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RESEARCH ARTICLE

Association between Herbal use Behavior and Hemoglobin A1c among Ethnic Minorities in Thai Border Communities

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Abstract:

Background:

Herbal use is a conventional wisdom of health care that falls under complementary alternative medicine. The purpose of this research was to study factors affecting herbal-use behavior and glycated hemoglobin (HbA1c) levels in ethnic minorities living in the northern border of Thailand.

Methods:

A cross-sectional study was conducted in the three northern border provinces located in the highlands and rural plains between May–July 2022 among ethnic groups, including Hmong, Karen, Lua, and Indigenous. A total of 413 people were recruited for the study using a convenient sampling method. The data were obtained from face-to-face interviews using questionnaires and from blood samples.

Results:

The mean age of the participant was 50.2 years. More than half of the participants had abnormal HbA1c (> 6.5) (55.7%). The mean score for herbal-use behavior was 19.2 (SD = 3.77). An analysis of Pearson's correlation coefficient found that herbal-use behavior was positively correlated with health literacy (r = 0.918). HbA1c was negatively correlated with health literacy and health behavior (r = -0.628, r = -0.557). Factors including age and people with diabetes were statistically significantly associated with herbal-use behavior, accounting for 42.3% of the variance. When adjusted for factors, health literacy was found to be statistically significantly associated with herbal-use behavior, which affected HbA1c levels.

Conclusion:

Health education programs among ethnic minorities should be focused on increasing health knowledge of the types and properties of herbs and herbal-use behavior to help lower blood sugar levels and understand the health effects and consequences of herbal-use.

Keywords: Herbal-use behavior, Health literacy, Hemoglobin A1c, Ethnicities, Thai border communities, Health behavior.

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1. INTRODUCTION

Diabetes is a major public health problem worldwide. According to the International Diabetes Federation (IDF) (2017), there were 425 million people aged 20–79 years living with diabetes. Current global estimates indicate that it will increase to 629 million people by 2045 [1]. A systematic review suggests that people with type 2 diabetes mellitus (T2DM) need to focus on adequate self-management and self-care behavior to maintain blood sugar levels to reduce or delay diabetes-related complications [2]. Cumulative average glucose (Hemoglobin A1c: HbA1c) is currently used as the standard for assessing diabetes control. Currently, there is only 23.7 percent among diabetes patients who are treated and well controlled to maintain blood sugar levels [3]. Some reports explain that HbA1c levels greater than 7 percent can significantly increase the likelihood of vascular complications of diabetes [4]. Previous studies have found that factors affecting the incidence of diabetes are physical inactivity, medication use, and stress, which are statistically significantly associated with glycemic control among non-insulin-dependent diabetes mellitus patients [5].

In Thailand, the 6th Thai Health Examination Survey Report 2019-2020 showed that the prevalence of diabetes as

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measured by HbA1c among the Thai population was found to be 15 years and over, which increased by 11.0%. In women, the prevalence is higher than in men (12.5 and 9.5%, respectively) [6]. Northern Thailand also continues to see a steady increase in the number of people with diabetes. According to a 2016-2020 report on the number and mortality of chronic non-communicable diseases (NCDs) by the District Health Service, District 1, the mortality rate from diabetes tends to increase approximately 1.8-3.4 times in 10 years [6]. Phayao Province is one of the northern provinces in Thailand with an increasing number of diabetic patients. In 2020, the mortality rate related to diabetes has increased to 18.61 percent of the total population in the province [6].

According to the World Health Organization (WHO), traditional medicine refers to knowledge, skills, and practices based on the theories, beliefs, and experiences indigenous to different cultures used in the maintenance of health and the prevention, diagnosis, improvement, or treatment of physical and mental illness [7]. Furthermore, it is a belief that it combines plants, animals, and mineral medicines in spiritual healing, preventing illness and maintaining well-being [7]. Herbal medicine (HM) is designated as an essential part of traditional medicine and as the most commonly used complementary and alternative medicine in various parts of the world [8]. Based on a literature review, 80% of people in developing countries rely on traditional medicine as a primary treatment for various ailments [9]. Some reports indicate that herbal medicine is popular, particularly among patients with chronic diseases [10]. Among the practices of traditional medicine, the use of herbal medicines is the most popular and common among the general population and among patients with diabetes [11]. Most traditional medicines are common foods that include vegetables, flowers, fruits, seeds, spices, and herbs. Some foods provide health benefits beyond their nutritional value and are effective in the prevention and treatment of various diseases [12].

According to the Thai Ministry of Public Health's Department of Thai Traditional and Alternative Medicine, herbs are plants that are part of natural medicine. They have essential ingredients for medicine and are important for humans in daily life [13]. Herbs can be processed into daily food products and health supplements and are also an important ingredient in Thai traditional medicine or pharmaceutical science [13]. The Thai government has a policy to support the use of herbs and Thai traditional medicine from the past to the present. Herbs have been announced to promote health treatment among noncommunicable chronic disease patients, such as diabetes and blood pressure. Herbal medicine is also promoted as an alternative medicine in controlling, preventing, and treating, in parallel with modifying self-care behaviors [14, 15]. A literature review found that developing countries, such as ninety percent of people in Africa and seventy percent of people in India, still rely on traditional medicine and herbal medicine for primary health care to address their health needs [16]. According to a national health interview report in the United States, approximately 40.6 million adults used herbs and supplements in 2012 [17]. Previous studies have identified a number of factors associated with herbal medicinal use, such as gender, education, higher socioeconomic status, and certain health conditions such as myalgia and chronic NCDs [18]. Many people still believe in the traditional way of life, which affects their health and health-seeking behavior. Traditional medicine is used as a main form of primary healthcare and is found in common food ingredients in many countries [12].

There are many ethnic groups residing in northern Thailand. Most of them are located in remote rural areas. Their healthcare is based on the culture and beliefs of the ancestors of each family or community [19]. According to the report, they are also designated as a vulnerable population and suffer from a range of health problems, including NCDs, such as diabetes, hyperlipidemia, and other diseases due to specific lifestyles and dietary cultures [19]. Previous reports have found that herbal-use behavior among rural Thais focuses on primary therapy in the presence of abnormal symptoms and the treatment of chronic conditions [20]. However, there are no studies on herbal-use behavior for health promotion among ethnic groups. Therefore, the purpose of this research was to study the factors affecting herbal-use behavior and glycated hemoglobin (HbA1c) levels in ethnic minorities living at the northern border of Thailand. The findings will be used in the development of appropriate health education programs among ethnic minority groups in accordance with their community contexts, cultures, traditions, and beliefs.

2. METHODOLOGY

2.1. Materials and Methods

2.1.1. Study Design and Participants

This research study was a cross-sectional survey under the Unit of Excellence Project "Health Promotion and Quality of Life". Data collection was performed in May–July 2022 in the northern border provinces, including Lamphun, Phayao, and Nan. The geographical locations of the study areas are rural, remote highlands and rural plains. It takes about hours to commute to primary and secondary healthcare centers, which are approximately 30–40 kilometers away from the city. The procedure selection of the study areas and recruitment of participants are described as follows: First, a purposive sampling method was employed to select the populations from the list of ethnic groups living on the northern border, including 11 main groups: Karen, Hmong, Lishu, Li-shaw, Lahu, Muser, Akah, Mien, Mlabri, Lua, and Indigenous [21]. Second, three provinces, including Phayao, Lamphun, and Nan were chosen from northern provinces of Thailand, where there are many ethnic minority groups residing in the area. Third, the researcher selected study districts using a draw lottery, which was one district per province and three sub-districts per province. Fourth, three villages were drawn per each selected subdistrict. Finally, a convenience sampling method was used to select the participants.

Prior to the research, the recruitment of volunteer research assistants to participate in the study was announced in the village with the help of village leaders and public health officers. The sample size was calculated using the formula of unknown sample size of Cochran [22], with a 95% confidence level and a 5% error, and the sample size of 385 was obtained

based on the calculation. However, to prevent the loss of the sample during the research, a 10% increase was added, and the total sample size was 424 people. Inclusion criteria were as follows: a) Female and male diagnosed in a diabetes risk group aged 20 years and over; b) Having HbA1c level at 5.7-6.4% [23]; c) No signs of cardiovascular disease such as chest pain; d) Not a patient with severe chronic disease; e) Belong in ethnic groups registered with the High Area Health Development Center (Marginalized Ethnic Group) Department of Health, Ministry of Public Health and municipalities in the area; f) Resided in the area not less than 2 years. Importantly, all participants voluntarily signed a consent form prior to participating in the research and were willing to participate in the study. Those who provided incomplete information, and people with health problems that could affect research participation were excluded from the study.

2.1.2. Procedures

After receiving ethics approval certification from the University of Phayao (Research project number UP-HEC 1.2/014/65), the researcher arranged a meeting with the Director of Health Promoting Hospital officers and research-related persons to introduce oneself and clarify the purpose of the study, research procedures, data collection technique, time schedule of the interview, and obtain basic information about the people at risk of diabetes group from each study area. Research assistants were recruited, and all of them were 15 village health volunteers from the study subdistrict. Prior to data collection, the researcher held a meeting with research assistants in each area to clarify the research objectives with the aim of helping everyone understand the procedures in the same direction. There were tests to measure knowledge, understanding, and skills regarding research procedures, the right and privacy of participants, and data collection techniques for research assistants to ensure everyone understood the procedures. Data collection was done in 9 days, 1 village per day. The interviews with participants lasted 10–15 minutes per person.

2.2. Questionnaires

Questionnaires were used as research instruments which were applied from literature review, theory, previous research, and related applications. The researcher ensured that the content of the questionnaires was suitable for the context of ethnic minorities and their cultures. The questionnaires consisted of three parts, which are described as follows: Part 1) General characteristics information including ethnic groups, gender, age, education, marital status, financial status, occupation, current disease, eating behavior, alcohol intake, smoking, and exercise; Part 2) Health Literacy Assessment Questionnaire about the use of herbs to control blood sugar levels. The researcher adapted and applied the concept of comprehensive health literacy [24] to construct the questionnaire and to ensure that the content would be appropriate for the context of ethnic groups. The questionnaire was divided into six skill areas: 1) access to health information, 2) cognitive, 3) health communication, 4) decision-making, 5) self-management, and 6) media literacy. There were 40 close-ended questions in total. The answers were provided as Yes (1-point), No (0-point), and Not Sure (0-point); all aspects were combined for a total score of 40 points. The questionnaire part 3) Herbal-use behavior to control blood sugar level questionnaire. The researcher developed from the concept of health behavior and applied from the existing material obtained from the Health Education Division [24]. The questionnaire is herbal-use behavior to reduce blood sugar levels. Using herbs in cooking and growing herbs for self-care with herbs that most people use to eat and drink to reduce blood sugar levels, such as okra, piper, and yanang leaf [25]. There were 10 items measuring as a rating scale including four levels: never practice, sometimes practice (2–3 times / week), often practice (4–5 times / week) and regularly practice (more than five times / week).

The questionnaires were checked for accuracy using the item-objective congruence (IOC) technique, and three experts in their respective fields (Internal Medicine, Herbal Alternative Medicine, and Public Health) checked the research materials to determine whether they were appropriate or not. A question with a score less than 0.5 was eliminated, and a score between 0.5-0.69 would be revised based on experts' feedback; questions with a score greater than 0.7 were considered acceptable for the research. The questionnaires were put on a tryout with 30 participants who had similar characteristics to the ethnic groups being studied. Parts 2 and 3 of the questionnaires were analyzed for reliability using Cronbach's alpha, which obtained coefficients of 0.79 and 0.80. After the researcher received the consent form, a 3-5 ml of blood sample was collected would be taken from the participants. Participants were interviewed face-to-face between 9:00 a.m. and 12:00 p.m. An analyzer was used to measure the HbA1c levels among the participants. A medical technician from the School of Allied Health Sciences within the University of Phayao (Thailand) undertook the collection and analyses of blood and interpretation of results. The laboratory equipment passed the required quality inspections.

2.3. Statistical Analysis

Statistical analysis was performed using IBM SPSS ® software (version 26.0, IBM, USA). Descriptive statistics were used to analyze general information, such as percentage, mean, standard deviation, minimum, and maximum. Correlation analysis was used to analyze the relationships among the variables. The differences in the mean scores of health literacy, herbal-use behavior, and HbA1c were analyzed using a t-test and ANOVA analysis. Factor analyses of herbal-use behavior and self-care behavior were performed using linear regression analysis. Multivariate factors were analyzed using the significance predictor $p < 0.05$.

3. RESULTS

A total of 413 people participated in this study. Females outnumbered males by 56.7% to 43.3%. An average age of the participant was 50.2 years. 56.9 percent of participants obtained a degree in primary education, while 80.1 percent had married, in terms of household income variable, 86.7 percent responded as insufficient revenue. More than half of them (62.5%) had no congenital disease. When the herbs used behavior scores for glycemic control were analyzed by item,

item 6: You use herbal medicine to reduce blood sugar levels, had the highest score (mean = 1.98), followed by item 4: You choose herbs that were grown in the house for cooking (mean = 1.96), and item 5: You drink okra tea to reduce blood sugar levels (mean = 1.95). Furthermore, among the behavioral items with low scores for using herbs for self-care was item 2: You use cinnamon herb to reduce blood sugar levels (mean = 1.84), as shown in Table **1**.

The results using Pearson's correlation coefficient analysis showed that health literacy was statistically positively correlated with herbal-use behavior in glycemic control (r = 0.944) and HbA1c. (r = -0.677); while herbal-use behavior in glycemic control was negatively correlated with HbA1c (r = -0.625, p < 0.01). Moreover, the researcher analyzed correlations separately among people with diabetes and without diabetes, as shown in Table **2**.

The analysis of the relationship between personal factors and herbal-use behavior in glycemic control revealed that factors including minority groups, age, income sufficiency, occupation, and congenital disease were found to be statistically significantly associated with herbal-use behavior in controlling blood sugar levels at $p < 0.05$. In the analysis of the relationship between personal factors and HbA1c, it was found that factors including age, income adequacy, occupation, and congenital disease were statistically significantly associated with herbal-use behavior in glycemic control at $p < 0.05$, as shown in Table **3**

Linear regression analysis found that factors including minority groups, age, occupation, and health literacy were statistically significantly associated with herbal-use behavior in glycemic control ($R^2 = 0.902$, B = 0.907). Interestingly, the study found that people with underlying diseases (diabetes) were associated with HbA1c levels ($R^2 = 0.479$). Finally, factors including age, people with diabetes, and herbal-use behavior in glycemic control were associated with HbA1c levels ($R^2 = 0.423$), as shown in Table **4**.

Table 1. Number and Percentage of samples classified each item by herbs used behavior for control blood sugar levels (n=413).

No.	Items	Frequency of Herbals used Behavior				
		Never n(%)	Sometimes n(%)	Often n(%)	Every day n(%)	x-
1	You use herbs to reduce blood sugar levels	6(1.5)	77(18.6)	273(66.1)	57(13.8)	1.92
2	You use cinnamon herb to reduce blood sugar levels	9(2.2)	98(23.7)	258(62.5)	48(11.6)	1.84
3	You use garlic for cooking to reduce blood sugar levels	10(2.4)	88(21.3)	240(58.1)	75(18.2)	1.92
4	You choose herbs that were grown in the house for cooking	7(1.7)	81(19.6)	246(59.6)	79(19.1)	1.96
5	You drink okra tea to reduce blood sugar levels.	6(1.5)	83(20.1)	250(60.5)	74(17.9)	1.95
6	You take herbal medicine to reduce blood sugar levels.	4(1.0)	85(20.6)	238(57.6)	86(20.8)	1.98
7	You choose sweet taste herbs to cook instead of sugar.	4(1.0)	86(20.8)	259(62.7)	64(15.5)	1.93
8	You eat Pepper (Piper sarmentosum *Roxb*.) to reduce blood sugar levels.	3(0.7)	83(20.1)	264(63.9)	63(15.3)	1.94
9	You drink Yanang leaf juice to relieve thirsty during the day.	10(2.4)	71(17.2)	268(64.9)	64(15.5)	1.93
10	You eat fresh bitter gourd to reduce blood sugar levels.	7(1.7)	88(21.3)	255(61.7)	63(15.3)	1.91

Table 2. Analysis of the correlation relationship between Health literacy, Health Behavior and HbA1c (n=413).

Variable	Mean ± SD	Min-Max	HL	Beh	HbA1c
All participants (n=413)	-	-	-	-	-
Health literacy (HL)	26.32 ± 3.99	18.00-35.00	1	-	-
Health Behavior (Beh)	19.28 ± 3.77	12.00-29.00	0.944**	1	-
HbA1c	6.69 ± 1.28	3.99-13.80	-0.677**	-0.625**	1
Participants without DM (n=309)	-	-	-	-	-
Health literacy (HL)	26.89 ± 3.96	18.00–35.00	1	-	-
Health Behavior (Beh)	19.76 ± 3.72	12.00-28.00	0.948**	1	-
HbA1c	5.48 ± 1.14	3.99-13.80	-0.672**	-0.627**	1
Participants with DM (n=104)	-	-	-	-	-
Health literacy (HL)	24.62 ± 3.60	18.00-33.00	1	-	-
Health Behavior (Beh)	17.85 ± 3.58	12.00-29.00	0.918**	1	-
HbA1c	7.32 ± 1.45	4.50-11.90	-0.628**	-0.557**	1

Note: ** Correlation is significant at the 0.01 level (2-tailed).

Table 3. Analysis of the differences of individual factors with Health Behavior and HbA1c (n=413).

Variable		n(%)	Health Behavior		HbA1c	
			Mean ± SD	P-value	Mean ± SD	P-value
Minority groups		-	-	-	-	-
-	Indigenous	68(16.5)	18.94 ± 4.09	0.012*	6.90 ± 1.56	0.220
-	lua	105(25.4)	18.38 ± 3.54		6.74 ± 1.32	
-	Karen	50(12.1)	19.48 ± 3.62		6.41 ± 1.10	
-	Mhong	190(46.0)	19.84 ± 3.74		6.66 ± 1.19	
Gender		-	-	-	-	-
-	Male	179(43.3)	19.18 ± 3.73	0.647	6.80 ± 1.33	0.139
-	Female	234(56.7)	19.35 ± 3.81		6.61 ± 1.24	
Age (years)		-	-	-	-	-
-	≤ 39	110(26.6)	20.38 ± 3.92	<0.001*	6.36 ± 1.30	0.001*
-	40-49	93(22.5)	18.45 ± 3.75		6.80 ± 1.17	
-	50-59	90(21.8)	18.37 ± 3.54		7.07 ± 1.51	
-	≥ 60	120(29.1)	19.58 ± 3.54		6.62 ± 1.06	
Education		-	-	-	-	-
-	Illiterate	98(23.7)	19.45 ± 3.90	0.127	6.56 ± 1.09	0.130
-	Primary School	235(56.9)	18.98 ± 3.74		6.80 ± 1.34	
-	≥High School	80(19.4)	19.34 ± 3.64		6.52 ± 1.29	
Marital Status		-	-	-	-	-
-	Single/Widowed/Separated	82(19.9)	19.12 ± 3.69	0.680	6.71 ± 0.94	0.840
-	Married	331(80.1)	19.31 ± 3.80		6.68 ± 1.35	
Financial status		-	-	-	-	-
-	Insufficient	358(86.7)	19.10 ± 3.77	0.013*	6.74 ± 1.29	0.041*
-	Sufficient	55(13.3)	20.45 ± 3.64		6.36 ± 1.18	
Occupation		-	-	-	-	-
-	Farmer	292(70.7)	19.64 ± 3.77	0.008*	6.59 ± 1.15	0.044*
-	Freelance worker	90(21.8)	18.36 ±3 .73		6.94 ± 1.64	
-	Merchant	31(7.5)	18.48 ± 3.39	-	6.90 ± 1.16	-
Congenital disease		-	-	-	-	-
-	No	258(62.5)	19.74±3.71	<0.001*	6.48±1.18	<0.001*
-	Without DM	51(12.3)	19.92±3.83		6.45±0.94	
-	With DM	104(25.2)	17.85±13.58		7.32±1.45	
Eating sweet food		-	-	-	-	-
-	No	337(81.6)	19.33±3.79	0.546	6.67±1.30	0.474
-	Yes	76(18.4)	19.04±3.73		6.78±1.18	
Smoke		-	-	-	-	-
-	No	331(80.1)	19.27 ± 3.81	0.990	6.73 ±1.23	0.217
-	Yes	82(19.9)	19.28 ± 3.65		6.53 ± 1.40	
Alcohol		-	-	-	-	-
-	No	240(58.1)	19.28 ± 3.70	0.658	6.74 ± 1.33	0.218
-	Yes	173(41.9)	19.47 ± 3.98		6.57 ± 1.56	
Exercise		-	-	-	-	-
-	No	194(47.0)	19.26 ± 3.92	0.927	6.70 ± 1.31	0.895
-	Yes	219(53.0)	19.29 ± 3.65		6.68 ± 1.25	

Note: T -test, Anova * p-value < 0.05.

Table 4. Factors associated with herbs used behavior and HbA1c by linear regression.

Factors		B	SE	Beta	P-value	95% CI	VIF
Outcome: Herbs used behavior							
Minority groups (Indigenous)		**Ref.**	**-**	**-**	**-**	**-**	**-**
-	Lua	-0.642	0.207	-0.074	0.002*	-1.049 - -0.235	2.326
-	Karen	-1.076	0.231	-0.093	<0.001*	-1.531 - -0.621	1.633
-	Mhong	-0.776	0.195	-0.103	<0.001*	-1.159 - -0.394	2.697
Age (<40 years)		Ref.	-	-	-	-	-
-	40-49 years	-0.356	0.173	-0.039	0.040*	-0.696 - -0.016	1.496
-	50-59 years	-0.215	0.178	-0.024	0.228	-0.565 – 0.135	1.546
-	≥60 years	-0.095	0.178	-0.011	0.595	-0.445 – 0.256	1.877
Financial status (Sufficient)		-0.048	0.181	-0.004	0.791	-0.404 – 0.307	1.082
Occupation (Farmer)		Ref.	-	-	-	-	-
-	Freelance worker	-0.106	0.154	-0.012	0.493	-0.409 – 0.197	1.159
-	Merchant	0.626	0.238	0.044	0.009*	0.158 – 1.093	1.125
Congenital disease (No)		Ref.	-	-	-	-	-
-	Without DM	0.111	0.190	0.010	0.586	-0.262 – 0.484	1.114
-	With DM	0.207	0.150	0.024	0.168	-0.088 - 0.502	1.214
Health literacy (score)		0.907	0.016	0.960	<0.001*	-0.875 – 0.940	1.234
-		**R^2 = 0.902**					
Outcome: HbA1c							
Age (<40 years)		Ref.	-	-	-	-	-
-	40-49 years	0.064	0.134	0.021	0.630	-0.198 – 0.327	1.478
-	50-59 years	0.262	0.136	0.085	0.055	-0.005 – 0.529	1.494
-	≥60 years	0.095	0.126	0.034	0.452	-0.153 – 0.343	1.551
Financial status (Sufficient)		-0.029	0.139	-0.008	0.834	-0.303 – 0.244	0.015
Occupation (Farmer)		Ref.	-	-	-	-	-
-	Freelance worker	0.040	0.115	0.013	0.727	-0.185 – 0.265	1.060
-	Merchant	-0.121	0.182	-0.025	0.505	-0.479 – 0.236	1.089
Congenital disease (No)		Ref.	-	-	-	-	-
-	Without DM	-0.059	0.144	-0.015	0.681	-0.343 – 0.224	1.067
-	With DM	0.363	0.112	-.123	0.001*	0.143 – 0.584	1.125
Health literacy (score)		-0.203	0.013	-0.633	<0.001*	-0.227- 0.178	1.179
-		**R^2 = 0.479**					
Age (<40 years)		Ref.	-	-	-	-	-
-	40-49 years	0.043	0.141	0.014	0.763	-0.235 – 0.320	1.490
-	50-59 years	0.291	0.143	0.094	0.043*	0.009 – 0.572	1.495
-	≥60 years	0.115	0.133	0.041	0.387	-0.146 – 0.376	1.550
Financial status (Sufficient)		-0.119	0.146	-0.032	0.415	-0.406 – 0.167	1.049
Occupation (Farmer)		Ref.	-	-	-	-	-
-	Freelance worker	0.076	0.120	0.025	0.527	-0.161 – 0.313	1.057
-	Merchant	0.072	0.190	0.015	0.705	-0.302 – 0.446	1.074
Current disease (No)		Ref.	-	-	-	-	-
-	Without DM	-0.002	0.152	-0.001	0.989	-0.301 – 0.296	1.067
-	With DM	0.465	0.117	0.158	<0.001*	0.235 – 0.696	1.106

(Table 4) contd.....

Factors	B	SE	Beta	P-value	95% CI	VIF
Outcome: Herbs used behavior						
Minority groups (Indigenous)	**Ref.**	-	-	-	-	-
Herbs used behavior (score)	-0.194	0.014	-0.571	<0.001*	-0.221 - -0.167	1.148
-	**R^2 = 0.423**					

Note: B = Beta of Unstardized Coefficients, SE = Standard Error, Beta = Beta of Stardized Coefficients, CI = Confidence interval, VIF = Variance Inflation Factor.

4. DISCUSSION

Studies have shown that multiple variables are associated with herbal-use behavior in glycemic control; health literacy is especially found to be associated with herb use behavior and the level of HbA1c among ethnic minorities living in northern Thailand. When analyzing herbal-use behavior in controlling blood sugar levels, It was shown that herbal medicine helps reduce blood sugar levels among participants, followed by using herbs grown in the house for cooking. Participants used herbs, including Roselle *(Hibiscus sabdariffa Linn*) and Betal leaf *(Piper sarmentosum Roxb*) to lower blood sugar levels (mean = 1.98, 1.96, 1.95, and 1.94, respectively). This is because the properties of Thai herbs help reduce high blood sugar and high blood pressure among people with diabetes [25]. Traditional Thai herbs can be easily obtained locally, especially in households [26]. A previous study explained that Roselle helps control blood sugar levels, especially when eaten fresh and processed in food [27]. Many studies have shown that the properties of betel leaves can help reduce blood sugar and digestion [28]. Previous studies found that local herbs, such as okra, yanang leaves, and stevia, help alleviate the symptoms of illness among patients; these people are aware of the benefits and tend to have health behavior toward herbal use for health care [29]. A study tested rats with high blood sugar injected with herbal extract (Chaplu leaves) mixed with water compared to glibenclamide to reduce blood sugar. The results showed that the blood sugar level of the rats was lower for the first time of the test, and the test ran for seven consecutive days; then, the results showed the same positive results [30]. Similar to studies in the Middle East, 67.3% of participants in Nigeria used herbal medicine for healthcare [8]; North Sudan and Saudi Arabia showed the prevalence of herbal use in T2DM patients at 52% and 25.8%, respectively [31, 32].

When analyzing health literacy, the study found a statistically significant positive correlation with herbal-use behavior in glycemic control. It can be explained through the definition of health literacy, which is defined as individuals' ability to obtain, process, and comprehend health information and services to make a decision and take action [33]. Additionally, health literacy enhances a person's ability to access health services and influences self-care decisions. This indicates that individuals with high health literacy result in increased self-care behaviors [34]. Some studies have also revealed that individuals with adequate health literacy are statistically significantly associated with the use of complementary alternative medicine (CAM). Those who use CAM have more access to healthcare providers than those who do not [35]. Studies have also shown that health literacy is a predictor of CAM use among people [36].

When analyzed, the relationship between herbal-use behavior in glycemic control and HbA1c. They were found to be statistically significantly associated. This can be explained by the fact that health literacy enhances. a person's cognitive skills (thinking, making decisions, and reflecting) to choose the right and most suitable health service for themselves [37]. This is consistent with a study in northeastern Thailand that explained that cognitive skills in health literacy are associated with glycemic control, this essentially means that individuals have access to information and understand health knowledge, leading them to promote their own health [38]. A literature review showed that people with diabetes were 1.6 times more interested in using CAM for glycemic control than drug use for diabetes treatment [39, 40]. Previous studies suggest that more than 1,200 types of herbs have health benefits and efficacy for treatment, which help lower blood sugar and diabetes complications [39]. Consistent with previous studies of people with type 2 diabetes, the majority of participants preferred to use herbs after being diagnosed with DM for their treatment [41]. Furthermore, their results showed that 56.0% of T2DM patients had taken the herbs, and patients felt that their health had improved, no weakness, blood sugar level was lower, and no tingling feeling in the legs [41].

The analysis showed that ethnic groups, age, income, occupation, and underlying diseases were statistically significantly associated with herbal-use behavior in glycemic control. Previous research has shown that biological and sociocultural factors influence individuals' behaviors toward health practices [42, 43]. Previous studies have indicated that highland ethnic groups have their own food consumption behaviors, which are influenced by their cultures. Indigenous herbs are mainly used in cooking, and there is also a belief that herbs are good for health [44]. Studies in Africa have shown that two-thirds of diabetic patients use alternative therapies, such as herbal medicine, to control their glucose levels and to improve their health [8, 45]. Previous studies focused on household income and health complications of diabetes and showed that they were identified as strong predictors of herbal medicine use [45]. Some studies have found that people with prediabetes, diabetes complications, and a longer duration of diabetes were associated with increased CAM use [31]. Studies have indicated that increased age is associated with an increased choice of alternative medicine among people with diabetes [31, 8]. Interestingly, this study found that age, income, occupation, and underlying diseases were statistically significantly associated with HbA1c. This is consistent with a study that showed that HbA1c was statistically associated with BMI, age, gender, socioeconomic status, education, occupation, and income. An increase in age was also associated with continued increases in HbA1c levels [46].

When adjusted for variables, the study found that health literacy was statistically associated with herbal-use behavior,

which had a significant effect on HbA1c levels. According to Pender's theory, knowledge and cognitive behavior are predictors of a person's healthcare behavior [43]. A study in Japan found that health literacy was statistically associated with glycemic control [47]. A study in the United States found inadequate health literacy to be a factor associated with poor glycemic control [48]. Aboriginal elderly people with inadequate knowledge and communication skills hinder their access to health information, making them unable to take care of themselves in diabetes control [49]. Some studies have shown that low health literacy results in decreased self-care skills and a greater likelihood of illness leading to hospitalization [50, 51].

There are several limitations to this study. First, the study was a cross-sectional survey; therefore, the researcher was unable to show causal inferences about the associated factors of variables associated with HbA1c. Second, the study participants were ethnic minorities. Therefore, the results of the study cannot be extended to other populations. Third, our herbal-use behavior questionnaire did not specifically identify certain types of herbs; subsequent studies should further identify the types and properties of the herbs and be consistent with their context of ethnic groups. Finally, the participants of this study were a small group and required significant information. Convenience sampling was used, so bias might be included. The results of the research cannot be referenced to other population groups. In the future, qualitative research focusing on the types of herbs and health literacy should be explored in the context of cultural beliefs and traditions.

CONCLUSION

The study found an association between health literacy and herbal-use behavior, which affects HbA1c levels, among ethnic minority groups in northern Thailand. Therefore, health promotion programs about the use of herbs to help lower blood sugar levels should be organized. Health education programs among ethnic minorities should be focused on increasing health knowledge of the types and properties of herbs and herbal-use behavior to help lower blood sugar levels and understand the health effects and consequences of herbal use. Relevant government and public health agencies should support and promote policies on the use of herbal medicine as alternative healthcare that aligns with ethnic minority people's cultural context and locality to further reduce diabetes incidence among ethnic minority groups.

LIST OF ABBREVIATIONS

T2DM	=	Type 2 diabetes mellitus
HbA1c	=	Hemoglobin A1c
NCDs	=	Non-communicable diseases
HM	=	Herbal medicine
CAM	=	Complementary alternative medicine
DM	=	Diabetes mellitus
BMI	=	Body mass index

AUTHORS' CONTRIBUTIONS

M Choowanthanapakorn, N Auttama led the conceptualization of the topic focus, design study, searched were relevant literature studies, provided research materials. M Choowanthanapakorn, N Auttama, P Tonchoy, K Seangpraw developed the methods section data collection. K Seangpraw, P Ong-Artborirak, M Choowanthanapakorn, N Auttama analyzed the data. K Seangpraw, M Choowanthanapakorn, N Auttama wrote a request for funding acquisition. S Boonyathee S Kantow were investigators of the article. M Choowanthanapakorn, N Auttama wrote the initial draft of the article, organized the discussion. All authors have critically reviewed approved the final draft are responsible for the content similarity index of the manuscript.

ETHICAL APPROVAL AND PARTICIPATE

This study was by the University of Phayao Human Ethics Committee, Thailand (UP-HEC 1.2/014/65).

HUMAN AND ANIMAL RIGHTS

No animals were used in this research. All human research procedures followed were in accordance with the ethical standards of the committee responsible for human research ethics, and with the Helsinki Declaration of 1975, as revised in 2013.

CONSENT FOR PUBLICATION

A written informed consent was obtained from each participant prior to the study.

AVAILABILITY OF DATA AND MATERIALS

The data that support the findings of this study are available on request from the corresponding author [M.C].

STANDARDS OF REPORTING

COREQ guidelines were followed.

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CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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