

Factors Influencing Preventive Health Behaviors in Middle–Aged Adults with Prediabetes: A Cross–Sectional Study

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Abstract: Prediabetes among middle-aged adults represents a significant public health concern, and engagement in preventive health behaviors is essential to reduce disease progression. However, evidence on the factors influencing preventive health behaviors among adults with prediabetes in Thailand remains limited. This descriptive, cross-sectional study aimed to test a hypothesized causal model of Preventive Health Behaviors in Thai Middle-Aged Adults with Prediabetes grounded in the Information-Motivation-Behavioral Skill model. A total of 325 Thai participants were recruited using a multistage sampling from nine health-promoting hospitals in one health region in Northern Thailand. Data were collected using structured questionnaires on demographic characteristics, knowledge, attitudes, risk perception, subjective norms, preventive behavioral skills, self-efficacy, and preventive health behaviors. Descriptive statistics and structural equation modeling were employed to analyze the data.

The findings demonstrated that the proposed model explained 40.8% of the variance in preventive health behaviors. Information, preventive behavioral skills, and self-efficacy had positive direct effects on preventive health behaviors, with preventive behavioral skills emerging as the strongest predictor. However, the unusually high coefficient should be interpreted with caution due to potential conceptual overlap between constructs. Attitude towards preventive health behaviors demonstrated a positive indirect effect on preventive health behaviors through preventive behavioral skills. Nurses can use these findings to develop innovative interventions that emphasize increasing knowledge, enhancing positive attitudes, and developing behavioral skills and self-efficacy, integrated with technology. However, such interventions should be tested before being widely used in practice.

Keywords: Information–Motivation–Behavioral Skills Model, Knowledge, Middle-aged adults, Prediabetes, Preventive health behaviors, Risk perception, Self-efficacy, Subjective norms

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Introduction

Prediabetes has emerged as a significant global public health concern due to its rapidly escalating prevalence, particularly among middle–aged adults.^{1,2} This condition not only affects individuals but also has broader implications for families and society. People with prediabetes are at greater risk of progressing to

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type 2 diabetes mellitus (T2DM), with an annual progression rate exceeding 10%, and may lead to microvascular and macrovascular complications over time.³ Prediabetes also contributes to increased healthcare utilization and costs and is a leading cause of loss of healthy life years in Thailand.⁴ The burden becomes critical as middle-aged adults transition to T2DM in later life.

Engagement in preventive health behaviors is a key strategy for mitigating the impact of prediabetes.^{1,5} Kasl and Cobb defined preventive health behaviors as activities undertaken by healthy individuals to prevent illness or detect disease at an early, asymptomatic stage.⁶ According to the American Diabetes Association (ADA), preventive health behaviors include following a healthy dietary pattern and engaging in at least 150 minutes of moderate-intensity physical activity per week.¹ Empirical evidence indicates that these behaviors can help delay disease progression and promote reversion to normoglycemia.⁷ Despite their potential benefits, overall health outcomes among individuals with prediabetes remain suboptimal. Previous research has shown that a large proportion of adults with prediabetes exhibit unhealthy dietary patterns and insufficient physical activity.⁸ In Thailand, preventive behaviors among middle-aged adults with prediabetes are generally low,⁹ which may contribute to disease progression, with more than 20% of middle-aged adults with prediabetes progressing to T2DM annually.²

Preventive health behaviors are particularly difficult to maintain in this population because individuals in this life stage often face multiple occupational, familial, and social responsibilities that compete with health-related priorities. These competing demands can limit engagement in healthy eating, physical activity, and other preventive behaviors. Moreover, these behaviors are influenced by multiple interrelated factors, including motivation, risk perception, social support, and behavioral skills, which may operate through both direct and indirect

pathways.^{10,11} Although previous studies have investigated factors associated with preventive health behaviors, most were conducted in general adult populations aged 18 years and older and primarily examined these factors independently rather than within an integrated theoretical framework. As a result, understanding of how these interrelated factors collectively influence preventive health behaviors in this population remains limited. This knowledge gap limits the development of targeted and theory-based interventions for this high-risk population.

Conceptual Framework and Review of Literature

The conceptual framework for this study was developed based on the Information-Motivation-Behavioral Skills (IMB) model,¹² which explains health behaviors through the interaction of cognitive, motivational, and skill-based determinants. According to the IMB model, preventive health behaviors are determined by three key components: 1) information, defined as accurate and relevant knowledge; 2) motivation, which includes personal motivation (e.g., attitudes toward preventive health behaviors and risk perception) and social motivation (e.g., subjective norms); 3) behavioral skills, encompassing both preventive behavioral skills and self-efficacy.^{12,13} Individuals with sufficient behavior-specific information and strong motivation are more likely to develop the necessary behavioral skills, which, in turn, facilitate consistent engagement in preventive health behaviors.

Within the IMB framework, information plays a critical role in shaping individuals' understanding of disease risk, progression, and prevention strategies. Adequate knowledge enhances awareness of the seriousness and preventability of prediabetes, thereby supporting informed decision-making and facilitating behavior change.¹³

Motivation influenced individuals' willingness to engage in preventive health behaviors through both

personal and social motivations.^{12,13} In particular, attitude towards preventive health behaviors reflects an individual's evaluation of the benefits and outcomes of diet and physical activity.¹⁴ Middle-aged adults with prediabetes who perceive these behaviors as beneficial are more likely to engage in learning, practicing, and refining the skills necessary to perform them effectively.¹³

Risk perception reflects individuals' subjective assessment of their likelihood of developing T2DM and its associated complications, encompassing perceived susceptibility and perceived severity.¹⁵ Individuals who recognize their vulnerability and the seriousness of potential health outcomes are more likely to engage in preventive measures.

Subjective norms represent perceived social expectations regarding engagement in preventive health behaviors.¹⁴ These norms reflect the extent to which individual beliefs that significant others, such as family members, peers, and healthcare providers, support and encourage such behaviors. When individuals perceive strong social endorsement, they are more likely to engage in preventive actions.

Behavioral skills refer to an individual's objective abilities and sense of self-efficacy in performing the actions necessary to maintain preventive health behaviors. The two variables are preventive behavioral skills and self-efficacy.^{12,16} According to the IMB model, preventive behavioral skills refer to an individual's ability to take action to engage in preventive behaviors.¹² In the context of prediabetes, preventive behaviors range from simple actions, such as reducing sugar intake, to complex tasks, such as carbohydrate counting and structured exercise planning. These behaviors require both knowledge application and practical competence.

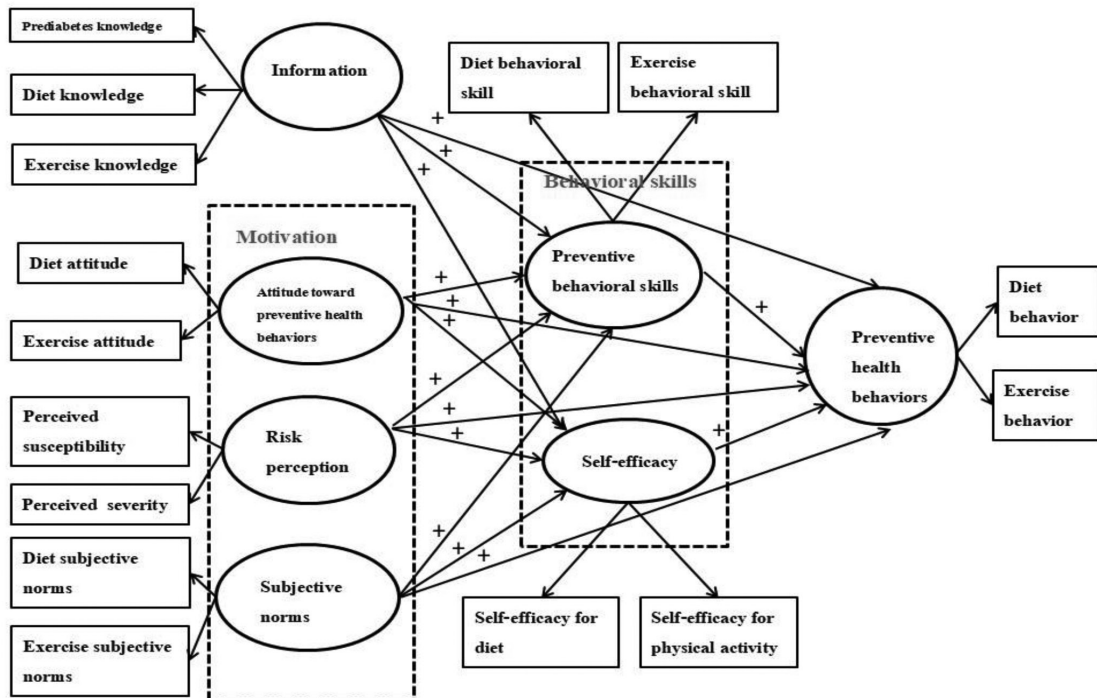
Self-efficacy is defined as subjective confidence in their ability to perform specific behaviors despite difficulties or obstacles.¹⁷ It also reflects individuals' confidence in their ability to overcome barriers and

maintain preventive actions. Among middle-aged adults with prediabetes, those with greater confidence in their ability to manage diet and physical activity are more likely to adopt and sustain preventive behaviors.

Previous studies have identified several factors associated with preventive health behaviors among adults with prediabetes. Knowledge is an important determinant of preventive health behaviors.¹⁸ Attitude¹⁹ and risk perception²⁰ have also been identified as predictors of behavioral engagement, with risk perception serving as a personal motivational factor for behavioral change. In addition, subjective norms may influence individuals through perceived expectations and support from significant others.²¹ Preventive behavioral skills may facilitate effective participation in preventive health practices,²² whereas self-efficacy¹⁸ reflects individuals' confidence in overcoming barriers to behavior change. Evidence from studies in similar populations further suggests that preventive behavioral skills mediate the relationships between information,²³ attitude,²² risk perception,²⁵ subjective norms,²¹ and preventive health behaviors among adults with T2DM. Therefore, information, attitude, risk perception, and subjective norms may influence these behaviors both directly and indirectly through preventive behavioral skills. Self-efficacy, however, is proposed to influence preventive health behaviors among these individuals directly.

Study Aim

This study aimed to test a hypothesized Causal Model of Preventive Health Behaviors in Thai Middle-Aged Adults with Prediabetes by examining the direct and indirect effects of information, motivation (attitude toward preventive health behaviors, risk perception, and subjective norms), and behavioral skills (preventive behavioral skills and self-efficacy) on preventive health behaviors. The hypothesized model is shown in **Figure 1**.



Note. ○ is a latent variable, □ is an observed variable

59 estimated parameters (calculated from 15 intercepts, 15 measurement errors of variances, 4 factors variance, 3 residual variances, 8 factors loading, and 14 regression coefficients)

Figure 1. The hypothesized model of preventive health behaviors in middle-aged adults with prediabetes

Methods

Design: This study employed a cross-sectional design, and this report was prepared in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement for cross-sectional studies.

Sample and Setting: The sample size was calculated according to the requirements for structural equation modeling (SEM), which typically necessitates a relatively large sample. A commonly recommended ratio is 5 to 10 participants per estimated parameter.²⁶ Given the number of variables and the study context, a ratio of 5 participants per parameter (5:1) was applied. With 59 estimated parameters, the calculated

minimum sample size was 295 participants. However, SEM studies generally recommend a minimum sample size of 300.²⁷ The target sample was set at 300. An additional 10% (30 participants) was added for potential attrition, resulting in a final sample size of 330 participants. The target population comprised Thai middle-aged adults with prediabetes residing in the service area of health region in the North, which has a relatively high prevalence compared to other regions.²

A multistage sampling design was employed to recruit participants from one Health Region in Northern Thailand, involving purposive selection of provinces, followed by random selection of districts and health-promoting hospitals, and proportional

allocation of participants. In the first stage, two provinces were purposively selected based on data from the Ministry of Public Health indicating a high prevalence of middle-aged adults with prediabetes.² In the second stage, nine districts were randomly selected from the selected provinces, using a 5:1 ratio. Subsequently, one health-promoting hospital was randomly selected from each district. In the third stage, participants were recruited from each health-promoting hospital using proportional allocation based on the number of eligible individuals in each setting.

Eligible participants were identified from hospital records and invited to participate. The number of participants required from each hospital was

calculated by multiplying the total sample size (330 participants) by the proportion of eligible individuals in each hospital relative to the total population across all nine hospitals (**Figure 2**). Participants were consecutively recruited based on the following inclusion criteria: aged between 40 and 60 years; diagnosed with prediabetes or having fasting plasma glucose (FPG) or fasting capillary plasma glucose (FCPG) levels of 100–125 mg/dL within the past year; able to perform activities of daily living independently; willingness to participate; and able to read and write Thai. Exclusion criteria included individuals diagnosed with a psychiatric disorder by a mental health professional and those who were pregnant.

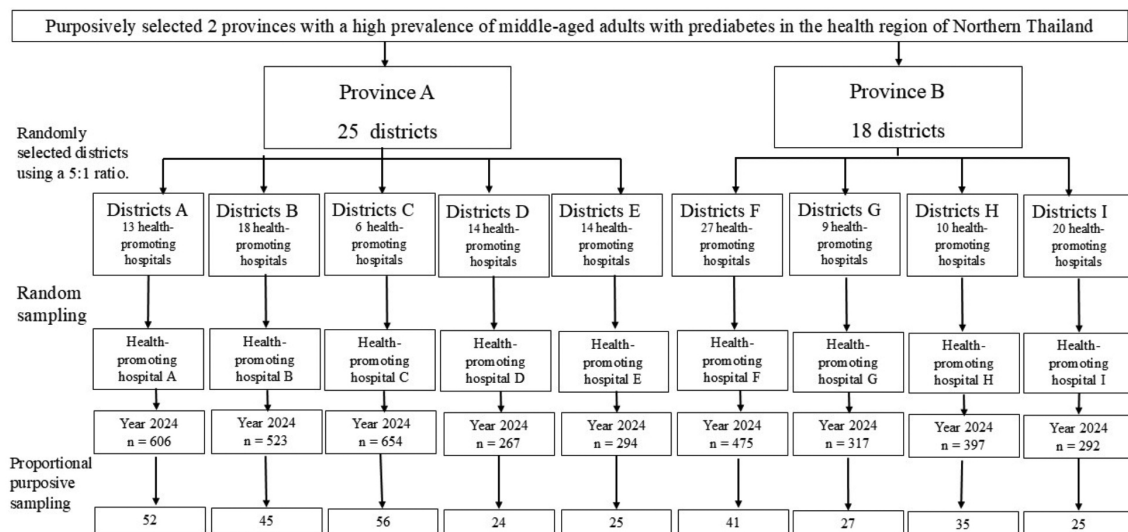


Figure 2. The multi-stage sampling technique of this study

Ethical considerations: The study was reviewed and approved by the Research Ethics Committee, Faculty of Nursing, Chiang Mai University (Research ID: 011/2025; Study code: 2567-EXP110). All participants received comprehensive information about the study procedures, voluntary participation, and assurances of privacy and confidentiality. Participants were informed that they could decline or withdraw from the study at any stage without adverse

consequences. Written informed consent was obtained before data collection.

Instruments: This study utilized eight research instruments. All instruments, except the Demographic Data Record Form, were translated into Thai with permission from the original authors using a standardized back-translation process.²⁸ The instruments were culturally adapted and modified to align with current recommendations for individuals with prediabetes.

Content validity was evaluated by a panel of six experts, including two nursing instructors specializing in adult prediabetes care and the IMB model, an endocrinologist, two advanced practice nurses specializing in prediabetes care, and a public health instructor with expertise in preventive behavior. The item-level content validity index (I-CVI)/scale-level content validity index (S-CVI) and reliability coefficients from both the

pilot study and the main study with 325 participants demonstrated satisfactory content validity, and most instruments showed acceptable internal consistency in both the pilot and main study samples. However, the Preventive Health Behaviors Questionnaire demonstrated marginally acceptable internal consistency²⁹ (Cronbach's $\alpha = 0.694$). Detailed psychometric results are presented in **Table 1**.

Table 1. Content validity index, Cronbach's alpha reliability, and examples of items of the instruments

Instruments	I-CVI S-CVI/Ave	Reliability		Example of items
		Pilot study	Main study	
Preventive Health Behaviors Questionnaire	1.00	0.949 ^a	0.694 ^b	How many days a week do you follow the healthcare professional's recommended diet?
Prediabetes and Preventive Health Behaviors Knowledge Test	1.00	0.772 ^c	0.730 ^c	People with prediabetes are more likely to develop T2DM than the general population.
Diet and Exercise Attitude Questionnaire	0.83–1.00	0.718 ^b	0.825 ^b	Exercising every day is good for health.
Perceived Susceptibility and Perceived Severity Questionnaire	0.98	0.839 ^b	0.795 ^b	If I get diabetes, I will only get more problems in the Future.
Diet and Exercise Subjective Norms Questionnaire	0.83–1.00	0.913 ^b	0.882 ^b	Most people who are important to me think I should exercise.
Diet and Exercise Behavioral Skills Questionnaire	0.99	0.917 ^b	0.860 ^b	You can effectively count carbohydrates for every meal.
Self-Efficacy for Diet and Physical Activity Questionnaire	1.00	0.970 ^b	0.920 ^b	I can manage to carry out my exercise, even when I am tired.

Note. ^a Pearson correlation, ^b Cronbach's alpha, ^c Kuder-Richardson-20

The Demographic Data Record Form collected information on gender, age, marital status, religion, education level, occupation, income, body weight, height, and waist circumference.

The Preventive Health Behaviors Questionnaire was developed by Brownell³⁰ to evaluate preventive health behaviors. The instrument consists of 8 self-report items across two domains: dietary behaviors and exercise behaviors. Participants reported the number of days they engaged in each behavior during the previous week, with scores ranging from 0 to 7. Mean scores were categorized as low (0–2.33), moderate (2.34–4.67),

and high (4.68–7.00) levels of preventive health behaviors.

The Prediabetes and Preventive Health Behaviors Knowledge Test was developed by Brownell³⁰ to evaluate knowledge within the specified demographic. The instrument consists of 12 self-report items, categorized into three domains: prediabetes, dietary, and exercise knowledge. Responses were recorded as “yes,” “no,” or “I do not know,” with correct answers scored as 1 and incorrect or “I do not know” responses scored as 0. Total scores ranged from 0 to 12, with higher scores indicating greater knowledge.

The Diet and Exercise Attitude Questionnaire was developed by Brownell³⁰ to evaluate attitude toward preventive health behaviors. The instrument consists of 16 self-report items across two domains: diet and exercise attitudes. Responses were measured using a five-point Likert scale, with possible scores ranging from 16 to 80; higher scores indicated more positive attitudes toward diet and exercise behaviors.

The Perceived Susceptibility and Perceived Severity Questionnaire was developed by Della et al.³¹ to assess risk perception. The questionnaire comprises 10 self-reported items across two domains: perceived susceptibility and perceived severity. Each item was rated on a 5-point Likert scale, with total scores ranging from 10 to 50; higher scores denote greater risk perception.

The Diet and Exercise Subjective Norms Questionnaire was developed by Brownell³⁰ to evaluate subjective norms. The instrument consists of 8 self-report items across two domains: diet and exercise subjective norms. Responses were recorded on a six-point Likert scale, with a total possible score range of 8 to 48. Elevated scores denote more favorable subjective norms.

The Diet and Exercise Behavioral Skills Questionnaire was developed by Brownell³⁰ to assess preventive behavioral skills. The questionnaire comprises 14 self-reported items categorized into two domains: diet and exercise behavioral skills. Responses were measured using a four-point Likert scale, with total scores range from 14 to 56, with higher scores indicating superior skills in preventive health behaviors.

The Self-Efficacy for Diet and Physical Activity Questionnaire was developed by Huttunen-Lenz et al.³² to assess confidence in engaging in preventive health behaviors related to diet and physical activity among individuals with prediabetes. The instrument comprises 10 items, divided into two domains: self-efficacy for diet and physical activity. Each item was rated on a 4-point Likert scale, with total scores ranging from 10 to 40; higher scores indicate greater self-efficacy.

Data collection: Data were collected from February to June 2025 by the primary investigator (PI). Following ethical approval, permission to collect data was obtained from relevant local health authorities. A nurse from each health-promoting hospital was appointed as a research coordinator to assist with registration. The PI distributed flyers inviting middle-aged adults with prediabetes within each health-promoting hospital's service areas. Interested individuals could register by scanning the QR code on the flyer or by visiting a health-promoting hospital for in-person sign-up. After one month, the PI compiled the list of registered individuals and selected participants based on predefined inclusion and exclusion criteria.

Subsequently, the research team contacted eligible participants by phone to schedule face-to-face meetings. On the day of data collection, the study purpose, procedures, and participant rights, including confidentiality and voluntary participation, were explained to all participants. Before participating in the study, participants provided written informed consent. Participants completed the questionnaires either at the health-promoting hospital or at their residences. The assessment began with the knowledge questionnaire to minimize response bias in subsequent sections. The entire process took approximately 30 to 45 minutes. The PI checked completed questionnaires for completeness. Participants received a small token of appreciation upon completion.

Data Analysis: Descriptive statistics were employed to summarize participants' demographic characteristics. An initial assessment of missing data indicated that no data were missing among 330 participants. Five outliers were identified and excluded, resulting in a final sample of 325 participants for analysis. The data were examined for statistical assumptions, including normality, linearity, homoscedasticity, and multicollinearity, and all assumptions were met for SEM analysis. SEM was conducted using Mplus. Model fit was evaluated using multiple fit indices based on the recommendations of Hu and Bentler³³

and interpreted in accordance with SEM guidelines described by Kline,³⁴ including the relative chi-square (χ^2/df) < 3.0, root mean square error of approximation (RMSEA $\leq$ 0.08), standardized root mean square residual (SRMR $\leq$ 0.08), comparative fit index (CFI $\geq$ 0.90), and Tucker-Lewis index (TLI $\geq$ 0.90).

Results

Demographic characteristics: Of the 325 participants, 61.80% were female and aged 40–60

years, with a mean age of 52.55 years (SD = 5.89). Most participants were married (72.00%) and identified as Buddhist (99.40%). Over half had completed elementary education (52.62%), and 32.92% were employed in general labor. The average monthly personal income was 9,139 THB (USD 281). The mean body weight was 62.68 kg (SD = 10.87), the average body mass index was 24.87 (SD = 3.99), and the mean waist circumference was 84.45 cm (SD = 9.02). Additional details are presented in

Table 2.

Table 2. Range, mean, and standard deviation of study variables (N = 325)

Variables	Possible score	Actual score	Mean	SD	Level
Preventive health behaviors	0–7	0–7	4.56	0.99	Moderate
Information	0–12	0–12	7.86	2.82	High
Attitude toward preventive health behaviors	16–80	35–80	62.48	7.85	High
Risk perception	10–50	17–50	34.93	6.54	Moderate
Subjective norms	8–48	15–48	35.42	6.60	High
Preventive behavioral skills	14–56	27–56	40.95	5.76	Moderate
Self-efficacy	10–40	10–40	26.76	5.68	Moderate

Model Testing: The measurement model was evaluated using confirmatory factor analysis (CFA) to assess the construct validity of the seven latent variables. The results indicated that all constructs

demonstrated acceptable model fit, with fit indices meeting the predefined criteria. These findings support the construct validity of the measurement model, as detailed in **Table 3**.

Table 3. Summary of fit statistics for the measurement model variables in confirmatory factor analysis

Measurement model	Chi-square	df	χ^2/df	CFI	TLI	RMSEA	SRMR
Preventive health behaviors	$\chi^2 = 0.000$ p = 0.998	1	0.000	1.000	1.000	0.000	0.000
Information	$\chi^2 = 0.003$ p = 0.958	1	0.003	1.000	1.000	0.000	0.001
Attitude toward preventive health behaviors	$\chi^2 = 0.000$ p = 0.999	1	0.000	1.000	1.000	0.000	0.000
Risk perception	$\chi^2 = 0.000$ p = 0.996	1	0.000	1.000	1.000	0.000	0.000
Subjective norms	$\chi^2 = 0.000$ p = 0.991	1	0.000	1.000	1.000	0.000	0.000
Behavioral skills	$\chi^2 = 0.000$ p = 0.987	1	0.000	1.000	1.000	0.000	0.000
Self-efficacy	$\chi^2 = 0.000$ p = 0.989	1	0.000	1.000	1.000	0.000	0.000

Note. The fit indices: χ^2 (Chi-square), χ^2/df (relative chi-square); RMSEA = Root mean square error of approximation; SRMR = Standardized root mean square residual; CFI = Comparative fit index; TLI = Tucker-Lewis index

Structural model assessment: The structural relationships specified in the proposed Causal Model of Preventive Health Behaviors in Thai Middle-Aged Adults with Prediabetes (**Figure 1**) were examined. Upon evaluation of the initial theoretical model, the fit statistics indicated that the model did not meet the established fit criteria (**Table 4**). Consequently, model modification was required. During this stage, the model was refined to improve model fit while maintaining theoretical consistency within the framework of preventive health behaviors. These modifications involved correlating residual error terms, guided by modification indices and theoretical justification. Most correlated residuals were added between indicators within the same behavioral domain

(e.g., diet-related or exercise-related indicators), which were theoretically expected to share unexplained variance beyond the latent construct. Modifications were implemented incrementally, with model fit indices evaluated after each step. The modified model demonstrated compatibility with the empirical data, as all fit indices met the prescribed criteria, except for the Chi-square test p-value, which is known to be sensitive to sample size. When the sample size exceeds 250, the p-value may become statistically significant. Nonetheless, it is recommended that overall model fit be evaluated using the relative Chi-square statistic.³³ The results of the structural model evaluation are presented in **Figure 3**.

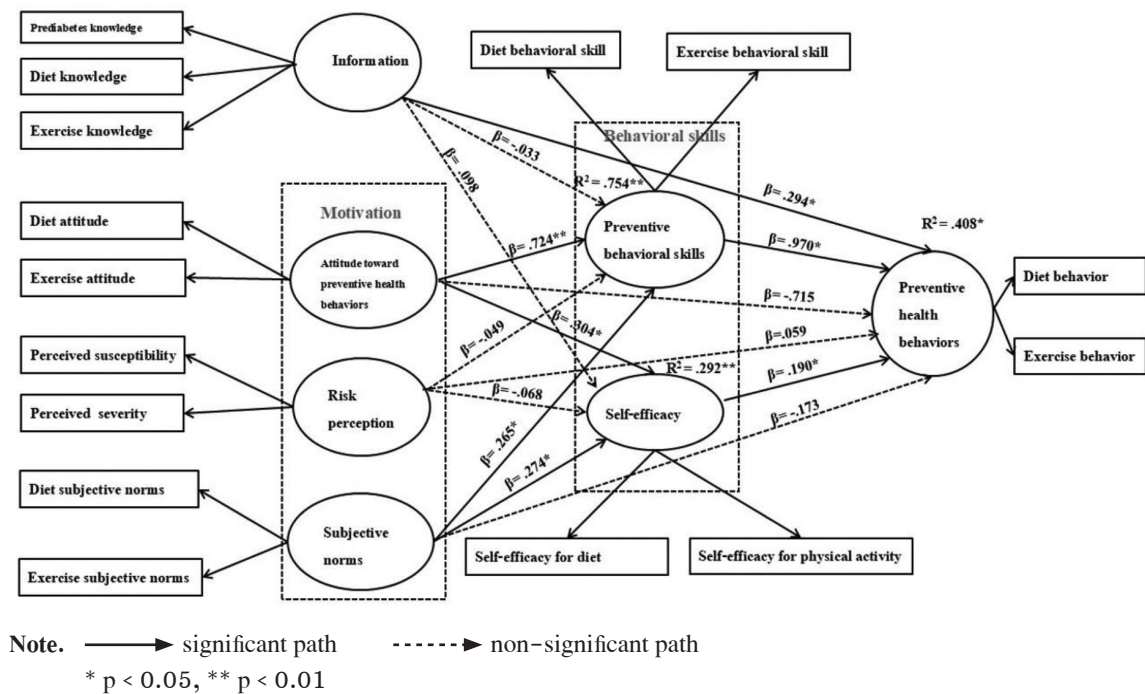


Figure 3. The final structural equation model (SEM) results illustrating the hypothesized relationships for preventive health behaviors in Thai middle-aged adults

Table 4. The goodness-of-fit indices in the final model modification of this study (N = 325)

Goodness-of-fit indices	Criteria of acceptability	Initial model	Modification model
Chi-square (χ^2)	Non-significant	452.768, p < 0.001	150.599, p < 0.001
Degree of freedom (df)	–	71	58
Relative Chi-square (χ^2/df)	< 3.00	6.377	2.596
Comparative fit index (CFI)	≥ 0.90	0.779	0.946
Tucker-Lewis fit index (TLI)	≥ 0.90	0.674	0.903
Root mean square error of approximation (RMSEA)	≤ 0.08	0.129	0.070
Standardized root mean square residual (SRMR)	≤ 0.08	0.089	0.060

Final model interpretation: The final model, incorporating four explanatory variables—namely, information, attitude toward preventive health behaviors, preventive behavioral skills, and self-efficacy—explained 40.8% of the variance in preventive health behaviors ($R^2 = 0.408$). Information, preventive behavioral skills, and self-efficacy demonstrated significant direct effects on preventive health behaviors, with preventive behavioral skills demonstrating the strongest effect. The model including attitudes toward preventive health behaviors and subjective norms explained 75.4%

of the variance in preventive behavioral skills ($R^2 = 0.754$) and 29.2% of the variance in self-efficacy ($R^2 = 0.292$) (Table 5). Additionally, the variable “risk perception” did not demonstrate statistically significant direct or indirect effects on preventive health behaviors. The coexistence of negative direct effects and positive indirect effects for attitude toward preventive health behaviors and subjective norms suggests inconsistent mediation or suppression within the structural model.

Table 5. Standardized direct effects, indirect effects, and total effects of independent variables on preventive health behaviors

Endogenous variables	R^2	Independent variables	TE	DE	IE
Preventive behavioral skills	0.754**	Attitude toward preventive health behavior	0.724**	0.724**	–
		Subjective norms	0.265*	0.265*	–
Self-efficacy	0.292**	Attitude toward preventive health behavior	0.304*	0.304*	–
		Subjective norms	0.274*	0.274*	–
Preventive health behaviors	0.408*	Information	0.294*	0.294*	–
		Attitude toward preventive health behavior	0.046	–0.715	0.760*
		Subjective norms	0.136	–0.173	0.309
		Preventive behavioral skills	0.970*	0.970*	–
		Self-efficacy	0.190*	0.190*	–

Note. TE = Total effect, IE = Indirect effect, DE = Direct effect; *p < 0.05, ** p < 0.01

Discussion

This study developed and tested the Causal Model of Preventive Health Behaviors in Thai Middle-Aged Adults with Prediabetes. The findings indicated that information, preventive behavioral skills, and self-efficacy had direct effects on preventive health behaviors. Attitudes toward preventive health behaviors demonstrated an indirect effect on these behaviors through preventive behavioral skills. Within the context of the IMB model, risk perception did not demonstrate a significant role in influencing preventive health behaviors. Additionally, subjective norms had no direct or indirect effects on preventive health behaviors; however, they influenced preventive behavioral skills and self-efficacy. Notably, preventive behavioral skills served as an important mediating variable in the model. This study extends the IMB model by highlighting the potential importance of behavioral skills in asymptomatic conditions such as prediabetes. Furthermore, this study provides one of the few SEM-based analyses of preventive health behaviors among individuals with prediabetes.

Information, preventive behavioral skills, and self-efficacy had direct effects on preventive health behaviors. These behaviors range from simple actions, such as replacing sweetened beverages with water or choosing to walk instead of using the elevator, to more complex activities, such as carbohydrate counting and exercise scheduling. Simple behaviors primarily require adequate information, as clear knowledge guides disease-risk reduction.³⁵ In contrast, more complex behaviors require specific skills. Behavioral skills play an important role in translating information and motivation into action, enabling individuals to perform tasks such as meal planning, calorie monitoring, and structured physical activity.¹² Furthermore, these skills can reduce behavioral complexity, facilitating the development of more automatic and sustainable habits.¹³ Self-efficacy had a significant direct effect on engagement in preventive behaviors. Individuals

with greater confidence in their capacity to carry out diet and exercise-related activities are more likely to persist despite challenges. Among middle-aged adults with prediabetes, those with higher self-efficacy are more likely to perceive barriers, such as time constraints, as manageable rather than prohibitive.¹⁷ Therefore, information, preventive behavioral skills, and self-efficacy had direct effects on preventive health behaviors, consistent with previous studies.^{18,23,24}

This study revealed that attitudes toward preventive health behaviors had an indirect effect on behavior through preventive behavioral skills. Attitudes reflect individuals' evaluation of behaviors as beneficial or unfavorable based on perceived outcomes. Individuals with more favorable attitudes tended to report stronger dietary management and exercise-related skills, which were associated with greater engagement in preventive health behaviors. The present findings are consistent with those reported in a previous study.²²

The findings indicated that subjective norms and risk perception were not directly or indirectly associated with preventive health behaviors. However, subjective norms were significantly associated with preventive behavioral skills and self-efficacy, suggesting that individuals who perceive stronger social expectations or approval from important others may demonstrate stronger capabilities in these domains. These findings are consistent with theoretical expectations and previous research highlighting the role of subjective norms in influencing psychological and behavioral antecedents of preventive health actions.¹²

An important finding of this study is that risk perception was not a significant predictor in the model. Middle-aged adults may interpret prediabetes as a "warning stage" rather than an immediate threat, thereby reducing its motivational impact. In asymptomatic conditions, perceived seriousness may remain abstract and insufficient to prompt behavioral action. A qualitative study conducted among adults with diabetes in

Singapore suggests that knowing someone diagnosed with diabetes makes the condition more tangible, compared to merely receiving information through reading or hearing.³⁶ Furthermore, middle-aged adults with prediabetes are often engaged in multiple daily responsibilities. Although they may be aware of diabetes, there may be a tendency to perceive prevention as something that can be postponed until later in life. In contrast, older adults who are retired may translate their perceived vulnerability into greater motivation to engage in preventive behaviors. Consequently, perceived susceptibility and severity alone is insufficient to promote engagement in preventive behaviors among middle-aged adults at risk.³⁷

Notably, preventive behavioral skills emerged as the strongest predictor, suggesting that possessing practical competence (“knowing how to act”) may be more influential than merely believing in one’s capability to act. This finding differs from previous studies^{18,38} that identified self-efficacy as the dominant predictor. These results underscore the importance of developing practical, actionable disease-prevention skills among middle-aged adults with prediabetes. In line with the IMB model, successful behavior change depends not only on what individuals know, but also on how effectively they apply that knowledge in real-life situations characterized by complexity and competing demands. Consequently, behavioral skills serve as the critical link between knowledge and action, making them a fundamental component of effective preventive health behaviors.

Limitations

Several limitations of this study should be considered. First, data were obtained through self-report questionnaires, which may be susceptible to recall bias and social desirability bias, thereby potentially affecting the accuracy of participants’ responses. Second, the preventive health behaviors questionnaire showed slightly lower reliability (Cronbach’s alpha = 0.694),

which may limit measurement precision, and this instrument needs to be redefined in the future. Third, participants were recruited from health-promoting hospitals in one health region in Northern Thailand; therefore the findings may have limited generalizability to other regions with different demographic and healthcare contexts. Fourth, the very high standardized effect of preventive behavioral skills may suggest potential conceptual overlap or shared measurement variance with preventive health behaviors. Although behavioral skills and preventive health behaviors were conceptualized as distinct constructs, some behavioral skill items may reflect behavioral enactment, which could partially contribute to the strong association observed. However, the moderate correlation between preventive behavioral skills and preventive health behaviors supports discriminant validity between the constructs. Therefore, the findings should be interpreted cautiously, and future studies should further validate construct distinctiveness. Fifth, the use of a cross-sectional study design limits conclusions regarding causality. Finally, the model explained 40.8% of the variance in preventive health behaviors, indicating that other unmeasured individual, social, and environmental factors may also contribute to variation in behavior.

Conclusions and Implications for Nursing Practice and Future Research

The findings indicated that information, preventive behavioral skills, and self-efficacy were significant influences on preventive health behaviors among Thai middle-aged adults with prediabetes. Among these factors, preventive behavioral skills were the strongest predictor, suggesting that nursing interventions may be most effective when they emphasize developing practical skills, action-oriented skills rather than focusing solely on risk communication. Although information and self-efficacy had direct

effects on behavior, their influence may be strengthened when combined with experiential learning, coaching, and feedback. Attitudes were found to exert an indirect effect on behavior through behavioral skills, highlighting the importance of fostering positive beliefs while simultaneously strengthening individuals' ability to translate intentions into action. The non-significant effect of risk perception suggests that fear-based approaches may be insufficient to promote sustained behavior change in this population. Therefore, nursing practice may benefit from shifting toward supportive, patient-centered, and skill-based interventions that facilitate sustained preventive health behaviors. These findings emphasize the importance of designing interventions that strengthen practical skills and support long-term behavior change. For nursing research, the Causal Model of Preventive Health Behaviors in Thai Middle-Aged Adults with Prediabetes should be tested in diverse populations and settings. Future longitudinal and experimental studies are needed to validate and refine the model.

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Author Contributions

Conceptualization, Methods and design: JJ, TK, CT, NS

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Data analysis and interpretation: JJ, TK, CT, NS

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Declaration regarding Conflict of Interest

The authors declare no competing interests.

Declaration of AI used for Scientific Writing

The authors used AI-assisted tools, ChatGPT (OpenAI) and Grammarly, to improve language clarity and grammar. The authors critically reviewed and revised the manuscript and accepted full responsibility for its content.

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ปัจจัยที่มีอิทธิพลต่อพฤติกรรมป้องกันโรคในผู้ใหญ่วัยกลางคนที่มี ภาวะก่อนเบาหวาน : การศึกษาภาคตัดขวาง

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บทคัดย่อ: ภาวะก่อนเบาหวานในผู้ใหญ่วัยกลางคนเป็นปัญหาสำคัญของระบบสุขภาพ การมีส่วนร่วมในพฤติกรรมป้องกันโรคเป็นแนวทางสำคัญในการลดความก้าวหน้าของโรค อย่างไรก็ตามในประเทศไทยข้อมูลเกี่ยวกับปัจจัยที่มีผลต่อพฤติกรรมป้องกันโรคในผู้ใหญ่วัยกลางคนที่มีภาวะก่อนเบาหวานยังมีอยู่อย่างจำกัด การศึกษาเชิงพรรณนาแบบภาคตัดขวางนี้มีวัตถุประสงค์เพื่อทดสอบสมมติฐานสมการโครงสร้างของพฤติกรรมป้องกันโรคในผู้ใหญ่วัยกลางคนไทยที่มีภาวะก่อนเบาหวาน อิงตามแบบจำลองข้อมูล แรงจูงใจ และทักษะพฤติกรรม คัดเลือกผู้เข้าร่วมวิจัยชาวไทยจำนวน 325 คนโดยการสุ่มแบบหลายขั้นตอน จากโรงพยาบาลส่งเสริมสุขภาพตำบลจำนวน 9 แห่งในเขตสุขภาพแห่งหนึ่งทางภาคเหนือของประเทศไทย เก็บรวบรวมข้อมูลโดยใช้แบบสอบถามเพื่อประเมินข้อมูลส่วนบุคคล ความรู้ ทัศนคติ การรับรู้ความเสี่ยง การคล้อยตามกลุ่มอ้างอิง ทักษะพฤติกรรมป้องกันโรค สมรรถนะแห่งตน และพฤติกรรมป้องกันโรค ใช้สถิติพรรณนาและโมเดลสมการโครงสร้างในการวิเคราะห์ข้อมูล

ผลการวิจัยพบว่าแบบจำลองที่เสนอสามารถอธิบายความแปรปรวนของพฤติกรรมป้องกันโรคได้ร้อยละ 40.8 โดยข้อมูลทักษะพฤติกรรมป้องกันโรค และสมรรถนะแห่งตนมีอิทธิพลทางตรงเชิงบวกกับพฤติกรรมป้องกันโรค ซึ่งทักษะพฤติกรรมป้องกันโรคเป็นตัวแปรที่มีอิทธิพลสูงสุด อย่างไรก็ตาม คำสัมภาษณ์ที่มีค่าสูงผิดปกติดังกล่าวควรได้รับการตีความด้วยความระมัดระวังเนื่องจากอาจมีความซ้อนทับกันในเชิงแนวคิดระหว่างตัวแปรต่าง ๆ ทัศนคติต่อพฤติกรรมป้องกันโรคมีอิทธิพลทางอ้อมเชิงบวกกับพฤติกรรมป้องกันโรคผ่านทักษะพฤติกรรมป้องกันโรค โรงพยาบาลสามารถนำผลการวิจัยเหล่านี้ไปใช้ในการพัฒนานวัตกรรมโดยเน้นการเพิ่มพูนความรู้ เสริมสร้างทัศนคติเชิงบวก และพัฒนาทักษะด้านพฤติกรรมและสมรรถนะแห่งตน โดยบูรณาการเทคโนโลยีเข้าด้วยกัน อย่างไรก็ตาม ควรมีการทดสอบก่อนนำไปปฏิบัติในวงกว้าง

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คำสำคัญ: แบบจำลองข้อมูล แรงจูงใจ และทักษะพฤติกรรม ความรู้ ผู้ใหญ่วัยกลางคน ภาวะก่อนเบาหวาน พฤติกรรมการป้องกันโรค การรับรู้ความเสี่ยง สมรรถนะแห่งตน การคล้อยตามกลุ่มอ้างอิง

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