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Factors Associated With Individual Components of Diabetes Self-Care Activities Among Outpatients With Type 2 Diabetes Mellitus in Indonesia: A Cross-Sectional Study

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Abstract

Background: Diabetes self-care is essential for preventing complications and improving health outcomes among individuals with type 2 diabetes mellitus (T2DM). Although locus of control, diabetes self-efficacy, and family attitudes are theorized to influence whether individuals engage in self-care behaviors, evidence regarding the factors associated with individual self-care components remains limited and inconsistent. Therefore, this study examined the independent associations of these factors with individual self-care components among T2DM outpatients.

Methods: This cross-sectional study was conducted between November 2024 and April 2025 in six outpatient healthcare facilities (four hospitals and two community health centers) in South Sulawesi Province, Indonesia. Adults with T2DM were recruited using convenience sampling from routine outpatient visits and the chronic-disease management program. Of 407 questionnaires returned, 239 with complete data were analyzed. Participants involved in this study were measured using self-administered validated questionnaires of diabetes-specific locus of control (internal, external, and chance), diabetes care self-efficacy, family attitudes, and diabetes self-care activities scale. Data were analyzed using Pearson correlation, followed by multiple linear regression analyses adjusted for demographic characteristics.

Results: Chance locus of control (B = −0.466; 95% CI: −0.770 to −0.163) and positive family attitudes (B = −0.785; 95% CI: −1.218 to −0.351) were negatively associated with general diet, while negative family attitudes were positively associated (B = 0.829; 95% CI: 0.419 to 1.240). For specific diet, external locus of control was positively associated (B = 0.407; 95% CI: 0.112 to 0.702), whereas chance locus of control was negatively associated (B = −0.269; 95% CI: −0.506 to −0.032). Physical activity was positively associated with chance locus of control (B = 0.357; 95% CI: 0.071 to 0.643), self-efficacy (B = 0.331; 95% CI: 0.133 to 0.530), and negative family attitudes (B = 0.813; 95% CI: 0.426 to 1.200), whereas positive family attitude was negatively associated (B = −0.421; 95% CI: −0.830 to −0.013). Chance locus of control was negatively associated with blood glucose monitoring (B = −0.143; 95% CI: −0.281 to −0.005), whereas positive family attitudes were positively associated (B = 0.260; 95% CI: 0.062 to 0.457). For foot care, chance locus of control (B = 0.791; 95% CI: 0.458 to 1.124), self-efficacy (B = 0.620; 95% CI: 0.389 to 0.851), and negative family attitudes (B = 0.802; 95% CI: 0.352 to 1.252) were positively associated, while internal locus of control (B = −0.620; 95% CI: −1.017 to −0.222) and positive family attitudes (B = −0.518; 95% CI: −0.994 to −0.043) were negatively associated.

Conclusion: No single factor was consistently associated with all components of diabetes self-care, indicating that the associations varied across self-care domains. Educational programs that address self-efficacy and family attitudes may be potential targets for future research. Strategies addressing locus of control may also need to be tailored to specific self-care domains. However, these findings should be interpreted cautiously because of the risk of false-positive findings due to multiple comparisons.

Categories: Family/General Practice, Public Health, Endocrinology/Diabetes/Metabolism
Keywords: diabetes self-care activities, family attitudes, locus of control, self-efficacy, type 2 diabetes mellitus

Introduction

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder characterized by persistent hyperglycemia. According to the International Diabetes Federation, the prevalence of T2DM is rapidly increasing owing to advancements in parallel factors such as an aging population, rising rates of overweight, and increasingly

sedentary lifestyle [1]. The Global Burden of Disease Study 2021 estimated that 529 million people worldwide were living with diabetes, corresponding to an age-standardized prevalence of 6.1%, of whom about 96% had T2DM [2]. Approximately 14.4-22.7% of patients with chronic diabetes mellitus (DM) are reported to be readmitted to the hospital within 30 days of discharge due to hyperglycemic emergencies [3], resulting from poor metabolic control and a sedentary lifestyle [4]. Enhancing self-care activities are critical.

Self-care refers to an individual's cognitive decision-making process involving activities that maintain physiological stability [5]. Complex components of self-care aimed at achieving well-being involve maintaining medication adherence, dietary regulation, physical activity, blood glucose monitoring, and foot care [6]. In order to effectively improve self-care, strategies focusing on the cognitive framework that shapes how individuals view their own traits and others have been introduced [7,8]. From an individual perspective, cognitive beliefs influence how individuals view their own traits when facing a medical condition [9]. Unlike motivation or illness perceptions alone, which tend to fluctuate depending on the situation and may not always be sufficient to drive behavior change [10,11], beliefs about the source of control over one's health (internal, external, or chance factors) and belief in one's own capability like self-efficacy tend to be trait-like that may influence on health outcomes [12,13]. By acknowledging the complexity of the self-care decision-making process, it is important to consider internal, external, and chance locus of control, and self-efficacy, when supporting diabetes self-care behaviors.

Internal locus of control refers to the belief that individuals have control over their health outcomes through their own actions. Conversely, external locus of control and chance locus of control refer to the belief that individuals' health outcomes are governed by outside forces such as the power of healthcare providers, random luck, destiny, and coincidence [9]. High internal locus of control is strongly correlated with regular glycemic control [14], while higher external and chance locus of control tend to be more passive in managing their daily treatment [15]. Previous studies have reported that patients whose healthcare providers support their autonomy tend to become more motivated to manage their blood glucose levels and develop greater confidence [16]. Beyond locus of control, another cognitive belief that shapes how individuals view their own capacity to manage the illness is self-efficacy. Patients with high self-efficacy have confidence in their ability to proficiently engage in self-care [17]. Self-efficacy in diabetes care significantly influences self-care [12] and in other chronic conditions such as heart failure [18].

In T2DM patients, self-care may also be related to how individuals perceive their surrounding environment, particularly family and social support [18,19]. Unlike inpatients, whose perception of how others judge their illness is shaped by patient-provider collaboration, outpatients' perception of how others judge their illness frequently involves the people closest to them, particularly family attitudes [8]. Family attitudes play a substantial role in decision-making [20], the provision of support [21], and sustaining health outcomes [22]. Thus, the implementation of each self-care component among T2DM outpatients may also appear to be associated with the role of family attitude.

An overall self-care approach may therefore be less targeted in addressing the needs of each component. Previous studies have predominantly examined diabetes self-care as an aggregate construct or focused on selected behavioral domains [23]. Consequently, whether locus of control, diabetes self-efficacy, and perceived family attitudes show domain-specific associations across distinct self-care behaviors remains insufficiently understood, particularly among T2DM Indonesian outpatients. Therefore, this study aimed to examine the independent associations of locus of control, self-efficacy, and family attitudes with dietary regulation, medication adherence, physical activity, blood glucose monitoring, and foot care, after adjustment for prespecified confounders. Identifying the role of locus of control, diabetes care self-efficacy, and family attitudes may help inform education and family-based programs aimed at improving each self-care component.

Materials And Methods

Data collection

This cross-sectional study was conducted in six outpatient healthcare facilities in South Sulawesi Province, Indonesia, comprising four hospitals, namely, Dr. Dody Sardjoto Air Force Hospital, Makassar, Hasanuddin University Hospital, Makassar, Prof. Dr. H. M. Anwar Makkatutu Regional General Hospital, Bantaeng District, and Arifin Nu'mang Regional General Hospital, Sidenreng Rappang District, and two community health centers, namely, Rappang Public Health Center, Sidenreng Rappang District, and Ulugalung Public Health Center, Bantaeng District. Data were collected from November 2024 to April 2025. Inclusion and exclusion criteria are presented in Table *1*. Participants were recruited through two channels: (1) T2DM outpatients attending routine visits at the participating facilities and (2) T2DM patients enrolled in the Program Pengelolaan Penyakit Kronis (PROLANIS) program at the participating community health centers, who were identified from program registration records and visited directly by the research team. Convenience sampling was used, as participants were drawn from those attending services or listed in program records during the recruitment period rather than selected randomly. The required sample size was determined a priori using G*Power version 3.1 (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany) for multiple regression. Assuming a medium effect size (f2 = 0.10), a Cronbach's α of 0.05, a power

of 0.95, and 19 predictors, the minimum required sample size was 217 participants. A total of 407 questionnaires were returned, of which 239 with complete data were included in the final analysis, exceeding the required minimum.

	Descriptions
Inclusion criteria	
Diagnosis	Diagnosed with T2DM by a physician, as documented in the medical record or PROLANIS registry
Age	Aged ≥18 years
Setting	Attending routine outpatient visits at one of the six participating facilities or enrolled in the PROLANIS program at the participating community health centers
Duration of diagnosis	Diagnosed with T2DM for ≥6 months
Communication	Able to communicate and complete the questionnaire, either independently or with assistance from the research team
Exclusion criteria	
Diabetes type	Diagnosed with T1DM, gestational diabetes, or other specific types of diabetes
Cognitive or psychiatric condition	Severe cognitive impairment or psychiatric disorder that would prevent reliable responses
Acute condition	Hospitalized or in acute severe illness at the time of data collection

TABLE 1: Inclusion and exclusion criteria

Participants with T1DM, with gestational diabetes, or who were hospitalized were excluded because differences in disease etiology, treatment regimens, and clinical conditions could confound the study outcomes.

T1DM: type 1 diabetes mellitus; T2DM: type 2 diabetes mellitus; PROLANIS: Program Pengelolaan Penyakit Kronis

Study questionnaire

Data were collected using a structured, self-administered questionnaire comprising five sections: sociodemographic characteristics, locus of control, diabetes self-efficacy, family behaviors, and diabetes self-care activities.

Sociodemographic Characteristics

The self-designed general information questionnaire was used to evaluate the demographic variables, including age, gender, marital status, educational background, employment status, living area, and time distance from the health facility.

Locus of Control

Locus of control was measured using the locus of control subscales of the Diabetes-Specific Health Belief Model scales (DSHBs) developed by Gutierrez and Long [24], as applied to Indonesian patients with T2DM by Asril et al. [14]. The instrument comprises three subscales (internal, external, and chance) with six items each (18 items in total), rated on a 6-point Likert scale (from 1 (disagree) to 6 (agree)). A high internal score reflects the belief that healthy lifestyle behaviors result from personal decisions, a high external score the belief that they are determined by external factors, and a high chance score the belief that they are determined by fate. Subscale scores were calculated as the mean of the six items (range 1-6), and no total score was computed because the subscales represent distinct beliefs. Cronbach's alpha for the three subscales was 0.91, 0.86, and 0.87, respectively [14].

Diabetes Self-Efficacy

Self-efficacy was assessed using a validated four-item scale measuring confidence in the ability to manage diabetes care [25], adapted for the Indonesian population [14]. The items assess confidence in the ability to manage diabetes, feeling capable of handling one's diabetes, being able to perform routine diabetes care independently, and being able to meet the challenge of controlling diabetes. Each item was rated on a 7-point scale from 1 (not at all true) to 7 (very true). The mean item score was converted to a 0-100 scale using

(mean − 1)/6 × 100, with higher scores indicating greater self-efficacy in managing diabetes [25].

Family Attitudes

Family attitudes were measured using the Diabetes Family Behavior Checklist (DFBC) [8], a 16-item instrument assessing the frequency of supportive (positive; nine items) and nonsupportive (negative; seven items) family behaviors. Items were rated on a 5-point scale from 1 (never) to 5 (at least once a day). Subscale scores were calculated as the mean of the items (range 1-5), with higher scores indicating more frequent positive or negative family behaviors, respectively. The Indonesian version has shown good reliability (Cronbach's α = 0.95) [14].

Diabetes Self-Care

Self-care was measured using a modified 12-item Indonesian version of the Summary of Diabetes Self-Care Activities (SDSCA) [6], which asks about the past seven days and uses response options from 0 to 7. The items cover general diet (item 1: following a healthy eating plan), specific diet (item 2: eating five or more servings of fruits and vegetables; item 3: eating high-fat foods such as fried foods, fatty meat, and chicken skin), physical activity (item 4: at least 30 minutes of physical activity; item 5: exercise such as jogging), medication adherence (item 6), blood glucose monitoring (items 7 and 8: how often blood glucose was checked and tested as recommended by the doctor), and foot care (items 9-12). The source questionnaire grouped items 1-3 as a single diet domain; we separated them into general and specific diet in line with the original SDSCA subscales [6]. Items were scored as the reported number (0 = 0, ..., 7 = 7), except item 3, the only unfavorable item, which was reverse-scored (0 = 7; 1 = 6; 2 = 5; 3 = 4; 4 = 3; 5 = 2; 6 = 1; 7 = 0). Reverse scoring was necessary because, unlike the other items, a higher frequency of eating high-fat foods indicates poorer self-care and reversal makes all items point in the same direction. Consistent with the SDSCA scoring approach [6], domain scores were calculated as the mean across items (range 0-7). Higher scores in every domain therefore indicate more frequent self-care. The modified version was reported to be valid (product-moment correlations $r > 0.632$, above the critical value of 0.228 at $p < 0.05$) and reliable (Cronbach's α = 0.923) [23]. Because the SDSCA domains assess distinct behaviors, each was analyzed separately, consistent with previous studies [6,23].

Statistical analysis

All statistical analyses were carried out using JMP Pro 19 (JMP Statistical Discovery LLC, Cary, NC, USA). Frequencies and percentages were used to describe the demographic characteristics. Pearson correlation analyses were conducted to examine the associations between locus of control, self-efficacy, family attitudes, and the specific domains of diabetes self-care.

Six separate multiple linear regression models were performed, with each of the six self-care domains (general diet, specific diet, physical activity, medication adherence, blood glucose monitoring, and foot care) treated as a separate dependent variable. The same set of six independent variables of interest (internal, external, and chance locus of control; self-efficacy; and positive and negative family attitudes) was included in each model, with demographic characteristics adjusted for in all models. Because six models with six predictors of interest each were fitted (36 tests in total), the risk of false-positive findings (type I error) is increased. We therefore report unadjusted p-values as the primary results and, as a sensitivity check, also interpreted the findings against a Bonferroni-adjusted threshold ($\alpha = 0.05/36 \approx 0.0014$) and a per-model threshold ($\alpha = 0.05/6 \approx 0.008$). Associations that did not meet these thresholds were considered exploratory.

The assumptions of multiple linear regression were assessed for each model, including multicollinearity, residual normality, and the presence of potentially influential observations. Multicollinearity was assessed using the variance inflation factor (VIF). Residual diagnostics included the Shapiro-Wilk test, studentized residuals, Cook's distance, and visual inspection of residual plots. The diagnostic results are presented in Appendices A-C.

Regression coefficients were reported as unstandardized coefficients (B), standard errors (SE), standardized coefficients (β), t-values, p-values, and 95% confidence intervals (CIs). Statistical significance was set at $p < 0.05$ (unadjusted); results were interpreted in light of the multiple-comparison thresholds described above.

Ethical considerations

This study followed the principles of the Declaration of Helsinki. Ethical approval was obtained from the Health Research Ethics Committee of the Faculty of Nursing, Hasanuddin University, Indonesia (approval number: UH2407154; July 25, 2024), and the Ethics Review Committee of Niigata University of Health and Welfare, Japan (approval number: 19372-241004; October 14, 2024). Before data collection, the research team explained to each potential participant the purpose and procedures of the study, that participation was voluntary, that they could stop at any time, and that their decision would not affect the care they received. Verbal informed consent was obtained from all participants. For participants with limited literacy, the research team read the information aloud.

Questionnaires were completed anonymously and contained no names or other direct identifiers. Each questionnaire was assigned a study code used only for data management. Only the research team had access to the data. Completed paper questionnaires were stored in a locked cabinet/room at Niigata University of Health and Welfare, Japan, and digital data were stored on password-protected computers. Data will be retained for 10 years and then destroyed. Results are reported in aggregate only. Therefore, individual participants cannot be identified.

Results

Of the 407 participants who received the questionnaire, 239 (58.7%) completed all questionnaire items and were included in the final analysis. The remaining 168 participants (41.3%) were excluded because their questionnaires were incomplete.

Characteristics of the participants

The mean age of participants was 55.28 years (SD = 9.73). The majority of participants (n = 164; 68.6%) were female. Other characteristics, including marital status, educational background, employment status, living area, and time distance from the health facility, are presented in Table *2*.

Variable	Category	n (%)
Age (mean = 55.28; SD = 9.73)	<60 years	170 (71.13)
	≥60 years	69 (28.87)
Gender	Male	75 (31.38)
	Female	164 (68.62)
Marital status	Married	177 (74.06)
	Divorced/widowed	52 (21.76)
	Not married	10 (4.18)
Educational background	Elementary school	74 (30.96)
	Junior high school	30 (12.55)
	Senior high school	70 (29.29)
	Diploma/university	59 (24.69)
	Non-formal education	6 (2.51)
Employment status	Housewife/house worker	139 (58.16)
	Professional worker/civil servant	76 (31.80)
	Retired/unemployed	24 (10.04)
Living area	Rural	175 (73.22)
	Semi-urban	31 (12.97)
	Urban	33 (13.81)
Time distance from the health facility	<30 minutes	216 (90.38)
	≥30 minutes	23 (9.62)

TABLE 2: Characteristics of the participants (n= 239)

n (%): number and percentage of the participants

Description of locus of control, self-efficacy, and family attitudes with self-care activities

The descriptive statistics of the study variables, including locus of control, self-efficacy, family attitudes,

and diabetes self-care activities (general diet, specific diet, physical activity, medication adherence, blood glucose monitoring, and foot care), are presented in Table 3. The highest mean score was observed for medication adherence (6.68; SD = 1.03), and the lowest mean score was for blood glucose monitoring (2.87; SD = 0.75).

Variables	M ± SD
Locus of control	
Internal locus of control	4.79 ± 0.63
External locus of control	4.56 ± 0.65
Chance locus of control	3.64 ± 0.93
Diabetes care self-efficacy	68.9 ± 17.9
Family attitudes	
Positive family attitudes	2.73 ± 0.60
Negative family attitudes	2.52 ± 0.64
Diabetes self-care activities (number of days/past week)	
General diet	5.09 ± 1.71
Specific diet	4.56 ± 1.30
Physical activity	4.22 ± 1.76
Medication adherence	6.68 ± 1.03
Blood glucose monitoring	2.87 ± 0.75
Foot care	4.77 ± 2.24

TABLE 3: Scores by self-efficacy, self-care components, locus of control, and family attitudes (n= 239)

M ± SD: mean ± standard deviation

Correlation of locus of control, self-efficacy, and family attitudes with self-care activities

Bivariate analyses were conducted to examine the correlation of internal locus of control, external locus of control, chance locus of control, self-efficacy, positive family attitudes, and negative family attitudes with each component of diabetes self-care activities. The results are presented in Table 4.

		General diet	Specific diet	Physical activity	Medication adherence	Blood glucose monitoring	Foot care
1.	Internal locus of control	0.022	0.009	0.006	0.035	0.130*	–0.114
2.	External locus of control	0.017	0.141*	0.183*	–0.072	0.023	0.118
3.	Chance locus of control	–0.265*	–0.110	0.309*	–0.112	–0.097	0.479*
4.	Self-efficacy	–0.133*	0.079	0.329*	–0.100	–0.008	0.406*
5.	Negative family attitudes	0.173*	0.131*	0.248*	–0.060	0.023	0.142*
6.	Positive family attitudes	–0.079	0.138*	0.015	–0.161*	0.185*	–0.035

TABLE 4: The correlation analysis

*p < 0.05; Pearson correlation

General Diet

Negative family attitudes (r = 0.173) were positively associated with general diet. Chance locus of control (r = -0.265) and self-efficacy (r = -0.133) were negatively associated with general diet.

Specific Diet

External locus of control (r = 0.141), negative family attitudes (r = 0.131), and positive family attitudes (r = 0.138) were positively associated with specific dietary behavior.

Physical Activity

External locus of control (r = 0.183), chance locus of control (r = 0.309), self-efficacy (r = 0.329), and negative family attitudes (r = 0.248) were positively associated with physical activity.

Medication Adherence

Positive family attitudes (r = -0.161) were negatively associated with medication adherence.

Blood Glucose Monitoring

Internal locus of control (r = 0.130) and positive family attitudes (r = 0.185) were positively associated with blood glucose monitoring.

Foot Care

Chance locus of control (r = 0.479), self-efficacy (r = 0.406), and negative family attitudes (r = 0.142) were positively associated with foot care.

Association of locus of control, self-efficacy, and family attitudes on self-care activities

To further examine the association of internal locus of control, external locus of control, chance locus of control, self-efficacy, positive family attitudes, and negative family attitudes, separate multiple linear regression analyses were conducted for individual components of diabetes self-care activities after adjusting for age, gender, marital status, educational background, employment status, living area, and time distance from the health facility. The results are presented in Table 5.

Dependent	Independent	B	SE	t	p	95% CI of B	Std.

						Lower	Upper	beta
General diet: R^2 = 0.194; R^2 adjusted = 0.124; F-test (19,219) = 2.779; p = 0.0002	Internal locus of control	0.065	0.184	0.356	0.7220	-0.297	0.428	0.024
	External locus of control	0.219	0.192	1.138	0.2566	-0.160	0.597	0.084
	Chance locus of control	-0.466	0.154	-3.029	0.0027	-0.770	-0.163	-0.256
	Self-efficacy	-0.144	0.107	-1.348	0.1789	-0.355	0.066	-0.091
	Negative family attitude	0.829	0.208	3.983	<0.0001	0.419	1.240	0.313
	Positive family attitude	-0.785	0.220	-3.568	0.0004	-1.218	-0.351	-0.280
Specific diet: R^2 = 0.153; R^2 adjusted = 0.079; F-test (19,219) = 2.081; p = 0.0064	Internal locus of control	-0.149	0.143	-1.037	0.3010	-0.431	0.134	-0.072
	External locus of control	0.407	0.150	2.717	0.0071	0.112	0.702	0.205
	Chance locus of control	-0.269	0.120	-2.241	0.0260	-0.506	-0.032	-0.194
	Self-efficacy	0.070	0.083	0.839	0.4023	-0.094	0.234	0.058
	Negative family attitude	0.079	0.162	0.484	0.6290	-0.241	0.398	0.039
	Positive family attitude	0.175	0.171	1.023	0.3073	-0.162	0.513	0.082
Physical activity: R^2 = 0.328; R^2 adjusted = 0.270; F-test (19,219) = 5.626; p < 0.0001	Internal locus of control	-0.224	0.173	-1.294	0.1972	-0.566	0.117	-0.080
	External locus of control	0.231	0.181	1.278	0.2027	-0.126	0.588	0.086
	Chance locus of control	0.357	0.145	2.458	0.0148	0.071	0.643	0.190
	Self-efficacy	0.331	0.101	3.289	0.0012	0.133	0.530	0.202
	Negative family attitude	0.813	0.196	4.143	<0.0001	0.426	1.200	0.297
	Positive family attitude	-0.421	0.207	-2.031	0.0434	-0.830	-0.013	-0.145
Medication adherence: R^2 = 0.105; R^2 adjusted = 0.027; F-test (19,219) = 1.347; p = 0.1565	Internal locus of control	0.175	0.117	1.498	0.1355	-0.055	0.406	0.107
	External locus of control	-0.075	0.122	-0.615	0.5395	-0.316	0.166	-0.048
	Chance locus of control	-0.087	0.098	-0.890	0.3744	-0.280	0.106	-0.079
	Self-efficacy	-0.070	0.068	-1.033	0.3025	-0.204	0.064	-0.073
	Negative family attitude	0.070	0.132	0.528	0.5979	-0.191	0.331	0.044
	Positive family attitude	-0.269	0.140	-1.925	0.0555	-0.545	0.006	-0.159
	Internal locus of	0.127	0.084	1.516	0.1309	-	0.292	0.106

	control					0.038		
Blood glucose monitoring: R^2 = 0.146; R^2 adjusted = 0.072; F-test (19,219) = 1.968; p = 0.0111	External locus of control	-0.004	0.087	-0.041	0.9676	-0.176	0.169	-0.003
	Chance locus of control	-0.143	0.070	-2.041	0.0424	-0.281	-0.005	-0.177
	Self-efficacy	0.014	0.049	0.278	0.7814	-0.082	0.109	0.019
	Negative family attitude	-0.095	0.095	-1.007	0.3151	-0.282	0.091	-0.081
	Positive family attitude	0.260	0.100	2.594	0.0101	0.062	0.457	0.209
Foot care: R^2 = 0.440; R^2 adjusted = 0.392; F-test (19,219) = 9.061; p < 0.0001	Internal locus of control	-0.620	0.202	-3.074	0.0024	-1.017	-0.222	-0.174
	External locus of control	0.159	0.211	0.757	0.4501	-0.256	0.575	0.046
	Chance locus of control	0.791	0.169	4.684	<0.0001	0.458	1.124	0.330
	Self-efficacy	0.620	0.117	5.294	<0.0001	0.389	0.851	0.297
	Negative family attitude	0.802	0.228	3.512	0.0005	0.352	1.252	0.230
	Positive family attitude	-0.518	0.241	-2.149	0.0328	-0.994	-0.043	-0.140

TABLE 5: The multiple regression analysis

Adjusted by age, gender, marital status, educational background, employment status, living area, and time distance from the health facility.

Self-care scores are the mean number of days per week (range 0-7). Higher scores indicate more frequent self-care in all domains. The high-fat diet item was reverse-scored before computing the specific diet score.

Variance inflation factors and tolerance for all predictors, and the results of the model diagnostics (residual-versus-predicted plots, normality of residuals), are presented in Appendices A and C and summarized in the Statistical analysis section.

B: unstandardized coefficients; SE: standard errors

General Diet

Chance locus of control (B = -0.466; 95% CI: −0.770 to −0.163; β = −0.256; p = 0.0027) and positive family attitudes (B = -0.785; 95% CI: −1.218 to −0.351; β = −0.280; p = 0.0004) were negatively associated with general diet, whereas negative family attitudes were positively associated with general diet (B = 0.829; 95% CI: 0.419 to 1.240; β = 0.313; p < 0.0001) (R2 = 0.194; R2 adjusted = 0.124; F-test (19,219) = 2.779; p = 0.0002).

Specific Diet

External locus of control was positively associated with specific diet (B = 0.407; 95% CI: 0.112 to 0.702; β = 0.205; p = 0.0071), whereas chance locus of control was negatively associated with specific diet (B = -0.269; 95% CI: −0.506 to −0.032; β = −0.194; p = 0.0260) (R2 = 0.153; R2 adjusted = 0.079; F-test (19,219) = 2.081; p = 0.0064).

Physical Activity

Chance locus of control (B = 0.357; 95% CI: 0.071 to 0.643; β = 0.190; p = 0.0148), self-efficacy (B = 0.331; 95% CI: 0.133 to 0.530; β = 0.202; p = 0.0012), and negative family attitudes (B = 0.813; 95% CI: 0.426 to 1.200; β = 0.297; p < 0.0001) were positively associated with physical activity. In contrast, positive family attitudes were negatively associated with physical activity (B = -0.421; 95% CI: −0.830 to −0.013; β = −0.145; p = 0.0434) (R2 = 0.328; R2 adjusted = 0.270; F-test (19,219) = 5.626; p < 0.0001).

Medication Adherence

The overall regression model for medication adherence was not statistically significant (R2 = 0.105; R2 adjusted = 0.027; F-test (19,219) = 1.347; p = 0.1565).

Blood Glucose Monitoring

Chance locus of control was negatively associated with blood glucose monitoring (B = -0.143; 95% CI: −0.281 to −0.005; β = −0.177; p = 0.0424), whereas positive family attitudes were positively associated with blood glucose monitoring (B = 0.260; 95% CI: 0.062 to 0.457; β = 0.209; p = 0.0101) (R2 = 0.146; R2 adjusted = 0.072; F-test (19,219) = 1.968; p = 0.0111).

Foot Care

Internal locus of control (B = -0.620; 95% CI: −1.017 to −0.222; β = −0.174; p = 0.0024) and positive family attitudes (B = -0.518; 95% CI: −0.994 to −0.043; β = −0.140; p = 0.0328) were negatively associated with foot care, whereas chance locus of control (B = 0.791; 95% CI: 0.458 to 1.124; β = 0.330; p < 0.0001), self-efficacy (B = 0.620; 95% CI: 0.389 to 0.851; β = 0.297; p < 0.0001), and negative family attitudes were positively associated with foot care (B = 0.802; 95% CI: 0.352 to 1.252; β = 0.230; p = 0.0005) (R2 = 0.440; R2 adjusted = 0.392; F-test (19,219) = 9.061; p < 0.0001).

Discussion

Locus of control, self-efficacy, and family attitudes were associated with the components of diabetes self-care with different directions among outpatients with T2DM. A previous study reported that diabetes self-care is a multidimensional set of behaviors that have different determinants [6].

Chance locus of control was negatively associated with general diet, specific diet, and blood glucose monitoring, but positively associated with physical activity and foot care. External locus of control was positively associated with specific diet, while internal locus of control was negatively associated with foot care. Self-efficacy was positively associated with physical activity and foot care.

Positive family attitudes were negatively associated with general diet, physical activity, and foot care, but positively associated with blood glucose monitoring. Negative family attitudes were positively associated with general diet, physical activity, and foot care.

General diet

In this study, chance locus of control and positive family attitudes were associated with lower general diet, while negative family attitudes were associated with higher general diet. The model explained about 12% of the variance in general diet, which suggests that other factors also play an important role. Similar to the previous study, people who believe their health is mainly determined by luck or chance may be less consistent in the routine parts of diabetes self-care [14]. General diet, such as following a healthy diet consistent with a recommended diabetes diet, may require regular planning. This might be explained by the nature of a diet that requires to be repeated by daily decisions [26]. Diet requires decisions about food selection, portion size, meal patterns, and dietary restrictions [27].

The pattern for family attitudes was different from what we expected, as positive family attitudes were associated with a lower general diet. However, the role of family members in diabetes diet is often ambivalent [28]. Very supportive families may make patients depend on others to manage their food, while demanding or critical attitudes may act as social monitoring that encourages patients to be more careful. Therefore, diet interventions should address fatalistic beliefs and involve family members, rather than replace patients' independence.

Specific diet

External locus of control was positively associated with specific diet, whereas chance locus of control was negatively associated with specific diet. The association involving external locus of control met the per-model threshold but not the Bonferroni-adjusted threshold, while the association involving chance locus of control did not meet either threshold. The model explained about 8% of the variance in specific diet. This suggests believing in the influence of identifiable external agents, including healthcare providers, family members, friends, and other people with diabetes [7,14,15]. Similar to a previous study among diabetes patients, external guidance could play a role in promoting adherence to structured self-care, including diet [15]. The practice of a specific diet (e.g., limiting sugar intake, reducing fat consumption, or following detailed dietary instructions) often involves clear guidelines and external reinforcement. Individuals with a higher external locus of control may be more responsive to recommendations from healthcare professionals or family members [29]. When individuals rely on external sources of control, such as powerful others [30], they may become more motivated to follow dietary recommendations and structured advice. Specific dietary practices may be more closely related to strict guidance on disease from healthcare providers, whereas

general dietary practices may involve broader daily food choices [15]. Therefore, healthcare providers should provide clear guidance and strengthen the external support system, which may improve adherence to a specific diet.

Physical activity

Chance locus of control, self-efficacy, and negative family attitudes were positively associated with physical activity, while positive family attitudes were negatively associated with physical activity. Among these associations, those involving self-efficacy and negative family attitudes met the Bonferroni-adjusted threshold, whereas those involving chance locus of control and positive family attitudes did not meet either the Bonferroni-adjusted or per-model threshold. The model explained about 27% of the variance in physical activity. These findings are consistent with a previous study reporting that higher self-efficacy is associated with increased physical activity [31], consistent with the previous studies reporting the association between self-efficacy and physical activity [12,32].

Chance locus of control was also positively associated with physical activity. This is in line with earlier studies, which suggest that physical activity is generally more flexible and easier to fit into daily routines and may also be influenced by positive expectations about health [33]. The family attitude results showed a similar pattern to the other domains: positive attitudes were associated with lower physical activity, and negative family attitudes were associated with higher physical activity. One possible explanation is that too much reliance on family support may reduce their own initiative, while demanding attitudes may act as social pressure to be active. However, this needs to be confirmed by longitudinal or qualitative studies. In practice, physical activity programs should strengthen self-efficacy through gradual goals and progress monitoring.

Blood glucose monitoring

Chance locus of control was negatively associated with blood glucose monitoring, while positive family attitudes were positively associated with blood glucose monitoring. However, neither association met the more stringent significance thresholds used to account for multiple comparisons. The model explained about 7% of the variance, suggesting that other factors may also contribute to blood glucose monitoring. In line with the previous study, patients who believe their health is determined by luck may see monitoring as an action that does not change their outcomes [14]. Similarly, previous quasi-experimental evidence showed that stronger beliefs in chance or fate may be associated with a lower sense of personal control over health behaviors [26].

Positive family support was associated with better blood glucose monitoring. Blood glucose monitoring requires practical resources combinations of hardware access, financial capacity, proper education, and behavioral support [1]. Positive family attitudes may provide emotional encouragement and practical help, which can make it easier for patients to monitor regularly [34,35]. Similarly, family support such as reminders, encouragement, and practical assistance may be particularly relevant to behaviors that require regular monitoring [36]. In practice, involving family members in monitoring education, including how to use the device and interpret the results, may help patients monitor their blood glucose.

Foot care

Foot care was the self-care domain with the highest explanatory power in this study, with the model explaining about 39% of the variance. Self-efficacy, chance locus of control, and negative family attitudes were positively associated with foot care and met the Bonferroni-adjusted threshold. Internal locus of control was negatively associated with foot care and met the per-model threshold but not the Bonferroni-adjusted threshold. Positive family attitudes were also negatively associated with foot care, but this association did not meet either threshold. Consistent with Bandura's self-efficacy theory and previous studies in patients with diabetes [17,25], patients who are confident in their ability to perform foot care tend to check their feet, keep them clean, and choose proper footwear more consistently. Foot care requires practical skills and daily routines that depend on belief in one's own ability [37].

The locus of control findings differs from the common assumption that internal locus of control leads to better health behaviors [14]. In this study, internal locus of control was associated with lower foot care, while chance locus of control was associated with higher foot care. These findings suggest that the relationship between locus of control and diabetes self-care may vary according to the type of behavior being performed [38]. One possible explanation is that foot care may be driven more by direct advice from health professionals than by a belief in personal control. Individuals with a high internal locus of control may prioritize behaviors they see as having a more direct impact while underestimating the importance of preventive practices [39]. Foot care is often perceived as less urgent, despite its critical role in preventing complications [40]. In addition, a strong internal locus of control may be accompanied by self-blame, in which individuals blame their own shortcomings for difficulties in diabetes management [41]. Self-blame may represent one possible mechanism that could reduce motivation to engage in routine self-care such as foot care, although it was not directly assessed in this study.

Positive family attitudes were associated with lower foot care, while negative family attitudes were associated with higher foot care. These findings are inconsistent with a previous study reporting that negative family interactions hinder diabetes management and reduce adherence to recommended behaviors [22]. These findings may also reflect differences in the type and timing of family involvement in diabetes management [42]. These are in line with studies showing that the role of family may be ambivalent [28]. Very supportive families may make patients depend on others, which can reduce their own initiative in self-care. In contrast, critical or demanding family attitudes may act as reminders or social pressure [43]. However, this interpretation should be tested in longitudinal studies. Therefore, future self-care education should support foot care through direct demonstration and practice that strengthens patients' confidence while also assessing the type of family involvement in diabetes management.

Limitation

Several limitations should be acknowledged. First, the exclusion of questionnaires with incomplete responses may have introduced selection bias if respondents with incomplete questionnaires differed systematically from those included in the final analysis. Second, the use of multiple regression models may have increased the risk of false-positive findings. Therefore, the statistically significant associations should be interpreted with caution. This study focused specifically on locus of control, self-efficacy, and family attitudes as indicators of individual traits and views of others. Future studies should consider additional frameworks to provide a more holistic understanding of the cognitive determinants of self-care in T2DM. Third, the cross-sectional design precludes causal inference, particularly regarding the unexpected associations; future studies are warranted to clarify these associations.

Conclusions

The complexity of self-care activities among T2DM outpatients is shaped by distinct combinations of individual and environmental cognitive beliefs. Self-efficacy was positively associated with physical activity and foot care. The mixed directions of family-attitude associations across self-care components highlight the varying relationships of family attitudes with different self-care activities. In contrast, locus of control, particularly chance locus of control, showed component-specific and, at times, opposing associations, being negatively associated with general diet, specific diet, and blood glucose monitoring, yet positively associated with physical activity and foot care. Therefore, self-care interventions should move beyond a one-size-fits-all approach and instead target the specific cognitive beliefs most relevant to each self-care component. Patient-centered programs may need to emphasize strengthening self-efficacy and fostering appropriate family involvement while addressing maladaptive chance locus of control, to collectively enhance holistic self-care among T2DM outpatients.

Appendices

Appendix A

Term	VIF
Intercept	-
Age category (<60)	1.3731344
Gender (male)	1.4202881
Marital status (not married)	3.6105118
Marital status (divorced/widowed)	4.2186871
Educational background (diploma/university)	2.0090146
Educational background (elementary school)	1.46958
Educational background (senior high school)	1.1667097
Educational background (junior high school)	1.1861042
Employment status (housewife/house worker)	2.2443537
Employment status (professional worker/civil servant)	1.2976035
Living area (rural)	2.3034247
Living area (semi-urban)	1.3695237
Time distance from the health facility (less than 30 minutes)	1.1706596
Internal locus of control	1.2474391
External locus of control	1.4764483
Chance locus of control	1.9380542
Self-efficacy	1.2344521
Negative family attitude	1.6730726
Positive family attitude	1.671748

TABLE 6: VIF

VIF: variance inflation factor

Appendix B

Model	Shapiro-Wilk p	Max (studentized residual)	Max Cook's D
General diet	0.0002	3.490	0.072
Specific diet	0.1490	3.396	0.077
Physical activity	<0.0001	3.283	0.143
Medication adherence	<0.0001	5.524	0.213
Blood glucose monitoring	<0.0001	5.480	0.214
Foot care	<0.0001	3.320	0.047

TABLE 7: Diagnostic per model

Appendix C

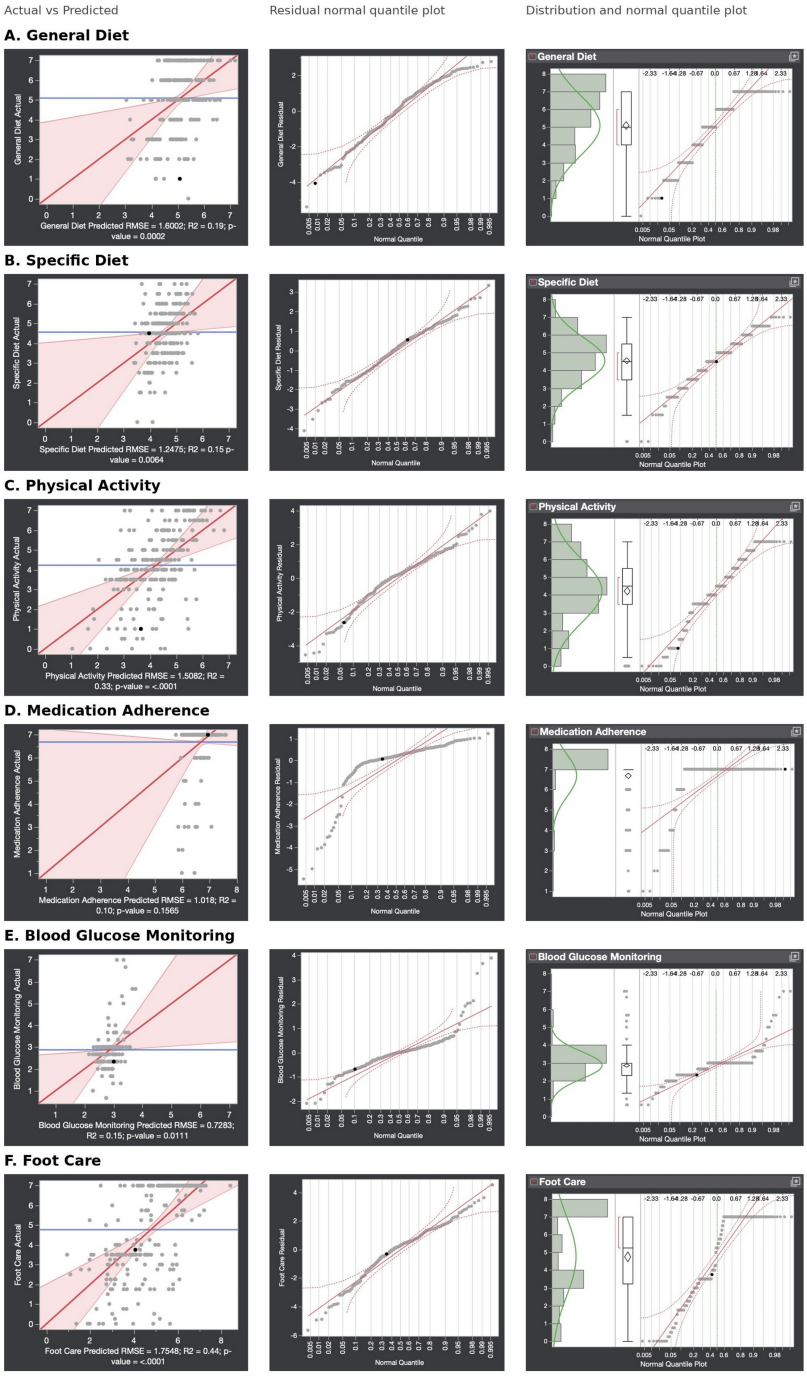


FIGURE 1: Visual impression of the residual plot and residual normality

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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Disclosures

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. Health Research Ethics Committee of the Faculty of Nursing, Hasanuddin University, Indonesia, and Ethics Review Committee of Niigata University of Health and Welfare, Japan, issued approval UH2407154 and 19372-241004. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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