Journal of Epidemiology and Public Health (2026), 11(02): 108-126
Master's Program in Public Health, Universitas Sebelas Maret

Original Research

Open Access

Health Belief Model Predictors of Tertiary Preventive Behavior and HbA1c Levels among Patients with Type 2 Diabetes Mellitus

Anindya Wahyu Utami[1)], Dono Indarto[2)], Erindra Budi Cahyanto[3)], Vitri Widyaningsih[4)], Eti Poncorini Pamungkasari[4)], Bhisma Murti[1)]

[1)]Master's Program in Public Health, Faculty of Medicine, Universitas Sebelas Maret
[2)]Doctoral Program in Medical Sciences, Faculty of Medicine, Universitas Sebelas Maret
[3)]Diploma IV of Anesthesiology Nursing, Vocational School, Universitas Sebelas Maret
[4)]Doctoral Program in Public Health, Faculty of Medicine, Universitas Sebelas Maret

Received: January 18, 2026; Accepted: February 25, 2026; Available online: April 16, 2026

ABSTRACT

Background: Type 2 diabetes mellitus (T2DM) remains a major public health challenge worldwide. This study applied the Health Belief Model (HBM) to examine its association with tertiary preventive behavior and HbA1c levels among patients with T2DM. The study aimed to analyze the effects of HBM constructs on tertiary preventive behavior and their impact on HbA1c levels in patients with T2DM.

Subjects and Method: A quantitative study with a cross-sectional design was conducted among 210 patients with T2DM receiving outpatient care at UNS Hospital. Data were collected between September and October 2025. The independent variables included perceived susceptibility, perceived severity, perceived benefits, self-efficacy, and cues to action. The dependent variables were tertiary preventive behavior and HbA1c levels. Data were analyzed using univariate analysis, bivariate analysis with simple logistic regression, and multivariate analysis using path analysis in STATA 13.

Results: Self-efficacy (b = 0.190; 95% CI = 0.029 to 0.350; p = 0.020), perceived benefits (b = 0.162; 95% CI = 0.021 to 0.301; p = 0.023), and cues to action (b = 0.294; 95% CI = 0.122 to 0.465; p = 0.001) had direct and significant effects on tertiary preventive behavior. Tertiary preventive behavior (b = −0.183; 95% CI = −0.307 to −0.085; p = 0.004), age (b = 0.134; 95% CI = 0.005 to 0.263; p = 0.041), duration of diabetes (b = 0.164; 95% CI = 0.035 to 0.295; p = 0.014), and family history of diabetes (b = 0.228; 95% CI = 0.104 to 0.351; p < 0.001) had direct and significant effects on HbA1c levels. Sex had direct but non-significant effects on both tertiary preventive behavior and HbA1c levels. Perceived susceptibility and perceived severity exerted indirect but significant effects on tertiary preventive behavior through perceived benefits.

Conclusion: Self-efficacy, perceived benefits, cues to action, and sex directly influenced tertiary preventive behavior, whereas perceived susceptibility and perceived severity exerted indirect effects through perceived benefits. Furthermore, tertiary preventive behavior, duration of diabetes, age, family history of diabetes, and sex directly affected HbA1c levels.

Keywords: Type 2 diabetes mellitus; Health Belief Model; tertiary preventive behavior

Correspondence:
Dono Indarto. Doctoral Program in Medical Sciences, Faculty of Medicine, Universitas Sebelas Maret. Jl. Ir. Sutami 36A, Surakarta, Central Java, 57126, Indonesia. Email: dono@staff.uns.ac.id.

Cite this as:
Utami AW, Indarto D, Cahyanto EB, Widyaningsih V, Pamungkasari EP, Murti B (2026). Health Belief Model Predictors of Tertiary Preventive Behavior and HbA1c Levels among Patients with Type 2 Diabetes Mellitus. *J Epidemiol Public Health*. 11(2): 108-126. https://doi.org/10.26911/-jepublichealth.2026.11.02.01.

BACKGROUND

Diabetes mellitus (DM) is a major public health concern worldwide, with its prevalence increasing substantially over recent decades. According to the International Diabetes Federation (IDF), the number of individuals living with diabetes aged 20–79 years continues to rise and is projected to increase further by 2050 (IDF, 2025). In Indonesia, diabetes remains a significant health burden. Data from the 2023 Indonesian Health Survey reported a high prevalence of diabetes across several provinces, including Central Java, highlighting the growing need for effective diabetes management and prevention strategies (Health Development Policy Agency, 2023).

Type 2 diabetes mellitus (T2DM) accounts for approximately 90–95% of all diabetes cases and is strongly associated with modifiable lifestyle factors, including unhealthy dietary habits, physical inactivity, and obesity (Sukoharjo District Health Office, 2019). Unlike type 1 diabetes, which is primarily autoimmune in nature, T2DM is largely influenced by environmental and behavioral factors. Recent national data indicate that the prevalence of T2DM has increased compared with previous years, emphasizing the need for interventions targeting behavioral determinants of disease management (Yuniarti et al., 2025).

Glycated hemoglobin (HbA1c) is widely recognized as a key indicator of long-term glycemic control and is routinely used in diabetes management. According to the Indonesian Society of Endocrinology (PERKENI), an HbA1c level of ≥6.5% indicates diabetes, while levels between 5.7% and 6.4% indicate prediabetes (Indonesian Society of Endocrinology, 2019). Maintaining optimal HbA1c levels is essential to reduce the risk of diabetes-related complications and improve patients' quality of life.

Tertiary prevention in diabetes focuses on preventing or minimizing disability among individuals who have already developed complications through early rehabilitation and comprehensive healthcare services (Indonesian Society of Endocrinology, 2021). Successful implementation of tertiary preventive behaviors requires patients' active engagement in disease management. Therefore, understanding the psychological factors that influence such behaviors is critical.

The Health Belief Model (HBM) provides a useful theoretical framework for explaining health-related behaviors. The model suggests that individuals are more likely to engage in preventive actions when they perceive themselves as susceptible to a disease, believe the disease has serious consequences, recognize the benefits of preventive actions, possess confidence in their ability to perform those actions, and receive cues that motivate behavior change (Arindari et al., 2024). Although the HBM has been widely applied to various health behaviors, evidence regarding its role in influencing tertiary preventive behavior and glycemic control among patients with T2DM remains limited.

Therefore, this study aimed to examine the influence of Health Belief Model constructs, including perceived susceptibility, perceived severity, perceived benefits, self-efficacy, and cues to action, on tertiary preventive behavior and HbA1c levels among patients with type 2 diabetes mellitus receiving outpatient care at UNS Hospital, Sukoharjo, Indonesia.

SUBJECTS AND METHOD

1. Study Design and Setting

This was a cross-sectional study conducted at UNS Hospital, Sukoharjo, Indonesia, between September and October 2025.

2. Participants and Sampling

The target population comprised patients with type 2 diabetes mellitus (T2DM) receiving outpatient care at the Internal Medicine Clinic of UNS Hospital. A total of 240 participants were selected using simple random sampling with the assistance of a Google random number generator. The inclusion criteria were: (1) diagnosed with T2DM, (2) having HbA1c data available within the previous three months, (3) registered as an outpatient at the Internal Medicine Clinic of UNS Hospital, and (4) willing to participate in the study. The exclusion criteria included: (1) hospitalization during the study period, (2) diagnosis of type 1 or gestational diabetes mellitus, (3) registration in neurology, surgery, cardiology, or otolaryngology clinics, (4) severe infectious disease during data collection, and (5) pregnancy or breastfeeding.

3. Study Variables

The independent variables were Health Belief Model (HBM) constructs, including perceived susceptibility, perceived severity, perceived benefits, self-efficacy, and cues to action. The dependent variables were tertiary preventive behavior and HbA1c levels. Sociodemographic and clinical covariates included age, sex, education, income, duration of diabetes, family history of diabetes, and diabetes-related complications.

4. Operational Definition of Variables

Perceived susceptibility refers to an individual's subjective assessment of the risk of developing disease or experiencing adverse health outcomes. Perceived severity reflects beliefs regarding the seriousness of a disease and its potential medical and social consequences. Perceived benefits represent an individual's belief in the effectiveness of health-related actions in reducing disease risk or severity. Self-efficacy is defined as confidence in one's ability to perform behaviors necessary to achieve desired health outcomes. Cues to action are internal or external stimuli that trigger health-related decision-making and behavior.

Tertiary preventive behavior was defined as actions undertaken to prevent disease progression and complications, including regular blood glucose monitoring, adherence to dietary recommendations, and engagement in appropriate physical activity. HbA1c level, obtained from medical records, was used as an indicator of average blood glucose control over the preceding two to three months.

Age was measured in years from birth to the time of data collection. Sex was categorized as male or female. Education referred to the highest level of formal education completed. Income was categorized according to the 2025 Sukoharjo Regency minimum wage standard. Duration of diabetes was defined as the time elapsed since the initial diagnosis of T2DM. Family history of diabetes referred to the presence of T2DM among biological relatives. Diabetes-related complications included both acute and chronic complications, such as hypoglycemia, diabetic ketoacidosis, retinopathy, nephropathy, neuropathy, cardiovascular disease, and diabetic foot disorders.

5. Data Collection Instruments

Data were collected using a structured questionnaire consisting of 33 items. The questionnaire included five items assessing perceived susceptibility, five items assessing perceived severity, five items assessing perceived benefits, four items assessing cues to action, five items assessing self-efficacy, and nine items assessing tertiary preventive behavior. HbA1c values were obtained from electronic medical records through the Hospital Information Management System (SIMRS) of UNS Hospital.

6. Statistical Analysis

Descriptive statistics were used to summarize participants' characteristics and study variables. Bivariate analysis using simple linear regression was performed to examine associations between independent and dependent variables. Multivariate analysis was conducted using path analysis to estimate direct and indirect effects among variables. All analyses were performed using STATA version 13, with statistical significance set at $p < 0.05$.

7. Ethical Considerations

Ethical principles, including informed consent, anonymity, and confidentiality, were strictly maintained throughout the study. Ethical approval was obtained from the Health Research Ethics Committee of UNS Hospital, Sukoharjo, Indonesia (Reference No. 092.1/UN27.46/TA.04.19/-KEP/EC/2025), issued on September 12, 2025.

RESULTS

1. Univariate analysis

Table 1 presents the demographic and clinical characteristics of the study participants. The majority of participants were female (n= 107, 50.95%), while males accounted for 103 participants (49.05%). Most participants had completed senior high school education (n = 81, 38.57%) and reported a monthly income equal to or above the Sukoharjo Regency minimum wage (n = 134, 63.81%). Nearly half of the participants reported a family history of diabetes (n = 103, 49.05%). Regarding diabetes-related complications, cardiovascular disease was the most frequently reported complication, affecting 92 participants (38.00%).

Table 1. Characteristics of Study Participants by Sex, Education, Income, HbA1c Level, Family History of Diabetes, and Diabetes-Related Complications

Characteristics	Category	n	%
Sex	Male	103	49.05%
	Female	107	50.95%
Education	Not attend school	5	2.38%
	Primary school	30	14.29%
	Junior high school	31	14.76%
	Senior high school	81	38.,57%
	College	63	30.00%
Income (IDR)	<minimum regional wage	76	36.19%
	≥ minimum regional wage	134	63.81%
HbA1C (%)	<6.5	76	36.19%
	≥6.5	134	63.81%
Family history	Yes	103	49.05%
	No	107	50.95%
Complication	Retinopathy	24	9.90%
	Neuropathy	57	23.60%
	Nephropathy	17	7.00%
	Cardiovascular disease	92	38.00%
	Diabetic foot and skin complications	5	2.10%
	No complications	100	41.30%

Table 2 presents the descriptive statistics of age, duration of diabetes, tertiary preventive behavior, and Health Belief Model (HBM) construct scores among the study participants. The mean age of patients with type 2 diabetes mellitus receiving outpatient care at the Internal Medicine Clinic of UNS Hospital was 58.70 years (SD = 10.66). The

mean score for tertiary preventive behavior was 27.11 (SD = 4.77). Regarding HBM constructs, the mean perceived susceptibility score was 20.23 (SD = 3.43), the mean perceived severity score was 18.77 (SD = 3.12), the mean perceived benefits score was 22.03 (SD = 2.74), the mean cues to action score was 21.53 (SD = 2.58), and the mean self-efficacy score was 20.95 (SD = 2.91).

Table 2. Descriptive Characteristics of Age, Duration of Diabetes, Tertiary Preventive Behavior, and Health Belief Model Constructs

Variables	Mean	SD	Minimum	Maximum
Age (years old)	58.70	10.66	20	83
Length of disease (years)	6.13	5.60	1	40
Tertiary preventive behavior (score)	27.11	4.77	13	36
Perceived susceptibility (score)	20.23	3.43	12	25
Perceived severity (score)	19.66	3.31	10	25
Perceived benefit (score)	22.03	2.74	5	25
Cues to action (score)	21.53	2.58	15	25
Self-efficacy (score)	20.95	2.91	13	25

2. Bivariate analysis

Table 3 presents the results of the simple linear regression analysis examining factors associated with tertiary preventive behavior among patients with type 2 diabetes mellitus. Perceived benefits (b = 0.62; 95% CI = 0.42 to 0.83; p < 0.001), cues to action (b = 0.87; 95% CI = 0.66 to 1.07; p < 0.001), and self-efficacy (b = 0.79; 95% CI = 0.61 to 0.97; p < 0.001) were positively and significantly associated with tertiary preventive behavior. In contrast, perceived susceptibility (b = 0.06; 95% CI = −0.13 to 0.25; p = 0.534), perceived severity (b = 0.09; 95% CI = −0.10 to 0.28; p = 0.363), and sex (b = 0.07; 95% CI= −0.03 to 0.18; p = 0.193) were not significantly associated with tertiary preventive behavior.

The regression coefficients indicate that a one-unit increase in perceived susceptibility was associated with a 0.06-unit increase in the tertiary preventive behavior score. Similarly, a one-unit increase in perceived severity was associated with a 0.09-unit increase in the tertiary preventive behavior score. A one-unit increase in perceived benefits was associated with a 0.62-unit increase in tertiary preventive behavior, while a one-unit increase in cues to action corresponded to a 0.87-unit increase in the behavior score. Likewise, each one-unit increase in self-efficacy was associated with a 0.79-unit increase in tertiary preventive behavior among patients with type 2 diabetes mellitus.

Table 3. Simple Linear Regression Analysis of Variables Influencing Tertiary Preventive Behavior

Independent Variables	Coefficient (b)	95% CI		p
		Lower limit	Upper limit	
Perceived susceptibility	0.06	-0.13	0.25	0.534
Perceived severity	0.09	-0.10	0.28	0.363
Perceived benefit	0.62	0.42	0.83	<0.001
Cues to action	0.87	0.66	1.07	<0.001
Self-efficacy	0.79	0.61	0.97	<0.001
Sex (male)	0.07	-0.03	0.18	0.193

Table 4 presents the results of the simple linear regression analysis examining factors associated with HbA1c levels among patients with type 2 diabetes mellitus. Sex (b = 0.09; 95% CI= −0.47 to 0.67; p = 0.733) and diabetes-related complications (b = −0.07; 95% CI = −0.66 to 0.52; p = 0.814) were not significantly associated with HbA1c levels. In contrast, age (b = 0.03; 95% CI = 0.00 to 0.05; p = 0.014), family history of diabetes (b = 1.13; 95% CI = 0.57 to 1.69; p < 0.001), duration of diabetes (b = 0.07; 95% CI= 0.03 to 0.12; p <0.001), and tertiary preventive behavior (b= −0.08; 95% CI= −0.14 to −0.02; p= 0.004) were significantly associated with HbA1c levels.

The regression coefficients indicate that each one-year increase in age was associated with a 0.03-unit increase in HbA1c levels. Similarly, participants with a family history of diabetes had HbA1c levels that were, on average, 1.13 units higher than those without a family history. Each additional year since diagnosis of type 2 diabetes mellitus was associated with a 0.07-unit increase in HbA1c levels. Conversely, a one-unit increase in the tertiary preventive behavior score was associated with a 0.08-unit decrease in HbA1c levels, indicating that better preventive behavior was related to improved glycemic control. Although complications showed a negative regression coefficient, the association with HbA1c levels was not statistically significant.

Table 4. Results of Simple Linear Regression Analysis of Factors Associated with HbA1c Levels

Independent Variables	Coefficient (b)	95% CI		p
		Lower limit	Upper limit	
Age (years old)	0.03	0.01	0.05	0.014
Sex (male)	0.09	-047	0.67	0.733
Family history of disease	1.13	0.57	1.69	<0.001
Length of illness	0.07	0.03	0.12	<0.001
Presence of complication	-0.07	0.52	-0.66	0.814
Tertiary preventive behavior	-0.08	-0.02	-0.14	0.004

3. Path analysis

a. Model Specification

Figure 1 illustrates the hypothesized path model linking the study variables. In this model, tertiary preventive behavior was directly influenced by perceived benefits, cues to action, self-efficacy, and sex. HbA1c levels were directly influenced by sex, family history of diabetes, age, and duration of diabetes. In addition, perceived benefits were directly influenced by perceived susceptibility and perceived severity.

b. Model Identification

The model consisted of 11 observed variables, including six exogenous variables and five endogenous variables, with a total of 20 estimated parameters. The model had 35 degrees of freedom (df), indicating that it was overidentified and suitable for path analysis.

c. Model Fit

The multivariate analysis demonstrated an excellent model fit. The goodness-of-fit indices were as follows: Chi-square test (p= 0.164), RMSEA= 0.036, CFI= 0.986, TLI= 0.978, SRMR= 0.041, and coefficient of determination (CD)= 0.812. These values indicate that the proposed model adequately represented the observed data.

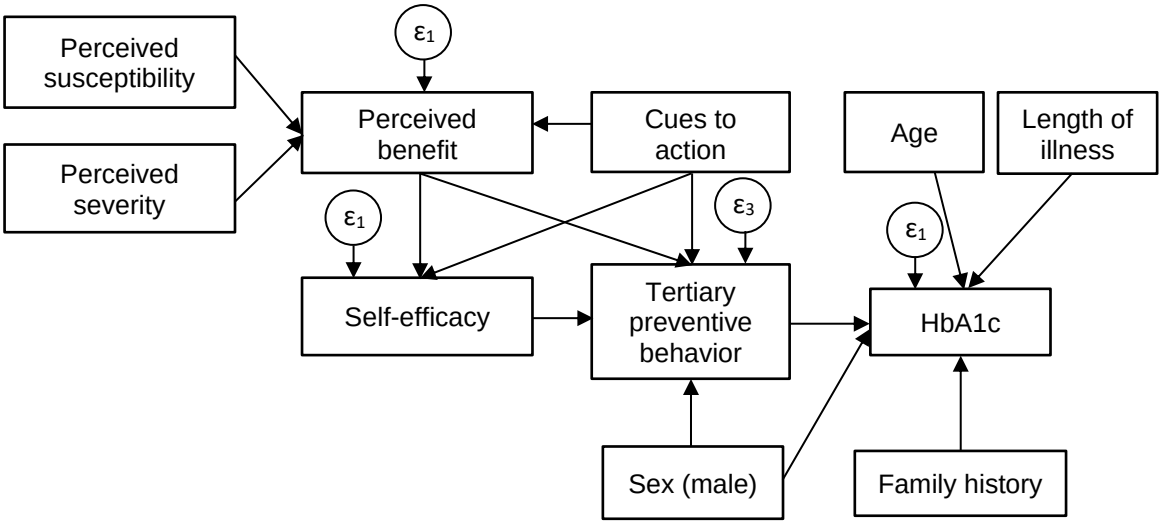

Figure 1. Path Analysis Model of Health Belief Model Constructs, Tertiary Preventive Behavior, and HbA1c Levels among Patients with Type 2 Diabetes Mellitus

d. Parameter Estimates

Perceived susceptibility had a positive and statistically significant indirect effect on tertiary preventive behavior through perceived benefits. A one-unit increase in perceived susceptibility was associated with a 0.360-unit increase in perceived benefits (b= 0.36; 95% CI = 0.25 to 0.47; p < 0.001).

Similarly, perceived severity showed a positive and statistically significant indirect effect on tertiary preventive behavior through perceived benefits. Each one-unit increase in perceived severity was associated with a 0.40-unit increase in perceived benefits (b = 0.40; 95% CI = 0.29 to 0.51; p < 0.001).

Self-efficacy was positively and significantly associated with tertiary preventive behavior. A one-unit increase in self-efficacy was associated with a 0.19-unit increase in the tertiary preventive behavior score (b= 0.19; 95% CI = 0.03 to 0.35; p = 0.020).

Perceived benefits also had a positive and significant direct effect on tertiary preventive behavior. Each one-unit increase in the perceived benefits score was associated with a 0.162-unit increase in tertiary preventive behavior (b= 0.16; 95% CI= 0.02 to 0.30; p = 0.023).

Cues to action demonstrated a positive and significant direct effect on tertiary preventive behavior. A one-unit increase in the cues-to-action score was associated with a 0.29-unit increase in tertiary preventive behavior (b = 0.29; 95% CI = 0.12 to 0.47; p= 0.001). Sex showed a positive but non-significant association with tertiary preventive behavior (b= 0.07; 95% CI= −0.04 to 0.19; p= 0.193).

Tertiary preventive behavior had a negative and statistically significant effect on HbA1c levels. Each one-unit increase in the tertiary preventive behavior score was associated with a 0.18% decrease in HbA1c levels (b= −0.18; 95% CI = −0.31 to −0.09; p= 0.004). Sex showed a positive but non-significant association with HbA1c levels (b= 0.04; 95% CI= −0.08 to 0.17; p = 0.502). Age was positively and significantly associated with HbA1c levels. A one-unit increase in age was associated with a 0.134% increase in HbA1c levels (b = 0.13; 95% CI= 0.01 to 0.26; p = 0.041).

Duration of diabetes was positively and significantly associated with HbA1c levels. A one-unit increase in duration of diabetes was associated with a 0.16% increase in HbA1c levels (b = 0.16; 95% CI = 0.04 to 0.30; p = 0.014).

Family history of diabetes was positively and significantly associated with HbA1c levels. Participants with a family history of diabetes had higher HbA1c levels than those without such a history (b = 0.23; 95% CI = 0.10 to 0.35; p < 0.001).

Perceived benefits had a positive and significant association with self-efficacy (b= 0.12; 95% CI = 0.01 to 0.23; p = 0.045). Likewise, cues to action were positively associated with self-efficacy (b = 0.65; 95% CI = 0.56 to 0.75; p < 0.001).

Cues to action also had a positive and significant effect on perceived benefits (b = 0.13; 95% CI = 0.02 to 0.25; p = 0.024). Duration of diabetes was positively associated with age (b= 0.29; 95% CI = 0.17 to 0.41; p <0.001), indicating that older participants tended to have lived with diabetes for a longer period.

Table 4. Results of Path Analysis of Health Belief Model Constructs, Tertiary Preventive Behavior, and HbA1c Levels

Dependent Variables		Independent variables	Path coef. (b)	95% CI		p
				Lower limit	Upper limit	
Direct effect						
Tertiary preventive behavior	←	Self-efficacy	0.19	0.03	0.35	0.020
	←	Perceived benefit	0.16	0.02	0.30	0.023
	←	Cues to action	0.29	0.12	0.47	0.001
	←	Sex (male)	0.07	-0.04	0.19	0.193
HbA1C (%)	←	Tertiary preventive behavior	-0.18	-0.31	-0.09	0.004
	←	Sex (male)	0.04	-0.08	0.17	0.502
	←	Age (years old)	0.13	0.01	0.26	0.041
	←	Length of illness	0.16	0.04	0.30	0.014
	←	Family history of illness	0.23	0.10	0.35	<0.001
Indirect effect						
Self-efficacy	←	Perceived benefit	0.12	0.01	0.23	0.045
	←	Cues to action	0.65	0.56	0.75	<0.001
Perceived benefit	←	Cues to action	0.13	0.02	0.25	0.024
	←	Perceived susceptibility	0.36	0.25	0.47	<0.001
	←	Perceived severity	0.40	0.29	0.51	<0.001
Age	←	Length of illness	0.29	0.17	0.41	<0.001
N observations = 210						
Log likelihood = -5122.28; p = 0.164 (>0.050); RMSEA = 0.04 (<0.08), CFI = 0.98 (>0.90); TLI = 0.98 (>0.90), SRMR = 0.04 (<0.050), CD= 81.2%						

DISCUSSION

Perceived Susceptibility and Tertiary Preventive Behavior

The bivariate analysis showed that perceived susceptibility was not significantly associated with tertiary preventive behavior among patients with type 2 diabetes mellitus. However, the multivariate path analysis revealed a significant indirect relationship between perceived susceptibility and tertiary preventive behavior through perceived benefits. This finding suggests that patients'

beliefs regarding their vulnerability to diabetes-related complications do not directly motivate engagement in preventive actions, such as regular medical check-ups, dietary management, physical activity, and adherence to treatment. Rather, perceived susceptibility may influence preventive behavior by enhancing patients' recognition of the benefits of these health-promoting practices.

This finding is consistent with the study by Darvishi et al. (2025a), which reported that perceived susceptibility was not significantly associated with diabetes self-management adherence, as some patients believed that complications could be avoided solely through medication. In contrast, Syauqy et al. (2025) found a significant association between perceived susceptibility and preventive behaviors aimed at reducing diabetes complications, particularly among patients who received intensive health education. In such cases, perceived susceptibility functioned as a positive motivational factor for behavior change.

The inconsistency across studies may be explained by differences in patients' clinical characteristics, particularly glycemic control and complication status. In the present study, most participants had HbA1c levels ≥6.5% and had already experienced diabetes-related complications. Consequently, complications may have been perceived as existing conditions rather than future risks that could be prevented, thereby reducing the motivational role of perceived susceptibility in promoting tertiary preventive behaviors.

Perceived Severity and Tertiary Preventive Behavior

The bivariate analysis indicated that perceived severity was not significantly associated with tertiary preventive behavior. This finding suggests that, although patients recognized the serious nature of type 2 diabetes mellitus and its potential complications, such awareness alone was insufficient to influence their engagement in preventive actions. However, the multivariate path analysis demonstrated that perceived severity was significantly associated with tertiary preventive behavior indirectly through perceived benefits. This finding indicates that the effect of perceived severity on preventive behavior operates through patients' beliefs regarding the advantages of engaging in preventive measures.

The present findings are consistent with those reported by Hu et al. (2022), who found that perceived severity did not directly enhance diabetes self-management behaviors but exerted its influence through perceived benefits and self-efficacy. In other words, individuals were more likely to adopt preventive behaviors when they believed that such actions would produce meaningful health benefits. Similarly, Rondhianto et al. (2023) reported that although patients understood the risks and seriousness of diabetes-related complications, they were unlikely to engage in foot care practices, HbA1c monitoring, or routine medical examinations unless they perceived clear benefits from these preventive actions.

These findings suggest that awareness of disease severity alone is insufficient to promote behavioral change. Rather, patients must also be convinced that preventive measures are effective and beneficial in reducing the risk of complications and improving health outcomes. Therefore, interventions aimed at enhancing tertiary preventive behavior among patients with type 2 diabetes mellitus should focus not only on increasing awareness of disease severity but also on strengthening patients' perceptions of the benefits associated with preventive health behaviors.

Perceived Benefits and Tertiary Preventive Behavior

The path analysis demonstrated that perceived benefits had a direct, positive, and statistically significant effect on tertiary preventive behavior. Individuals with higher perceived benefits were more likely to engage in tertiary preventive behaviors than those with lower perceived benefits. This finding suggests that patients who recognize the value and effectiveness of preventive measures are more inclined to adopt behaviors aimed at preventing or minimizing diabetes-related complications.

The present findings are consistent with previous studies highlighting the important role of perceived benefits in promoting self-care and tertiary preventive behaviors among individuals with diabetes. A meta-analysis conducted by Rondhianto et al. (2024) reported that perceived benefits had a significant influence on tertiary preventive behavior (aOR = 1.76; p = 0.020). These findings support the notion that individuals who perceive greater benefits from preventive actions are more likely to engage in behaviors such as regular health examinations, glycemic monitoring, and adherence to diabetes management recommendations.

Similar results were reported by Zhang et al. (2022) in a study involving 1,140 patients with type 2 diabetes mellitus in China. The study identified perceived benefits as one of the primary determinants of diabetes self-care behaviors ($p < 0.01$). Although the study focused on self-care rather than tertiary preventive behavior specifically, self-care practices such as blood glucose monitoring, dietary management, medication adherence, and physical activity are closely related to the prevention of diabetes complications. Therefore, the findings further support the role of perceived benefits as a key motivational factor underlying health-promoting behaviors among patients with type 2 diabetes mellitus.

Cues to Action and Tertiary Preventive Behavior

The path analysis revealed a direct, positive, and statistically significant association between cues to action and tertiary preventive behavior. This finding supports the Health Belief Model, which identifies cues to action as a critical component in initiating and sustaining health-related behaviors. The results indicate that the greater the exposure to cues from healthcare professionals, family members, or health information sources, the more likely patients are to engage in tertiary preventive behaviors aimed at preventing diabetes-related complications.

This finding is consistent with previous studies emphasizing the importance of external and internal stimuli in motivating individuals to adopt and maintain preventive health behaviors. Patients who regularly receive reminders, recommendations, and encouragement from healthcare providers and family members may become more aware of the importance of disease management and are therefore more likely to adhere to recommended preventive practices, including routine medical check-ups, blood glucose monitoring, medication adherence, healthy dietary habits, and physical activity.

The present findings are also supported by research demonstrating that motivational and psychosocial factors play a crucial role in diabetes self-management. Effective cues to action can enhance patients' readiness to act, reinforce the perceived importance of preventive behaviors, and facilitate long-term adherence to diabetes care recommendations. In the context of chronic disease management, such cues may serve as ongoing reminders that help patients translate their health beliefs into concrete preventive actions.

Cues to Action and Tertiary Preventive Behavior

The path analysis revealed a direct, positive, and statistically significant association between cues to action and tertiary preventive behavior. This finding provides empirical support for the Health Belief Model (HBM), which identifies cues to action as a key component in initiating and maintaining health-promoting behaviors. The results indicate that the greater the intensity of cues received by individuals, whether from healthcare professionals, family members, or health information sources, the greater the likelihood that patients will engage in tertiary preventive behaviors. In other words, various forms of external encouragement and reminders serve as important stimuli that enhance patients' awareness and motivation to manage their disease continuously.

From a theoretical perspective, these findings reinforce Rosenstock's HBM framework, which proposes that cues to action function as triggers that transform health-related perceptions into actual behavior. Individuals may recognize the seriousness of diabetes and the benefits of preventive actions, but behavioral change is more likely to occur when prompted by specific internal or external cues.

The present findings are consistent with those reported by Zhang et al. (2022) in Wuhou Village, China, who found that cues to action had both direct and indirect effects on chronic complication screening behaviors among patients with diabetes. Patients who received encouragement from healthcare providers or family members were more motivated to undergo routine examinations and take preventive measures to avoid disease progression. These findings suggest that social and professional support can play a critical role in motivating patients to engage in preventive health behaviors.

Further support comes from the qualitative study conducted by Buana et al. (2023) at Perumnas Primary Health Center, Rejang Lebong Regency, Indonesia. The study reported that patients' readiness to initiate treatment emerged after receiving health education and counseling from healthcare professionals regarding diabetes medication management. Such findings highlight the importance of educational interventions and professional guidance as effective cues to action that encourage patients to adopt and maintain recommended self-management practices.

Sex and Tertiary Preventive Behavior

The present study found a positive association between sex and tertiary preventive behavior among patients with type 2 diabetes mellitus; however, the relationship was not statistically significant. This finding suggests that sex alone may not be a significant determinant of engagement in tertiary preventive behaviors among patients with type 2 diabetes mellitus. Both male and female patients may be equally likely to participate in preventive activities such as medication adherence, dietary management, physical activity, and routine medical follow-up when they have comparable access to healthcare services and diabetes education.

The findings are consistent with previous studies reporting minimal or non-significant sex differences in diabetes self-care and preventive health behaviors. Although some studies have suggested that women tend to demonstrate greater adherence to specific aspects of diabetes management, such as dietary regulation and routine health monitoring, the overall evidence remains inconsistent. For example, Baroni et al. (2022), in their literature review, concluded that findings regarding sex differences in diabetes self-care behaviors are heterogeneous. While several studies

indicated that women were more likely to adhere to dietary recommendations and attend regular medical appointments, other studies reported no meaningful differences between men and women.

Similarly, Kautzky-Willer et al. (2023) emphasized that the influence of gender on diabetes management is often mediated by social, cultural, and familial factors rather than biological differences alone. Factors such as health literacy, family support, healthcare accessibility, socioeconomic status, and cultural expectations may play a more substantial role in shaping preventive behaviors than sex itself.

Tertiary preventive behavior with HbA1c level

Tertiary preventive behavior was significantly associated with lower HbA1c levels, indicating that patients who adhered to recommended self-management practices achieved better glycemic control. These behaviors include medication adherence, healthy dietary practices, regular physical activity, self-monitoring of blood glucose, and routine complication screening. This finding is consistent with previous studies demonstrating that diabetes self-care behaviors are strongly associated with improved glycemic outcomes. For example, Wondm et al. (2024) reported a significant relationship between glycemic control and self-care practices, including diet, physical activity, foot care, and blood glucose monitoring. Evidence from a meta-analysis of nine randomized controlled trials further showed that dietary modification reduced HbA1c levels by an additional 0.49 percentage points compared with usual care (Kusumaningrum et al., 2022). Similarly, a six-month low carbohydrate dietary intervention was associated with significant reductions in HbA1c among patients with type 2 diabetes (Dorans et al., 2022). Previous studies have also identified self-monitoring of blood glucose as one of the strongest predictors of good glycemic control, alongside regular physical activity and dietary management. These behaviors may improve insulin sensitivity, optimize glucose metabolism, and facilitate treatment adjustments, thereby contributing to lower HbA1c levels.

Sex with HbA1c level

Sex (male) showed a positive but non-significant association with HbA1c levels in the path analysis. This finding is consistent with previous studies reporting no meaningful effect of sex on glycemic control. Ahmed et al. (2023) found that after adjusting for age and body mass index (BMI), differences in HbA1c levels between men and women were not statistically significant. Similarly, Alguwaihes (2025) reported comparable mean HbA1c levels across sexes with no significant differences observed.

However, some studies have reported significant sex related differences in HbA1c levels within specific age groups, with men exhibiting slightly higher HbA1c levels than women (Stedman et al., 2025). Likewise, Butalia et al. (2024) demonstrated that although minor variations in HbA1c existed between sexes, these differences had limited impact on clinical outcomes, particularly cardiovascular risk. Collectively, these findings suggest that the relationship between sex and HbA1c may be context dependent and influenced by factors such as age, metabolic status, and hormonal profiles. Variations across studies may also reflect differences in population characteristics, study design, sample size, and adjustment for potential confounding factors.

Age with HbA1c level

Age was positively and significantly associated with HbA1c levels, indicating that increasing age is linked to poorer glycemic control. This finding suggests that aging may adversely affect glucose metabolism and contribute to elevated HbA1c levels. The

result is consistent with previous studies reporting higher HbA1c levels among older adults. Huang et al. (2025) found that older individuals had significantly higher HbA1c levels than younger adults, with participants aged approximately 46 years showing mean HbA1c levels below 5.7%, whereas those aged 61 years and older were more likely to have HbA1c levels of 6.5% or higher. These findings support the notion that age is an important determinant of glycemic control, potentially due to age related declines in insulin sensitivity and increased insulin resistance.

Length of illness with HbA1c level

Duration of diabetes was positively and significantly associated with HbA1c levels, indicating that patients with a longer history of type 2 diabetes tend to have higher HbA1c levels and poorer glycemic control. This finding suggests that disease duration is an important determinant of glycemic outcomes among individuals with type 2 diabetes. Consistent with the present study, Wondm et al. (2024) reported that patients with diabetes duration exceeding five years had approximately twice the risk of poor glycemic control compared with those with a shorter disease duration. This relationship may be explained by the progressive decline in pancreatic β cell function and worsening insulin resistance over time, both of which contribute to elevated HbA1c levels. Similar findings were reported by Garedo et al. (2024), who identified diabetes duration as a significant predictor of HbA1c levels. In their multivariable analysis, patients with a disease duration of ten years or longer were more likely to experience poor glycemic control than those who had been more recently diagnosed.

Family history with HbA1c level

Family history of diabetes was positively and significantly associated with HbA1c levels, indicating that individuals with a family history of diabetes tend to have higher HbA1c levels than those without such a history. This finding suggests that both genetic predisposition and shared familial environmental factors play important roles in glycemic control among patients with type 2 diabetes. Consistent with the present study, Ndetei et al. (2024) reported that a history of diabetes among first and second degree relatives was associated with higher HbA1c levels and an increased risk of chronic diabetes related complications. The authors proposed that genetic susceptibility may contribute to impaired pancreatic β cell function and increased insulin resistance, thereby resulting in poorer glycemic control. In addition to genetic influences, De Zoysa et al. (2024) found that individuals with parental histories of diabetes were more likely to develop the disease at an earlier age and exhibit variable glycemic outcomes. In some cases, stronger hereditary predisposition was associated with higher HbA1c levels, further highlighting the role of family history in diabetes management and glycemic regulation.

Perceived benefit with self-efficacy

Perceived benefits were positively and significantly associated with self-efficacy, indicating that individuals who perceive greater benefits from diabetes management are more likely to have stronger confidence in their ability to perform self-care behaviors, including dietary regulation, regular physical activity, and medication adherence. This finding suggests that awareness of the positive outcomes associated with diabetes management serves as an important foundation for developing self-efficacy in disease control. Patients who recognize the value of health-related actions may be more motivated and confident to engage in recommended self-management practices.

This result is consistent with the study by Cahyani et al. (2024), which reported a

positive relationship between perceived benefits and self-efficacy among patients with type 2 diabetes mellitus. Their findings indicated that patients with higher perceived benefits demonstrated greater confidence in performing behaviors aimed at controlling blood glucose levels. Enhanced understanding of the advantages of health-related actions may strengthen both motivation and confidence to maintain healthy behaviors consistently. Similarly, Halizah et al. (2024) found that perceived benefits had a significant influence on tertiary preventive behaviors among patients with diabetes ($p = 0.020$). Although their study focused on preventive behaviors rather than self-efficacy, the findings support the present study by highlighting perceived benefits as a key construct of the Health Belief Model that contributes to the development of self-efficacy and the adoption of positive health behaviors.

Cues to action with self-efficacy

Cues to action were strongly and significantly associated with self-efficacy, indicating that individuals who receive stronger prompts or encouragement, such as recommendations from healthcare professionals, family support, or personal experiences related to diabetes, are more likely to have greater confidence in their ability to manage the disease. This finding suggests that external and internal cues play an important role in strengthening patients' beliefs in their capacity to perform diabetes self-management behaviors. Supportive reminders and guidance may encourage individuals to initiate and maintain health promoting actions, thereby enhancing self-efficacy.

The present finding is consistent with the study by Darvishi et al. (2025), which demonstrated that cues to action significantly influence both self-efficacy and diabetes self-management behaviors. The authors reported that patients who received encouragement from healthcare providers, health education programs, or family members were more confident in adhering to dietary recommendations, engaging in physical activity, and following medication regimens. Similarly, Adiman et al. (2024) found that cues to action could enhance self-efficacy both directly and indirectly through increased perceptions of risk and perceived benefits. These findings suggest a common psychological mechanism in which cues to action strengthen individuals' confidence in their ability to cope with health-related challenges.

Further support comes from Gulentie et al. (2020), who reported that patients receiving external cues, such as motivation from healthcare professionals and social support, demonstrated higher levels of self-efficacy than those without such support. The authors proposed that cues to action function as both reminders and sources of reassurance, reinforcing patients' beliefs that they can effectively control their condition through appropriate self-management behaviors.

Cues to action with perceived benefit

Cues to action were positively and significantly associated with perceived benefits, indicating that individuals who more frequently receive prompts, reminders, or encouragement from healthcare professionals, family members, or media sources are more likely to perceive greater benefits from engaging in health-related behaviors. This finding suggests that external stimuli can strengthen individuals' recognition of the positive outcomes associated with diabetes self-management and preventive practices.

The present result is consistent with the findings of Darvishi et al. (2025), who reported that health education and reminders provided by healthcare professionals enhanced patients' perceptions of the

benefits of self-care behaviors. Similarly, Gulentie et al. (2020) found that patients who regularly received encouragement and educational support demonstrated higher perceived benefits regarding blood glucose control and medication adherence. These findings highlight the importance of continuous health communication in reinforcing patients' understanding of the value of diabetes management behaviors.

However, not all studies have reported similar results. Oktaviani and Fauziah (2025) found no significant association between cues to action and perceived benefits among the general population. The authors suggested that limited exposure to health information and low intensity of educational interventions may have reduced the effectiveness of cues in enhancing perceptions of the benefits of diabetes prevention behaviors. Differences across studies may be attributable to variations in participant characteristics, particularly educational level, access to health information, and the frequency of exposure to health-related cues. Overall, the present findings suggest that repeated educational messages, motivation, and reminders can strengthen perceived benefits and may ultimately encourage the adoption of more adaptive behaviors for the management of chronic diseases such as diabetes mellitus.

Length of illness with age

Duration of diabetes was positively and significantly associated with respondents' age, indicating that individuals who had lived with diabetes for a longer period were generally older at the time of the study. This finding is expected, as increasing age naturally corresponds with a longer period of living with a chronic condition such as type 2 diabetes mellitus. The result highlights the close relationship between age and disease duration, both of which are important factors influencing the health status and disease progression of individuals with diabetes.

This finding is consistent with the study by Nanayakkara et al. (2021), which reported that current age, age at diagnosis, and duration of diabetes were all significantly associated with the risk of vascular complications among patients with type 2 diabetes. Their results suggest that age and disease duration are interrelated factors that jointly contribute to diabetes related health outcomes. Similarly, Vitale et al. (2024) found that age at diagnosis and disease duration influenced mortality among individuals with type 2 diabetes. The authors noted that patients diagnosed at a younger age often experience a longer disease duration, resulting in greater cumulative exposure to the metabolic burden of diabetes over time. This evidence further supports the interconnected nature of age and disease duration in shaping long term health outcomes.

However, Wang et al. (2023) reported that the relationship between age and diabetes duration is not always linear, as it may be influenced by factors such as glycemic control, lifestyle behaviors, and the presence of comorbidities. Despite these complexities, their findings still indicated that prolonged exposure to diabetes is associated with greater health consequences, indirectly reflecting the positive association between disease duration and age. Overall, the present study reinforces the notion that age and duration of diabetes are closely linked and should be considered together when evaluating disease progression and patient outcomes.

FUNDING STATEMENT

This research received no external funding and was supported through personal funding by the authors.

ACKNOWLEDGMENTS

Anindya Wahyu Utami made substantial contributions to the conception and design of the study, data collection, data analysis, and data interpretation, and drafted the original manuscript.

Dono Indarto made substantial contributions to the study design and methodology, supervised the research process, critically reviewed the manuscript for important intellectual content, and provided academic guidance throughout the study.

Erindra Budi Cahyanto contributed to the study design, data analysis and interpretation, and critically reviewed the manuscript for important intellectual content.

Bhisma Murti contributed to the study design, data analysis and interpretation, and critically reviewed the manuscript for important intellectual content.

Vitri Widyaningsih contributed to the validation of data analysis and interpretation and provided critical revisions to the manuscript for important intellectual content.

Eti Poncorini Pamungkasari contributed to the critical review of the manuscript and provided important intellectual input.

CONFLICT OF INTEREST

Nil.

REFERENCES

Adiman R, Razak NA, Muhammad M, Wee F (2024). Cues to action and self-efficacy in the Health Belief Model: Perceived risk as mediating roles towards enhancing customer engagement. Inf Manag Bus Rev. 16(4): 128-138. https://doi.org/10.22610/imbr.-v16i4(I).4283.

Alguwaihes AM (2025). Gender differences in type 1 diabetes management and mental health burden: findings from a national survey in saudi arabia. J Clin Med. 14(16). https://doi.org/10.33-90/jcm14165777.

Amran P, Rahman (2018). Gambaran Hasil Pemeriksaan HbA1C Pada Penderita DiabetesMelitus Tipe II di RSUD Labuang Baji Makassar. Jurnal Media Analis Kesehatan, 9(2): 149–155. http://journal.poltekkes-mks.ac.id/-ojs2/index.php/mediaanalis

Asari A, Zulkarnaini, Hartatik, Litamahuputty JV, Dewadi FM, Prihastuty DR, Maswar, Syukrilla WA, Murni NS, Sukwika T (2023). Pengantar Statistika (A. Asari, Ed.). PT Mafy Media Literasi Indonesia.

Baroni I, Caruso R, Dellafiore F, Ausili D, Barello S, Magon A, Conte G, et al. (2022). Self-care and type 2 diabetes mellitus (T2DM): a literature review in sex-related differences. Acta Biomedica. 93(4). https://doi.org/10.23750-/abm.v93i4.13324.

Buana C, Tarwoto, Bakara DM, Sutriyanti Y, Sridiany (2023). Implementasi Health Believe Models Dalam Perilaku Pencegahan Komplikasi Diabetes Mellitus. Quality (Jurnal Kesehatan), 17(1): 10–18. https://doi.org/10.36082/qjk.v17-i1.875.

Butalia S, Chu LM, Dover DC, Lau D, Yeung RO, Eurich DT, Senior P, Kaul P (2024). Association between hemoglobin A1c and development of cardiovascular disease in canadian men and women without diabetes at baseline: a population-based study of 608 474 Adults. J Am Heart Assoc. 13(9): 1–10. https://doi.org/10.1161/JAHA.123.03 1095.

Darvishi A, Hassani L, Mohseni S, Shahabi N (2025). Predicting preventive self-care behaviours among type 2 diabetes based on the health belief model in Bandar Abbas city: A cross-sectional

study. BMJ Open, 15(1). https://doi.-org/10.1136/bmjopen-2024-091420.

De Zoysa W, Weerarathna TP, Wasana KGP, Weerarathna MK, Senadeera V (2024). Positive parental history of diabetes is associated with early diagnosis, better dietary compliance, and glycemic control among type 2 diabetes patients in southern Sri Lanka. Diabetology and Metabolic Syndrome. 16(1). https://doi.org/10.-1186/s13098-024-01394-w.

Dorans KS, Bazzano LA, Qi L, He H, Chen J, Appel LJ, et al. (2022). Effects of a low-carbohydrate dietary intervention on hemoglobin A1c: a randomized clinical trial. JAMA Network Open, 5(10), E2238645. https://doi.org/10.1001/-jamanetworkopen.2022.38645.

Garedo AW, Tesfaye GT, Tamrat R, Wynen-daele E (2024). Glycemic control and associated factors in patients with type 2 diabetes in Southwest Ethiopia: a prospective observational study. BMC Endocrine Disorders, 24(1). https://-doi.org/10.1186/s12902-024-01795-y.

Gebermariam AD, Tiruneh SA, Ayele AA, Tegegn HG, Ayele BA, Engidaw M (2020). Level of glycemic control and its associated factors among type II diabetic patients in debre tabor general hospital, northwest Ethiopia. Metabolism Open. 8: 100056. https://doi.org/10.1016/j.metop.2020 .100056.

Gulentie TM, Yesuf EM, Yazie TS, Kefale B (2020). Predictors of diabetes self-care practice among patients with type 2 diabetes in public hospitals in northeastern Ethiopia: A facility-based cross-sectional study. Diabetes, Metabolic Syndrome and Obesity, 13: 3137–3147. https://doi.org/10.2147/DMSO-.S273682.

Gunawan Y, Dewi SR (2018). Health behavior of essential hypertension patients in public health center in Waingapu. Jurnal Kesehatan Primer, 3(1): 1–7. https://doi.org/10.31965/jkp.

Halizah AN, Murti B, Tamtomo G (2024). Meta analysis: application of health belief model on tertiary preventive behavior in type 2 diabetes mellitus patients. J Health Promot Behav. 09(03): 185–198. https://doi.org/10.-26911/thejhpb.2024.09.03.01.

Health Development Policy Agency. (2023). Indonesia Health Survey (SKI) in Figures. Ministry of Health of the Republic of Indonesia. Retrieved from https://www.badankebijakan.kemkes.go.id/ski-2023-dalam-angka/.

Hu Y, Liu H, Wu J, Fang G (2022). Factors influencing self-care behaviours of patients with type 2 diabetes in China based on the health belief model: A cross-sectional study. BMJ Open, 12(8): 1–6. https://doi.org/10.1136/-bmjopen-2020-044369.

Huang Y, Ni W, Zhou Y, Li D, Zhang R, Jin T, Zhong Y (2025). Association between glycated hemoglobin and coronary artery calcification in middle-aged and elderly chinese checkup populations. J Endocrinol Metab. 23(1): 1–8. https://doi.org/-10.5812/ijem-158710.

Kautzky-Willer A, Leutner M, Harreiter J (2023). Sex differences in type 2 diabetes. Diabetologia, 66: 986–1002. https://doi.org/10.1007/s00125-023-05891-x.

Kusumaningrum U, Murti B, Prasetya H (2022). Meta-analysis of the effects of diet and physical activity on hbA1c in type II diabetes mellitus patients. Indones J Med. 07(02): 172–187. https://doi.org/10.26911/theijmed.20 22.07.02.06.

Nanayakkara N, Curtis AJ, Heritier S, Gadowski AM, Pavkov ME, Kenealy T, et al. (2021). Impact of age at type 2 diabetes mellitus diagnosis on mortality and vascular complications: systematic review and meta-analyses. Diabetologia, 64: 275–287. https://doi.org/10.1007/s00125-020-05319-w/.

Ndetei DM, Mutiso V, Musyimi C, Nyamai P, Lloyd C, Sartorius N (2024). Association of type 2 diabetes with family history of diabetes, diabetes biomarkers, mental and physical disorders in a Kenyan setting. Sci Rep. 14(1). https://doi.org/10.1038/s41598-024-61984-6.

Oktaviani A, Fauziah M (2025). Faktor risiko yang berhubungan dengan perilaku pencegahan DM tipe 2 berdasarkan teori health belief model pada remaja. Vitalitas Medis : Jurnal Kesehatan dan Kedokteran, 2(3): 298–310. https://doi.org/10.62383/vimed.v2i3.2119.

Indonesian Society of Endocrinology (PERKENI). (2019). Guidelines for the Management and Prevention of Type 2 Diabetes Mellitus in Adults in Indonesia. (in Indonesian language).

Indonesian Society of Endocrinology (PERKENI). (2021). Guidelines for the Management and Prevention of Type 2 Diabetes Mellitus in Adults in Indonesia (1st ed.). retrieved from https://pbperkeni.or.id/catalog-buku/pedoman-pengelolaan-dan-pencegahan-diabetes-melitus-tipe-2-di-indonesia-2021.

Rondhianto, Widayati N, Qur'aini S (2023). Foot care behavior among people with type 2 diabetes mellitus: overview and sociodemographic factors impact. Nurs Health Sci J. 3(2): 213–221. https://doi.org/10.53713/nhsj.v3i2.257.

Siregar MA, Kaban AR, Harahap YA, Lasmawanti S (2023). Deteksi Dini dan Edukasi Pencegahan Diabetes Mellitus (DM) Pada Remaja Putri di SMP Swasta Amanah Tahfidz Qur'an Deli Serdang Untuk Peningkatan Produktivitas Remaja. Jurnal Pengabdian Masyarakat, 3(2): 296–302. https://ojs.unhaj.ac.id/index.php/jukeshum/index.

Sukoharjo District Health Office. (2019). Sukoharjo District Health Profile. (in Indonesian language).

Sukoharjo District Health Office. (2023). Sukoharjo District Health Profile. (in Indonesian language).

Syauqy A, Justisia A, Gading BW, Aurora PW, Kusdiyah WID, Witri E (2025). Application of the health belief model in developing a community-based health literacy kit for diabetes prevention. Proceedings Academic Universitas Jambi, 1(2): 50512.

Vitale M, Orsi E, Solini A, Garofolo M, Grancini V, Bonora E, et al. (2024). Association between age at diagnosis and all-cause mortality in type 2 diabetes: the Renal Insufficiency and Cardiovascular Events (RIACE) Italian Multicenter Study. Acta Diabetologica, 61(9): 1107–1116. https://doi.org/10.1007/s00592-024-02294-1.

Wang XM, Zhong SP, Li GF, Zhuge FY (2023). Diabetes duration or age at onset and mortality in insulin-dependent diabetics: a systematic review and meta-analysis. Diabetol Metab Syndr. 15: 147. https://doi.org/10.1186/s13098-023-01113-x.

Wondm SA, Zeleke TK, Dagnew SB, Moges TA, Tarekegn GY, Belachew EA, Tamene FB (2024). Association between self-care activities and glyce-

mic control among patients with type 2 diabetes mellitus in northwest ethiopia general hospitals : a multicenter cross-sectional study. Sci Rep. 14(1): 1–15. https://doi.org/10.1038/s41598-024-72981-0.

Yuliana NA, Murti B (2020). Application of Social cognitive theory on the tertiary preventive behavior in patients with type II diabetes mellitus in ponorogo hospital. J Health Promot Behav. 05(03): 157–168. https://doi.org/10.-26911/thejhpb.2020.05.03.02.

Yuniarti T, Haryanto BAH, Kalpikawati AB, Aryawati RN, Khasanah NH, Annisa AS, Rofiah, Safitri Y (2025). Promosi Kesehatan dan Implementasi Pemberian Kapsul Habbatusauda Untuk Mencegah Diabetes Melitus. Jurnal Pengabdian Komunitas, 4(1): 1–9.

Zhang A, Wang J, Wan X, Zhang J, Guo Z, Miao Y, et al. (2022). Mediation effect of self-efficacy between health beliefs and glycated haemoglobin levels in elderly patients with type 2 diabetes mellitus: a cross-sectional study. Patient Prefer Adherence. 16: 3015–3026. https://doi.org/10.2147/PPA.S-388967.