GLYCEMIC CONTROL AND BMI AMONG ETHNIC MINORITY OLDER ADULTS IN NORTHERN THAILAND: IMPACT OF HEALTH LITERACY AND SELF-MANAGEMENT

Khanittha Pitchalard[1,2], Katemanee Moonpanane[1,3], Onnalin Singkhorn[1] and Mei-Ju Chi[2,4]

[1]School of Nursing, Mae Fah Luang University, Chiang Rai Province, Thailand; [2]International PhD Program in Gerontology and Long-Term Care, College of Nursing, Taipei Medical University, Taipei City, Taiwan; [3]Nursing Innovation Research and Resource, Mae Fah Luang University, Chiang Rai Province, Thailand; [4]School of Gerontology and Long-Term Care, College of Nursing, Taipei Medical University, Taiwan

Abstract. Type 2 diabetes mellitus imposes a disproportionate health burden on older adults of ethnic minorities in northern Thailand. These groups face a "double burden" of geographic isolation and language barrier, the latter stemming from the use of Thai in health information dissemination. The study aimed to examine the predictive relationships of health literacy (HL), diabetes distress and self-management behaviors with clinical outcomes (fasting blood sugar [FBS] and body mass index [BMI]). A cross-sectional predictive correlational study was conducted among 150 ethnic minority older adults recruited from five sub-district health-promoting hospitals in Chiang Rai Province, northern Thailand. Data were collected through face-to-face interviews using the Diabetes Self-Management Questionnaire (DSMQ) and Diabetes Distress Scale (DDS-17). Participants (66 ± 6 years of age) exhibited high vulnerability, namely 70% with no formal education and 58% obesity. Multiple linear regression models revealed that age (β = -0.296, *p*-value <0.001) and HL (β = -0.263, *p*-value = 0.001) are significant negative predictors of FBS; whereas self-management is a significant positive predictor of FBS (β = 0.169, *p*-value = 0.029), suggesting a "reactive management". Age is the sole significant negative predictor of BMI (β = -0.166, *p*-value = 0.047). HL acted as a critical determinant of glycemic control, distinct from diabetes distress. The findings indicated that public health interventions should shift from text-based directives to visual, bilingual models to overcome any language barrier.

Keywords: ethnic minority, health literacy, linguistic barrier, self-management, type 2 diabetes

Correspondence: Mei-Ju Chi, School of Gerontology and Long-Term Care, College of Nursing, Taipei Medical University, Taipei 11031, Taiwan
Tel: +886 931 131 009 E-mail: mjchi@tmu.edu.tw

INTRODUCTION

Type 2 diabetes mellitus (T2DM) represents an escalating global public health crisis, with the disease burden falling disproportionately on older adults over 60 years of age in low- and middle-income regions (Sun *et al*, 2022). In Thailand, this epidemiologic trend is particularly pronounced among ethnic minority communities in the northern provinces; the prevalence of T2DM in these populations is 16.8%, significantly higher than the 9.2% observed in the general elderly Thai population (Tamornpark *et al*, 2017). Ethnic groups, such as Akha, Karen and Lahu, the prevention of morbid complications from the general population (Lin *et al*, 2025). As the majority of national health directives and diabetes education modules are communicated in Thai - a language many elders in these communities do not speak fluently - these populations face a heightened risk of low health literacy (HL). This language barrier restricts access to essential health services and complicates the comprehension of primary health information, thereby exacerbating disparities in clinical outcomes (Apidechkul *et al*, 2022; Boonyathee *et al*, 2022; Sakboonyarat *et al*, 2023).

Optimal glycemic control remains the definitive benchmark for successful chronic T2DM management and the prevention of self-management is not merely an act of individual willpower complications (Bradley and Hsueh, 2016). However, maintaining clinical stability in older adults is frequently undermined by a triad

of disease complications, functional limitation and diabetes distress (Volčanšek *et al*, 2023). Diabetes distress is notably prevalent in this demographic group, affecting an estimated 15% - 40% of older Thai adults with T2DM (Frazão *et al*, 2023; Rony *et al*, 2024). Existing literature suggests that diabetes distress acts as a primary barrier to patients' motivation, leading to suboptimal engagement in self-management behaviors and a subsequent deterioration in physiological outcomes, specifically body mass index (BMI) and blood glucose level (Andrade *et al*, 2022).

Effective self-management, involving dietary adherence, physical activity, medication persistence, and rigorous glucose monitoring, is fundamental in interrupting the decline in health (Maina *et al*, 2023). Robust self-management correlates with improved glycemic level and reduced prevalence of retinopathy, nephropathy and diabetic foot ulcers (Pahn *et al*, 2025). Yet, for ethnic minority older adults in northern Thailand, self-management is not merely a matter of individual willpower; it is a complex cognitive challenge navigated within a landscape of cultural and communication barriers (Pitchalard *et al*, 2022). While the link between self-management deficit and poor clinical outcome is well-documented (Al-Dwaikat *et al*, 2023), the internal mechanisms driving this relationship in patients with depression remain largely unclear. Michaelsen and Esch (2023) posit that motivation for self-care of individuals with depression is contingent upon a recognized need for help, a perceived sense of benefit and an acquisition of empowerment. However, research into how these factors manifest within the cognitive constraints of linguistically isolated older adults constitutes a critical knowledge gap.

Health literacy (HL), defined as the cognitive and social capability to access, interpret and apply health information, may provide the "missing link" in this

knowledge gap. Contemporary frameworks emphasize that HL is not a static trait but a dynamic resource, which enables individuals to navigate among their specific health landscapes. High HL fosters resilience in disease management (Griffin *et al*, 2022; Claussen *et al*, 2026), whereas limited HL is a potent predictor of glycemic instability and increased risk of disease complications (Chen *et al*, 2020; Butayeva *et al*, 2023; Ren *et al*, 2025).

In our study, we hypothesized that HL acts as a "cognitive bottleneck," since without the knowledge provided by adequate HL, the deleterious effects of depression on self-management are amplified, leading to a precipitous decline in glycemic control (Limpawattana and Manjavong, 2021; Escriche-Martinez *et al*, 2025). Our primary aim was to examine the relationships among diabetes distress, health literacy, self-management behavior, and clinical outcome (fasting blood sugar and BMI) among the elderly ethnic minorities in northern Thailand. Specifically, we sought to clarify the extent to which HL and self-management behavior function as independent predictors of glycemic control, versus acting as mediating pathways through which distress and sociodemographic factors influence clinical status. The findings should provide a foundation for designing targeted, appropriate language interventions for this underserved population.

MATERIALS AND METHODS

Study design, location and participants

We employed a cross-sectional predictive correlation design to investigate the predictive relationships between diabetes distress, self-management behaviors and HL among older adults with T2DM. The reporting of our study adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines (von Elm *et al*, 2007).

We used a multi-stage sampling approach in five sub-district health-

promoting hospitals (SDHPHs) within Mae Chan and Mae Fah Luang Districts of Chiang Rai Province based on the high density of ethnic minority elderly residents in these regions (Tasak *et al*, 2023). Participants were recruited directly from the diabetes clinics in these districts. To ensure a representative distribution across the local hill tribe populations, 30 participants were recruited from each of the five SDHPHs. Inclusion criteria were: (i) clinically diagnosed T2DM for at least two years, (ii) ≥60 years of age, (iii) self-identified as belonging to an ethnic minority group; and (iv) capable of communicating in Thai or the local dialect. Exclusion criteria were (i) exhibiting signs of severe cognitive impairment (Mini-Cog score <3) (Limpawattana and Manjavong, 2021), and (ii) presenting acute diabetic complications (*eg*, ketoacidosis, retinopathy and/or severe foot wound).

The sample size for our cross-sectional study was determined using Cochran's formula for estimating a population proportion (Cochran, 1977). The expected prevalence of adequate glycemic control among older adults with T2DM was estimated at 89.0% (value = 0.89) (Bin Rakhis *et al*, 2022). Assuming a standard normal deviation (Z) of 1.96 at a 95% confidence level and a margin of error (d) of 0.05 (5%), the minimum required sample size was calculated to be 150, which was the number of recruited participants.

Tools

We employed the following tools.

1. Sociodemographic and clinical data

Data were collected on age, sex, ethnicity, and socioeconomic status via structured face-to-face interviews.

2. Primary clinical outcomes

To ensure objective accuracy of clinical outcomes, data on fasting blood sugar (FBS) and body mass index (BMI) were obtained from official medical records at the SDHPHs using the following

protocols. For FBS, the most recent laboratory result recorded within two weeks of the interview, following an 8-hour fast. Suboptimal glycemic level is defined as FBS >130 mg/dl (Diabetes Association of Thailand and the Endocrine Society of Thailand, 2023). For BMI, this was measured by trained staff using calibrated medical-grade equipment and categorized according to the WHO Asia-Pacific criteria (WHO WPRO, 2000): underweight (<18.5 kg/m²), normal (18.5-22.9 kg/m²), overweight/at-risk for obesity (23.0-24.9 kg/m²), and obese (grade I 25.0-29.9 kg/m², grade II ≥30.0 kg/m²).

3. Diabetes distress

Diabetes distress was measured using the validated Thai 17-item Diabetes Distress Scale (DDS-17) (Polonsky *et al*, 2005; Hendrieckx *et al*, 2021), which assesses emotional, regimen, physician, and interpersonal burden. Responses were scored on a 6-point Likert scale (1 = no problem to 6 = very serious problem) and averaged to yield total and domain scores, categorized as low (<2.0), moderate (2.0-2.9) or high (≥3.0) distress. The back-translated version (Thanakwang *et al*, 2014) tool demonstrated excellent internal consistency in our pilot cohort involving 30 participants who were not included in our main cohort (Cronbach's α = 0.95).

4. Health literacy (HL)

HL was assessed using a 15-item Thai tool modified from by the Health Education Division, Ministry of Public Health (MoPH) encompassing functional, interactive and critical domains (Health Education Division, 2023). Responses were scored on a 5-point Likert scale (1 = never to 5 = every time) and averaged to yield total and domain scores, categorized as low (<45 overall, <15 domain), moderate (45-59 overall, 15-19 domain) or high (≥60 overall, ≥20 domain). The tool demonstrated acceptable internal consistency in our pilot cohort (Cronbach's α = 0.75).

5. Self-management behaviors

Self-management behaviors

were evaluated using the validated Thai Diabetes Self-Management Questionnaire (DSMQ) (Thojampa and Mawn, 2017), which encompasses glucose, dietary, physical activity, and medication management domains. The tool underwent standardized forward- and back-translation procedures to ensure cross-cultural equivalence. The tool demonstrated acceptable internal consistency in our pilot cohort (Cronbach's α = 0.89).

Data collection

Data collection was conducted at the SDHPHs by a team of registered nurses and village health volunteers (VHVs) fluent in both Thai and the local language. To accommodate limited literacy, face-to-face interviews utilized a "read-aloud" technique. Questions were translated into the native language following a standardized translation protocol. All personal data were anonymized and stored on password-protected devices to ensure confidentiality.

Data analysis

Continuous variables were presented as means ± SD and categorical variables as frequencies. Bivariate associations were examined using Pearson's or Spearman's rank correlation based on normality testing. The primary hypotheses were tested using multiple linear regression to evaluate the adjusted associations among HL, self-management and depressive symptoms on the clinical outcomes of FBS and BMI. Statistical significance is accepted at value <0.05. Data were analyzed using the Statistical Package for the Social Sciences (SPSS), version 27.0 (IBM Corp, Armonk, NY).

Ethical consideration

The study protocol was approved by the Province Public Health Research Ethics Committee (Approval no. CRPPHO 059/2568) and the Taipei Medical University-Joint Institutional Review Board (Approval no. N202511006). All study procedures were conducted in strict adherence to the ethical

principles outlined in the Declaration of Helsinki. Prior written consent or a thumbprint with a witness signature was obtained from each participant.

RESULTS

Baseline characteristics and clinical profile

The final study cohort consisted of 150 ethnic minority older adults (mean ± SD age, 66 ± 6 years; 75% females) (Table 1). Socioeconomic vulnerability was assessed as high, with 70% of participants having no formal education and 61% with insufficient income. The mean duration of T2DM was 9 ± 7 years. Clinical benchmarks revealed suboptimal metabolic control, namely a mean FBS of 135 ± 25 mg/dl and 58% exceeding the glycemic target (130 mg/dl). The mean BMI was 26.3 ± 4.9 kg/m², with 58% classified as obese (Table 1).

Table 1

Sociodemographic and clinical characteristics of hill tribe participants (N = 150), Chiang Rai Province, Thailand, November 2025 - January 2026

Characteristic	Frequency* *n* (%)
Sex	
Male	38 (25)
Female	112 (75)
Average age (years), mean ± SD	66 ± 6
Age group	
60-69 years	113 (75)
70-79 years	31 (21)
≥80 years	6 (4)

Table 1 (cont)

Characteristic	Frequency* *n* (%)
Marital status	
Single/Widowed/Divorced/Separated	47 (31)
Married	103 (69)
Ethnicity	
Tai Yai	59 (39)
Lahu	33 (22)
Akha	20 (13)
Lua	16 (11)
Tai Lue	12 (8)
Mien/Yao/Lisu	10 (7)
Education	
None	105 (70)
Primary school	39 (26)
Secondary school	6 (4)
Household monthly income	
≤ THB 9,999 (insufficient)	91 (61)
≥ THB 10,000 (sufficient)	59 (39)
Average duration of diabetes (years), mean ± SD	9 ± 7
Diabetes duration	
<10 years	84 (56)
≥10 years	66 (44)
Average FBS (mg/dl), mean ± SD	135 ± 25
FBS	
<130 mg/dl	63 (42)
130-159 mg/dl	60 (40)
≥160 mg/dl	27 (18)
Average BMI (kg/m^2), mean ± SD	26.3 ± 4.9

Table 1 (cont)

Characteristic	Frequency* *n* (%)
BMI	
<18.0 kg/m^2(underweight)	8 (5)
18.0-22.9 kg/m^2 (normal)	31 (21)
23.0-24.9 kg/m^2(overweight, risk of obesity)	24 (16)
25.0-29.9 kg/m^2 (obese grade I)	57 (38)
≥30 kg/m^2 (obese grade II)	30 (20)
Comorbidity	
No	9 (6)
Yes	141 (94)
Diagnosed of having comorbidity (N = 141)	
Hyperlipidemia	118 (79)
Hypertension	107 (71)
Heart disease	16 (11)
Kidney disease	14 (9)
Diabetes medication	
No medication	2 (1)
Oral medication	133 (89)
Insulin	6 (4)
Both insulin and oral medication	9 (6)

*Unless otherwise stated

BMI: body mass index; FBS: fasting blood sugar; kg/m^2: kilograms per square meter; mg/dl: milligrams per deciliter; SD: standard deviation; THB: Thai baht (approximately THB32 = USD1)

HL, self-management and diabetes distress

The mean overall HL score was 32.45 ± 11.48. At the domain level, the mean score was 8.6 ± 5.2, 13.3 ± 4.2 and 10.5 ± 5.1 for functional, communicative/interactive and critical HL, respectively, with all domains being classified as low, with functional HL, the ability to process basic health information, having the lowest score (Table 2).

The mean diabetes self-management score was 31.8 ± 18.9. At the domain level, while foot care engagement score was highest (14.4 ± 11.4), blood glucose monitoring was critically low (0.08 ± 0.38) (Table 2).

The mean diabetes distress score (DDS-17) was low (1.3 ± 0.3), indicating little or no distress. At the domain level, the mean score was 1.7 ± 0.9, 1.1 ± 0.2, 1.3 ± 0.7, and 1.0 ± 0.1 for emotional burden, physician-related distress, regimen-related distress, and interpersonal distress, respectively. All domain scores fell within the "little or no distress" range, although emotional burden remained the most predominant domain (Table 2).

Bivariate correlations

Spearman's rank correlation analysis identified age as a central correlate of both cognitive and physiological status (Table 3). Age was significantly negatively associated with HL (ϱ = -0.237, value = 0.003) and FBS (ϱ = -0.276, value = 0.001). In contrast, we observed a positive correlation between self-management and FBS (ϱ = 0.233, value = 0.004).

Predictors of clinical outcomes

Using a multivariable regression model for FBS (R^2 = 0.162, adjusted R^2 = 0.139, model value <0.001), age (β = -0.296, value <0.001) and HL (β = -0.263, value = 0.001) emerged as the strongest independent predictors (Table 4). Self-management is also a significant predictor (β = 0.169, value = 0.029), whereas diabetes distress is not associated with glycemic levels (value = 0.173).

Table 2

Health literacy, diabetes self-management and diabetes distress scores of hill tribe participants (N = 150), Chiang Rai province, Thailand, November 2025 – January 2026

Category	Mean ± SD	Health literacy level, *n* (%)		
		Low	Moderate	High
Health literacy score				
Functional	8.6 ± 5.2	128 (85)	18 (12)	4 (3)
Communicative/interactive	13.3 ± 4.2	92 (61)	46 (31)	12 (8)
Critical	10.5 ± 5.1	110 (73)	32 (22)	8 (5)
Total	32.4 ± 11.5	124 (83)	23 (15)	3 (2)
Diabetes self-management score				
Diet	13.0 ± 7.6	81 (54)	23 (15)	46 (31)
Exercise	4.3 ± 5.5	99 (66)	11 (7)	40 (27)
Blood glucose monitoring	0.1 ± 0.4	149 (99)	1 (1)	0 (0)
Foot care	14.4 ± 11.4	75 (50)	17 (11)	58 (39)
Total	31.8 ± 18.9	101 (67)	31 (21)	18 (12)

Table 2 (cont)

Category	Mean ± SD	Health literacy level, *n* (%)		
		Low	Moderate	High
Diabetes distress score				
Emotional burden	1.7 ± 0.9	104 (69)	24 (16)	22 (15)
Physician-related distress	1.1 ± 0.2	147 (98)	3 (2)	0 (0)
Regimen-related distress	1.3 ± 0.7	135 (90)	10 (7)	5 (3)
Interpersonal distress	1.0 ± 0.1	149 (99)	1 (1)	0 (0)
Total	5.1 ± 1.9	142 (95)	8 (5)	0 (0)

Diabetes distress scale -17 classification: <2.0 = little or no distress; 2.0-2.9 = moderate; ≥3.0 = high

Diabetes self-management total score classification: <42.0 = low; 42.0-55.9 = moderate; ≥56.0 = high

Health literacy total score classification: <45.0 = low; 45.0-59.9 = moderate; ≥60 = high

Domain classification: <15.0 = low; 15.0-19.9 = moderate; ≥20.0 = high

SD: standard deviation

Table 3

Spearman's rank correlation coefficients among age, body mass index, health literacy, self-management, diabetes distress, and fasting blood sugar

Variable	Spearman's rank correlation coefficient between variables (*p*-value)					
	Age	BMI	HL	DSMS	DDS	FBS
Age	1.000					
BMI	-0.175 (0.032)*	1.000				
HL	-0.237 (0.003)†	-0.077 (0.351)	1.000			
DSMS	0.030 (0.719)	-0.053 (0.518)	0.100 (0.223)	1.000		
DDS	-0.087 (0.292)	0.129 (0.117)	-0.043 (0.599)	-0.069 (0.402)	1.000	
FBS	-0.276 (0.001)†	0.075 (0.361)	-0.134 (0.101)	0.233 (0.004)†	0.160 (0.050)	1.000

*Significant *p*-value <0.05 (2-tailed); †significant *p*-value <0.01 level (2-tailed)

BMI: body mass index; DDS: diabetes distress score; DSMS: diabetes self-management score; FBS: fasting blood sugar; HL: health literacy

Applying the multivariable regression model for BMI (R^2 = 0.054, adjusted R^2 = 0.028, model value = 0.087), age is again the sole significant independent predictor (β = -0.166, value = 0.047), with HL, self-management and diabetes distress showing no significant associations with BMI (Table 4).

DISCUSSION

Our identification of HL as a significant independent predictor of glycemic control reinforces Nutbeam's framework, which positions health literacy as a critical asset for enhancing health behaviors (Griffin *et al*, 2022). However, our findings contrast with previous studies among the urban Thai population, which typically report higher functional health literacy scores (Suksatan *et al*, 2021). The differences observed in our study with those of Suksatan *et al* (2021) suggest that for hill tribe ethnic minority older adults, the healthcare system's reliance on the Thai language may present a significant barrier to the transfer of health information (Bradley and Hsueh, 2016; Volčanšek *et al*, 2023). While older patients may possess high motivation, the language difference may hinder the translation of information into effective disease management (Truong and Fenton, 2022). Consequently, health literacy in this context is a potential determinant of health equity, as language barriers significantly impede the transfer of clinical instructions for health improvement in minority groups (Al Shamsi *et al*, 2020).

Age emerged as a robust predictor of both FBS and BMI; however, the negative direction of this relationship suggests a "double vulnerability" rather than a successful regulation. This likely reflects age-related physiological shifts or the "obesity paradox", where the older patients experience unintentional weight loss and reduced metabolic reserves associated with frailty (Henney *et al*, 2025). This physiological decline is potentially compounded by attrition in health literacy with

Table 4

Spearman's rank correlation coefficients among age, body mass index, health literacy, self-management, diabetes distress, and fasting blood sugar

Outcome	Predictor	B	SE	β	t	*p*-value	95% CI for B	R^2	Adj R^2	Model *p*-value*
FBS	Age	-1.191	0.314	-0.296	-3.79	<0.001	-1.812 - -0.570	0.162	0.139	<0.001
	HL	-0.580	0.173	-0.263	-3.35	0.001	-0.922 - -0.238			
	DSMS	0.226	0.102	0.169	2.21	0.029	0.024 - 0.429			
	DDS	7.894	5.759	0.105	1.37	0.173	-3.488 - 19.276			
BMI	Age	-0.130	0.065	-0.166	-2.00	0.047	-0.259 - -0.002	0.054	0.028	0.087
	HL	-0.055	0.036	-0.129	-1.55	0.124	-0.126 - 0.015			
	DSMS	-0.015	0.021	-0.058	-0.72	0.475	-0.057 - 0.027			
	DDS	1.597	1.195	0.108	1.34	0.183	-0.764 - 3.958			

Enter method; two-tailed tests

*Overall regression model

Adj R^2: adjusted coefficient of determination; B: unstandardized coefficient; BMI: body mass index; CI: confidence interval; DDS: diabetes distress score; DSMS: diabetes self-management score; FBS: fasting blood sugar; HL: health literacy; R^2: coefficient of determination; SE: standard error; t: t statistics; β: standardized coefficient

age. Hill tribe ethnic minority older adults face overlapping challenges, such as age-related cognitive decline, limited formal education and a lack of understanding of the digital media that restricts access to modern means of communication (including health-related topics) (Oosman *et al*, 2021; Kim *et al*, 2025). Older adults may experience lower confidence in interpreting complex medical information and identifying medical misinformation (Xie *et al*, 2022; Chaimongkon *et al*, 2025; Wu *et al*, 2025). This convergence of physiological frailty and low literacy potentially leaves older adults with fewer resources for effective self-management.

Nevertheless, the positive correlation we observed between diabetes self-management and FBS suggests a phenomenon termed "reactive management", where, in high-risk, low-literacy settings, patients may intensify self-care efforts, such as dietary restriction, after experiencing symptoms of hyperglycemia. This interpretation is supported by the limited access to blood glucose monitoring, which prevents real-time physiological feedback (Gomes and Romão, 2025). However, due to the cross-sectional design of our study, temporal effects cannot be established. It is equally possible that individuals with poorer glycemic control increased their self-management efforts in response to their clinical status, or that self-reported data introduced measurement bias. Regardless of the reasons, our findings suggest that current self-management efforts are not related to the optimal clinical outcomes in this population.

Notably, the multivariable regression modelling provided explanatory factors, which indicated that HL and self-management were partial contributors rather than explainers of metabolic health. The lack of association between diabetes distress and FBS may be attributed to low average distress levels or limited variability in the scores among our enrolled participants.

Furthermore, HL and self-management are not significantly

associated with BMI. This suggests that BMI values in the older ethnic minority adults may be influenced more heavily by long-term lifestyle factors, genetics and/or chronic nutritional patterns than by current literacy levels or daily self-care behaviors. As noted in the systematic review by Xie *et al* (2022), while HL influences health-related behaviors, its direct impact on long-term physiological markers is often attenuated by broader environmental and biological determinants. These findings emphasized the need for multi-factorial interventions that address the social and structural determinants of health beyond individual literacy.

These findings suggest a need to transition from traditional biomedical models to literacy-sensitive self-management frameworks in geriatric nursing (Schaffler *et al*, 2018; Alfaraj *et al*, 2025). For ethnic minority older adults, standard health education materials often present significant comprehension challenges due to differences in language. Clinical interventions should, therefore, move towards multimodal supportive models, including visual aids, bilingual resources and community-led initiatives, which align with the patients' existing linguistic and cognitive capacities. Replacing text-heavy directives with culturally tailored pictograms and integrating health literacy assessments into routine clinical screenings may help mitigate linguistic barriers. Such adaptations can transition self-management from a difficult-to-attain benchmark to a more accessible clinical goal for this underserved population (Wang *et al*, 2025).

Several methodological limitations need to be considered when interpreting these findings. Firstly, the cross-sectional design precludes the determination of causal relationships or temporal directionality among health literacy, self-management, diabetes distress, and metabolic outcomes. Secondly, the relatively small sample size and participants' recruitment from

limited geographic areas within northern Thailand may restrict the generalization of our results to the broader ethnic minority populations. Thirdly, our reliance on self-reported behavioral measures introduces the potential for recall and social desirability biases. And fourthly, while rigorous linguistic adaptation protocols were employed, translating and administering standardized psychometric instruments across multiple regional dialects present inherent challenges in maintaining strict cross-cultural equivalence. Future longitudinal studies utilizing larger, multi-regional cohorts are required to validate and extend our findings.

In conclusion, our study identified age, health literacy (HL) and self-management as the key interrelated factors influencing glycemic control among hill tribe ethnic minority older adults in Chiang Rai Province, northern Thailand. The elderly individuals in these communities might be at an increased risk for suboptimal metabolic outcomes, as their abilities to navigate through the healthcare system were often complicated by both age-related health problems and linguistic barriers. Achieving health equity in diabetes care for these groups requires a shift in approach that addresses the structural and communication barriers that prevent effective implementation of medical advice to the vulnerable older adults. Future intervention programs should prioritize linguistically accessible and culturally-based approaches to support health actions in the care of all geriatric ethnic minority groups in northern Thailand.

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CONFLICT OF INTEREST DISCLOSURE

The authors declare no conflict of interest.

REFERENCES

Al Shamsi H, Almutairi AG, Al Mashrafi S, Al Kalbani T. Implications of language barriers for healthcare: a systematic review. *Oman Med J* 2020; 35(2): e122.

Al-Dwaikat TN, Ali AM, Khatatbeh H. Self-management social support in type 2 diabetes mellitus: a concept analysis. *Nurs Forum* 2023; 2023: 1753982.

Alfaraj SA, Vos RC, Spruit M, Groenwold RHH, Mook-Kanamori D. Towards personalized diabetes management: Identifying stability for efficient care using primary care data. *J Med Surg Public Health* 2025; 7: 100218.

Andrade DMB, Rocha RM, Ribeiro ÍJS. Depressive symptoms among older adults with diabetes mellitus: a cross-sectional study. *Sao Paulo Med J* 2022; 141(4): e2021771.

Apidechkul T, Chomchiei C, Upala P, Tamornpark R. Epidemiology of prediabetes mellitus among hill tribe adults in Thailand. *PLoS One* 2022; 17(7): e0271900.

Bin Rakhis SA Sr, AlDuwayhis NM, Aleid N, AlBarrak AN, Aloraini AA. Glycemic control for type 2 diabetes mellitus patients: a systematic review. *Cureus* 2022; 14(6): e26180.

Boonyathee S, Ong-Artborirak P, Seangpraw K, *et al*. Health behavior, level of hemoglobin A1c, and quality of life among agricultural workers of various ethnicities in Thai border communities. *Front Med (Lausanne)* 2022; 9: 796955.

Bradley D, Hsueh W. Type 2 diabetes in the elderly: challenges in a unique patient population. *J Geriatr Med Gerontol* 2016; 2(2): 14.

Butayeva J, Ratan ZA, Downie S, Hosseinzadeh H. The impact of health literacy interventions on glycemic control and self-management outcomes among type 2 diabetes mellitus: a systematic review. *J Diabetes* 2023; 15(9): 724-35.

Chaimongkon S, Sakulwattana W, Ong-Artborirak P, Liyanage E, Seangpraw K. Health literacy and behaviors of patients and caregivers related to glycemic control among individuals with type 2 diabetes in Chiang Mai Province, Thailand. *Patient Prefer Adherence* 2025; 19: 753-65.

Chen AMH, Yehle KS, Plake KS, *et*

al. The role of health literacy, depression, disease knowledge, and self-efficacy in self-care among adults with heart failure: an updated model. *Heart Lung* 2020; 49(6): 702-8.

Claussen C, Papadimos E, Magliano DJ, *et al*. Prevalence of type 2 diabetes among global Indigenous adult populations: a systematic review. *Diabetologia* 2026; 69(3): 582-99.

Cochran WG. Sampling Techniques. 3rd ed. New York, NY: John Wiley & Sons; 1977.

Diabetes Association of Thailand and the Endocrine Society of Thailand. Clinical practice guideline for diabetes, 2023 [cited 2025 Jul 03]. Available from: URL: https://thaipedendo.org/clinical-practice-guideline-for-diabetes-2023/ [in Thai]

Escriche-Martinez S, Diaz-Orueta U, Gala-Serra C, Sierra-Martínez E, López-Crespo G, López-Antón R. Cognitive decline in hospitalized older adults: a scoping review. *Psychogeriatrics* 2025; 25(6): e70102.

Frazão MCLO, Viana LRdC, Ferreira GRS, *et al*. Correlation between symptoms of depression, attitude, and self-care in elderly with type 2 diabetes. *Rev Bras Enferm* 2023; 76(3): e20220741.

Gomes J, Romão M. Evaluating maturity models in healthcare information systems: a comprehensive review. *Healthcare (Basel)* 2025; 13(15): 1847.

Griffin G, Ali M, Nau SZ, Riggs E, Dantas JAR. Accessing and navigating healthcare: a scoping review of the experiences of women of refugee background from Myanmar. *Health Soc Care Community* 2022; 30(6): e3459-76.

Health Education Division. Health literacy assessment tool, 2023 [cited 2025 Jul 03]. Available from: URL: https://hed.hss.moph.go.th/wp-content/uploads/2024/06/เครื่องมือสำหรับวัยสูงอายุในหมู่บ้านปรับเปลี่ยนพฤติกรรมสุขภาพ.zip [in Thai]

Hendrieckx C, Halliday JA, Beeney LJ, Speight J. Diabetes and emotional health: a practical guide for health professionals supporting adults with type 1 and type 2 diabetes, 2021 [cited 2026 Jan 13]. Available from: URL: https://diabetes.org/sites/default/files/media/ada_mental_health_workbook_r4.pdf

Henney AE, Wilding JPH, Alam U, Cuthbertson DJ. Obesity

pharmacotherapy in older adults: a narrative review of evidence. *Int J Obes* 2025; 49(3): 369-80.

Kim S, Hwang S, Lee J, Choi M. Health literacy disparities in South Korea: insights from a latent profile analysis. *BMC Public Health* 2025; 25(1): 1830.

Limpawattana P, Manjavong M. The Mini-Cog, Clock Drawing Test, and Three-Item Recall Test: rapid cognitive screening tools with comparable performance in detecting mild NCD in older patients. *Geriatrics (Basel)* 2021; 6(3): 91.

Lin L, Chen P, Zhang Y, *et al*. Burden of type 2 diabetes mellitus and risk factor attribution among older adults: a global, regional, and national analysis from 1990 to 2021, with projections up to 2040. *Diabetes Obes Metab* 2025; 27(8): 4330-43.

Maina PM, Pienaar M, Reid M. Self-management practices for preventing complications of type II diabetes mellitus in low and middle-income countries: a scoping review. *Int J Nurs Stud Adv* 2023; 5: 100136.

Michaelsen MM, Esch T. Understanding health behavior change by motivation and reward mechanisms: a review of the literature. *Front Behav Neurosci* 2023; 17: 1151918.

Oosman S, Nisbet C, Smith L, Abonyi S. Health promotion interventions supporting Indigenous healthy ageing: a scoping review. *Int J Circumpolar Health* 2021; 80(1): 1950391.

Pahn J, Yang Y, Kim SH. Factors influencing self-management and health-related quality of life in low-income patients with diabetes: a predictive model. *IJNS Advances* 2025; 8: 100349.

Pitchalard K, Wimolphan P, Singkhon O, Agazio JBG, Moonpanane K. "Life is Bitter and Sweet": The lived experience of ethnic minority elders with type 2 diabetes mellitus in rural, Thailand. *Asian Nurs Res* 2022; 16(3): 155-61.

Polonsky WH, Fisher L, Earles J, *et al*. Assessing psychosocial distress in diabetes: development of the diabetes distress scale. *Diabetes Care* 2005; 28(3): 626-31.

Ren J, Zhu Y, Lin J, Fang J, Huang R. Exploring the mechanism of self-management: the role of social

support, self-efficacy, and health literacy based on meta-analytic structural equation modeling. *BMC Public Health* 2025; 26(1): 128.

Rony MKK, Parvin MR, Wahiduzzaman M, Akter K, Ullah M. Challenges and advancements in the health-related quality of life of older people. *Adv Public Health* 2024; 2024: 8839631.

Sakboonyarat B, Sangkool T, Poovieng J, *et al*. Trends in the prevalence of type 2 diabetes among Royal Thai Army personnel and associated factors from 2017 to 2021. *J Southeast Asian Med Res* 2023; 7: e0160.

Schaffler J, Leung K, Tremblay S, *et al*. The effectiveness of self-management interventions for individuals with low health literacy and/or low income: a descriptive systematic review. *J Gen Intern Med* 2018; 33(4): 510-23.

Suksatan W, Prabsangob K, Choompunuch B. Association between health literacy, self-care behavior, and blood sugar level among older patients with type 2 diabetes in rural Thai communities. *Ann Geriatr Med Res* 2021; 25(4): 318-23.

Sun H, Saeedi P, Karuranga S, *et al*. IDF Diabetes Atlas: Global, regional and country-level diabetes prevalence estimates for 2021 and projections for 2045. *Diabetes Res Clin Pract* 2022; 183: 109119.

Tamornpark R, Apidechkul T, Upala P, Inta C. Factors associated with type 2 diabetes mellitus among the elderly hill tribe population in Thailand. *Southeast Asian J Trop Med Public Health* 2017; 48(5): 1072-82.

Tasak N, Apidechkul T, Law ACK, *et al*. Prevalence of and factors associated with scrub typhus exposure among the hill tribe population living in high incidence areas in Thailand: a cross-sectional study. *BMC Public Health* 2023; 23(1): 2394.

Thanakwang K, Thinganjana W, Konggumnerd R. Psychometric properties of the Thai version of the Diabetes Distress Scale in diabetic seniors. *Clin Interv Aging* 2014; 9: 1353-61.

Thojampa S, Mawn B. Psychometric evaluation of the Thai translation of the Diabetes Self-management Questionnaire in type 2 diabetes.

Int J Nurs Sci 2017; 4(3): 236-8.

Truong M, Fenton SH. Understanding the current landscape of health literacy interventions within health systems. *Perspect Health Inf Manag* 2022; 19(Spring): 1h.

Volčanšek Š, Lunder M, Janež A. Health-related quality of life assessment in older patients with type 1 and type 2 diabetes. *Healthcare (Basel)* 2023; 11(15): 2154.

von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP; STROBE Initiative. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. *Lancet* 2007; 370(9596): 1453-7.

Wang X, Si J, Li Y, *et al*. Effectiveness and safety of AI-driven closed-loop systems in diabetes management: a systematic review and meta-analysis. *Diabetol Metab Syndr* 2025; 17(1): 238.

World Health Organization Western Pacific Region (WHO WPRO). The Asia-Pacific perspective: redefining obesity and its treatment, 2000 [cited 2025 Jul 03]. Available from: URL: https://iris.who.int/bitstreams/53228dc6-9520-421b-b5a2-f826967090cb/download

Wu K, Qi X, Li A, Dong H, Wang X, Ji M. Association of health information literacy and health outcomes among individuals with type 2 diabetes and metabolic syndrome. *Nurs Rep* 2025; 15(3): 90.

Xie L, Zhang S, Xin M, Zhu M, Lu W, Mo PK. Electronic health literacy and health-related outcomes among older adults: a systematic review. *Prev Med* 2022; 157: 106997.