro-trauma, and bone metabolic disorders leads to

inflammation, osteolysis, fractures, dislocations, and deformities (Mishra *et al.*, 2017).

This study shows that foot self-care maintenance does not directly affect the risk of DFU, but it does affect foot self-care monitoring. Patients with DM as a chronic disease must perform good and regular self-care to prevent complications (Ausili *et al.*, 2017). Self-care maintenance has a positive influence on self-care monitoring behavior. Patients with DM who carry out foot care independently have a positive relationship with the behavior of monitoring foot care. According to theory (Riegel *et al.*, 2019), self-care maintenance is directly related to self-care monitoring and self-care management. Theoretically, self-care maintenance is a complex and diverse dimension of self-care (Ausili *et al.*, 2017). Active symptom monitoring can provide awareness and interpretation of body changes as a symptom of a disease. Likewise, with the incidence of DFU in patients with DM, the ability to monitor the condition of the feet is essential to detect it early and prevent it.

The behavior of foot self-care monitoring in this study was not directly related to the incidence of DFU but influenced the behavior of foot self-care management. Even so, the data in this study indicate that most DM patients are quite capable of monitoring the signs and symptoms that occur in their bodies. Most patients experience foot abnormalities such as dry skin, callus, brittle toenails, and cracked heels. The self-observation of changes in signs and symptoms is the link between self-care maintenance and self-care management. Higher self-care monitoring was also associated with lower HbA1c in patients with diabetes (Ausili, Rebora and Valsecchi, 2020). Other studies have also indicated that self-management behavior is strongly associated with HbA1c (Thojampa and Acob, 2020).

Regarding foot care, careful inspection and examination of the feet is an integral part of the medical review that all individuals with diabetes can undertake (Boulton, 2022). Patients with DM who have no risk factors for DFU or have healthy feet should still receive general advice on foot hygiene, nail care, and purchasing footwear. Their DFU risk status should be checked annually (Boulton, 2022). Individuals with some risk factors should be checked more frequently and educated about preventive foot care (Joeliantina *et al.*, 2022).

So patients with DM who are not at risk and are at risk for DFU, still have to have the ability to recognize signs and symptoms or changes that occur in their foot. This ability can prevent early complications from DFU or the development of wounds that can lead to foot amputation.

The results showed that most patients with DM can't perform foot care independently or autonomously, but most patients were able to perform consultative foot care. DM patients have not been able to apply comprehensive foot care which includes recognizing symptoms, determining the risk of DFU, caring for the feet daily, caring for the feet if there are wounds, and carrying out foot exercises. Patients tend to choose consultative behavior to get treatment from doctors or other health workers. Other studies in line with this show that the practice of foot care which consists of examining the feet, drying between the toes, and cutting the toenails is still low (Khunkaew, Fernandez and Sim, 2019). It has also been found that self-care behaviors are effective in preventing DFU and are significantly associated with a lower risk of DFU (McInnes *et al.*, 2011; Chin *et al.*, 2014' Hemmati Maslakpak *et al.*, 2018))). Patients with diabetes who have poor foot self-care practices are 3.6 times more likely to develop diabetic foot ulcers than diabetic patients who have good foot self-care practices (Regas *et al.*, 2021).

Patients with DM must be sensitive to the signs and symptoms that occur. This response is in the form of behavior aimed at preventive action against DFU risk. Patient education plays an important role in the prevention of diabetic foot problems. The aim is to increase foot care knowledge, awareness, and self-protective behavior, and to increase motivation, skill, and adherence to foot care behavior.

Nurses should take part in preparing and implementing training programs to change patient behavior and improve patient quality of life. Nurses must have sufficient knowledge about foot care and provide appropriate information to DM patients about preventing the formation of diabetic foot and treating diabetic foot ulcers (Kaya and Karaca, 2018; Schaper *et al.*, 2019). There was a significant improvement, indicating that improved self- and family management from a three-month support program resulted in improvements in DFU patients (Subrata *et al.*, 2020). Health care workers (doctors or nurses) must be aware that one in two DM patients uses Complementary and Alternative Medicine (CAM) to manage their disease, so when evaluating patient they must ensure that the use of CAM is carried out correctly (Joeliantina, Norontoko and Anugrahini, 2021). This is so that patients can minimize the development of complications including DFU.

This study has some limitations. First of all, the researchers obtained data about the implementation of foot self-care through direct reports from patients, not through direct observation using concrete parameters. Second, the participants in this study were not specific to patients with foot ulcers, so they still had a bias in exploring foot self-care behavior. Third, the data were obtained through a cross-sectional survey. Based on the reasons above, patients with DM must get the right information so that patients can easily understand it. Patient independence in performing foot care can help to prevent DFU. These studies show that self-management support strategies can help individuals with DM avoid developing DFU as a clinical result, and they recommend incorporating these strategies into clinical care. Collaboration between nurses and other health professional teams is still needed to achieve successful DFU management. The Health Education Program about foot self-care must be continuous so problems don't develop more severely.

Conclusions

This research described a behavioral model of self-care of chronic illness to prevent the risk of DFU in patients with DM. Foot self-care management was a factor that directly correlates with the risk of DFU. Foot self-care maintenance and monitoring factors, although they did not directly correlate with DFU risk, should still receive attention, because they correlate with foot self-care management. Autonomous self-care management behaviors still needs to be improved, because most patients still had behaviors that were inadequate. This condition has a high risk of developing into a DFU. Further research is needed to improve the quality of behavior of DM patients in carrying out independent foot care management, both for those who do not have an injury and those who do. Research on the use of herbs also needs to be considered as an intervention to treat diabetic foot problems.

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Conflict of interest

The authors declare no competing interests.

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