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Herbal and Dietary Supplement Use among Patients with Type 2 Diabetes Mellitus (T2DM) from a Rural Region in Malaysia: A Cross-Sectional Study

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ABSTRACT

Background: Herbal and dietary supplements (HDS) are commonly used for diabetes management and health maintenance due to their perceived safety and benefits. However, HDS can have potential adverse effects, and data on their use among rural communities in Malaysia are limited. **Objective:** This study explores the prevalence, associated factors, and disclosure rates of HDS use among diabetic patients in a rural region of Malaysia. **Methods:** A multicentre cross-sectional survey of Type-2 Diabetes Mellitus (T2DM) patients was conducted in seven healthcare facilities located in Hulu Selangor, Malaysia. Data were collected from randomly sampled patients using an interviewer-administered questionnaire and from patient medical records. Logistic regression analyses examined the association between HDS use in general and for diabetes management with various patient characteristics. **Results:** A total of 273 patients responded to the survey. 34.8% of patients reported HDS use in the past month, while 13.5% of patients attributed the use of HDS to T2DM management. The most common form of HDS used for diabetes was *Momordica charantia* (14%), followed by functional beverages (12%). 16% of these identified HDS were either unknown to patients or were unregistered products. Indian patients were significantly less likely to consume HDS compared to Malay patients. The odds of HDS consumption increased by 62.7% with each higher income bracket and by 45.2% with higher physical activity levels. Patients with secondary education or higher were more than twice as likely to use HDS for diabetes management. Less than 17% of patients disclosed the use of HDS to healthcare professionals. **Conclusion:** The use of HDS among T2DM patients in the studied rural region is slightly lower but broadly comparable to that reported in more developed settings. Efforts to educate patients on safe HDS use while optimising its disclosure to healthcare providers are crucial to prevent adverse events or compromised therapy.

INTRODUCTION

Type 2 Diabetes Mellitus (T2DM) is the most common form of diabetes globally, afflicting over 463 million people worldwide [1]. It is also one of the most prevalent non-communicable diseases in Malaysia, with relative prevalence rates increasing by 39.3% from 11.2% in 2011 to 15.6 % in 2023 [2]. Current statistics estimate that about 3.6 million Malaysians above the age of 18 are suffering from T2DM.

While many pharmacological treatment options exist for diabetes, some patients use herbal and dietary supplements (HDS) as an adjunct in the management of diabetes. HDS is a type of complementary and alternative medicine (CAM) that includes products with plant-derived materials, dietary ingredients, and traditional herbal medications from various ethnicities in Malaysia, such as Malay, Chinese, Indian, and Indigenous groups, and is widely used due to its accessibility and availability over the counter [3-7].

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HDS is widely accepted for health maintenance and disease management, particularly among patients with diabetes [8, 9]. In the National Health & Morbidity Survey 2015 (NHMS 2015), Malaysian patients with diabetes have been reported using TCM for better disease control and fewer side effects from conventional medication [10]. Local studies revealed that 44.7% of patients with diabetes attributed their very good health status to HDS use, while 80% of respondents in a similar study found HDS somewhat effective, and 35% perceived it as very effective [11, 12].

However, the concurrent use of HDS and conventional medication can lead to possible compliance issues whilst posing risks of supplement-drug interactions that could result in adverse events. CAM users tend to be 6.16 times less compliant with prescribed anti-diabetic medication than non-CAM users [6], and a significant number of patients fail to inform healthcare professionals about their HDS use [5, 13, 14].

Rural areas show higher usage of alternative treatments, including HDS. In both the US and Australia, rural populations exhibit significantly higher rates of HDS use and self-prescribed supplement use compared to their urban counterparts [15, 16].

Given the potential for supplement-drug interactions and the high prevalence of HDS use in rural areas, there is a need to better understand HDS usage patterns among patients with T2DM and their disclosure practices with healthcare professionals. However, published research on HDS use among Malaysia's rural population remains limited. Locally conducted studies tend to focus on general CAM use with limited attention to rural dwellings [3, 11, 17]. Therefore, the primary objective of this study is to determine the prevalence and factors associated with the active use of HDS among Malaysian patients with T2DM living in a rural region, with active use defined as consumption of HDS within the past month. This study also attempts to investigate patients' expenditure to purchase HDS, sources of acquisition, and disclosure rates for its use to attending healthcare professionals as secondary objectives.

METHODS

Study design and setting

A cross-sectional survey of patients with T2DM registered in Kuala Kubu Bharu Hospital, a district public hospital, and six public health clinics, namely Serendah Polyclinic, Selisik Polyclinic, Kalumpang Polyclinic, Ulu Yam Bharu Polyclinic, Soeharto Polyclinic, and Rasa Polyclinic, was conducted from April 2018 to December 2018. All these public health facilities are in the Hulu Selangor district of Selangor, a state located on the west coast of Malaysia. It has the second lowest population density (140 people per km^2) [18] in the state and has a rural population of 64,640 individuals, which represents the largest share (22%) of the total rural population in Selangor, which is predominantly Bumiputera (74.9%), with a significant minority of Indian (13.3%) and Chinese (11.3%) [18]. Most of the polyclinics operate in district subdivisions classified as rural based on population size as stipulated in the Population and Housing Census of Malaysia 2020 [19]. While the hospital and Serendah Polyclinic are in sub-districts that surpass the rural threshold, the population demographics of these two study sites are unlikely to differ much from other clinics, especially since 19 out of the 25 sub-districts (76%) can be classified as rural regions [18, 19], and the hospital remains the sole secondary care facility available in the region [18]. Thus, patients recruited from these sites will also be assumed to be from a rural locality.

Study participants

Registered Malaysian patients with T2DM who are at least 18 years old and currently residing in the Hulu Selangor region were eligible for this study. Patients who were unable to communicate, cannot give consent, or were pregnant were excluded.

Sample size and sampling procedure

Based on the prevalence of HDS use in local studies, which was approximately 77% [4, 5], together with a precision of 5% and a 95% confidence interval, an estimated sample size of 273 participants was required. After accounting for a 10% non-responder rate, we attempted to recruit 304 participants. A list of active patients with T2DM currently receiving treatment in Hulu Selangor was obtained from the Selangor State Health Department, and each patient was assigned a running number from which 304 numbers were randomly selected.

These patients were then approached by trained interviewers whilst waiting to collect their medications at the pharmacy. They were given explanations regarding the nature and methodology of this study and were allowed to pose any questions before deciding to participate. When a language barrier prevented patients from full participation, family members or a suitable language translator were allowed to answer on behalf of the patient.

Informed consent was then obtained from patients who agreed to participate before a 15–20-minute face-to-face interview was conducted. Participants were assigned identification numbers to avoid capturing personal identifiers and to preserve their anonymity.

Data Collection

Patient's data were collected using two questionnaires. The first questionnaire was adapted and modified from three previously developed surveys on CAM/HDS use: a primary care survey developed by Kuo GM et al., which provided a foundational template for multiethnic patient survey design; a Malaysian primary care survey by Ching SM et al., and a tertiary hospital survey at Hospital Pulau Pinang by Saw JT et

Table I: Socio-demographic and lifestyle characteristics of the study population and their association with HDS use

Characteristics	Overall (n=273)	Active HDS users (n=95)	Non-active HDS users (n=178)	p-value	Active HDS user for DM (n=38)	Non active HDS user for DM	p-value
Age (years) (n=273), (mean±SD)	58.92 (± 10.29)	58.76 (±10.35)	59.00(±10.28)	0.8535	56.03 (±9.60)	59.38 (±10.34)	0.0619
Weight (kg) (n=272), median (IQR)	68.5 (60.0 – 78.0)	67.0 (62.0-77.0)	69.0 (60.0-78.0)	0.999	70.0 (65.0 – 78.0)	68.0 (60.0-78.0)	0.433
Gender (n=273), n (%)							
Male	102 (37.36%)	35 (36.84%)	67 (37.64%)	0.897	13 (34.21%)	89 (37.87%)	0.665
Female	171 (62.64%)	60 (63.16%)	111 (62.36%)		25 (65.79%)	146 (62.13%)	
Marital status (n=273), n (%)							
Single	9 (3.30%)	4 (4.21%)	5 (2.81%)	0.553	1 (2.63%)	8 (3.40%)	0.524
Married	233 (85.35%)	83 (87.37%)	150 (84.27%)		32 (84.21%)	201 (85.53%)	
Divorce	2 (0.73)	1 (1.05%)	1 (0.56%)		1 (2.63%)	1 (0.43%)	
Widow	29 (10.62%)	7 (7.37%)	22 (12.36%)		4 (10.53%)	25 (10.64%)	
Ethnicity (n=273), n (%)							
Malay	167 (61.17%)	62 (65.26)	105 (58.99)	0.027	29 (76.32)	138 (58.72%)	0.117
Chinese	43 (15.75%)	19 (20.00)	24 (13.48)		3 (7.89)	40 (17.02))	
Indian	60 (21.98%)	12 (12.63)	48 (26.97)		5 (13.16)	55 (23.40)	
Other	3 (1.10%)	2 (2.11)	1 (0.56)		1 (2.63)	2 (0.85)	
Monthly salary (RM), (n = 245), n (%)							
< 1,500	153 (62.45%)	48 (53.33%)	105 (67.74%)	0.035	20 (54.05%)	133 (63.94%)	0.207
1,500 – 4,000	77 (31.43%)	32 (35.56)	45 (29.03%)		13 (35.14%)	64 (30.77%)	
4,000-9,000	11 (4.49%)	7 (7.78%)	4 (2.58%)		2 (5.41%)	9 (4.33%)	
> 9,000	4 (1.63%)	3 (3.33%)	1 (0.65%)		2(5.41%)	2 (0.96%)	
Education level (n=272), n (%)							
No education	28 (10.29%)	8 (8.42%)	20 (11.30%)	0.419	2 (5.26%)	26 (11.11%)	0.079
Primary	102 (37.5%)	32 (33.68%)	70 (39.55%)		9 (23.68%)	93 (39.74)	
Secondary	121 (44.49%)	45 (47.37%)	76 (42.94%)		24 (63.16%)	97 (41.45%)	
Tertiary	21 (7.72%)	10 (10.53%)	11 (6.21%)		3 (7.89%)	18 (7.69%)	
Length of diagnosis for diabetes (years); Median (IQR) (n = 273)	(5 – 15)	8 (5 – 13)	8 (5 – 15)	0.9038	8 (5 – 13)	8 (5 – 15)	0.5921

Table I: Socio-demographic and lifestyle characteristics of the study population and their association with HDS use (continued)

Characteristics	Overall (n=273)	Active HDS users (n=95)	Non-active HDS users (n=178)	p-value	Active HDS user for DM (n=38)	Non active HDS user for DM	p-value
Diabetic family history (n=273), n (%)							
Yes	167 (61.17%)	62 (65.26%)	105 (58.99%)	0.585	26 (68.42%)	141 (60.00%)	0.613
No	88 (32.23%)	27 (28.42%)	61 (34.27%)		10 (26.32%)	78 (33.19%)	
Not sure	18 (6.59%)	6 (6.32)	12 (6.74%)		2 (5.26%)	16 (6.81%)	
Smoking status (n=273), n (%)							
Yes	29 (10.62%)	10 (10.53%)	19 (10.67%)	0.970	3 (7.89%)	26 (11.06%)	0.556
No	244 (89.38)	85 (89.47%)	159 (89.33%)		35 (92.11%)	209 (88.94)	
Smoking history if currently not smoking (n=243), n (%)							
Yes	22 (9.05%)	6 (7.06%)	16 (10.13%)	0.713	3 (8.57)	19 (9.13%)	0.914
No	221 (90.95%)	79 (92.94%)	142 (89.87%)		32 (91.43%)	189 (90.87%)	
Alcohol consumption status (n=273), n (%)							
Yes	19 (6.96%)	7 (7.37%)	12 (6.74%)	0.846	1 (2.63%)	18 (7.66%)	0.258
No	254 (93.04%)	88 (92.63%)	166 (93.26%)		37 (97.37%)	217 (92.34%)	
Alcohol consumption history if currently not drinking (n=254), n (%)							
Yes	18 (7.09%)	6 (6.82%)	12 (7.23%)	0.903	2 (5.41%)	16 (7.37%)	0.666
No	236 (92.91%)	82 (93.18%)	154 (92.77%)		35 (94.59%)	201 (92.63%)	
Physical activity (n=273), n (%)							
Low	70 (25.64%)	19 (20.00%)	51 (28.65%)	0.048	9 (23.68%)	61 (25.96%)	0.517
Moderate	67 (24.54%)	19 (20.00%)	48 (26.97%)		7 (18.42%)	60 (25.53%)	
High	136 (49.82%)	57 (60.00%)	79 (44.38%)		22 (57.89%)	114 (48.51%)	
Insulin therapy (n=273), n (%)							
Yes	114 (41.76%)	36 (37.89%)	78 (43.82%)	0.344	17 (44.74%)	97 (41.28%)	0.688
No	159 (58.24%)	59 (62.11%)	100 (56.18%)		21 (55.26%)	138 (58.72%)	

DM, Diabetes Mellitus; HDS, Herbal and dietary supplement; IQR, Interquartile range; RM, Ringgit Malaysia; SD, Standard deviation.
p-value is based on Chi Square, t-test, or Mann-Whitney test to measure association between active and nonactive users of HDS in general and for DM management. The p-value is considered significant at $p < 0.05$

al., both of which comprehensively informed locally relevant attitudes and reasons for use among Malaysian diabetics, expenditure patterns, and predictors of use, thereby ensuring the questionnaire's applicability to local disease and cultural patterns [3, 13, 20]. The questionnaire was then translated into the Malay language for use in our Malay majority constituency and was validated by three subject experts to ensure that the questionnaire was suitable for local use. The questionnaire was pilot tested with 35 individuals. Pilot test data were not included in the final data analysis.

The final version of the questionnaire is divided into four domains: socio-demographic characteristics, disease and family medical history, lifestyle (smoking habits and alcohol consumption), and HDS use.

The second questionnaire is a self-administered Malay language version of the International Physical Activity Questionnaire (IPAQ-Short form), which was used to assess the physical activity of recruited subjects [21].

Documented diabetes-specific information, such as duration of DM, insulin usage, and the number of drugs and anti-diabetic medications prescribed, were extracted from patient's medical records.

Statistical Analysis

Descriptive and inferential analyses were performed using Stata version 16, with a significance level set at 0.05. Chi-square tests and multivariate logistic regression analyses were used to examine the association between HDS use and socio-demographic characteristics as well as physical activity.

Ethics Statement

This study (NMRR-18-513-40025) was approved by the Medical Research and Ethics Committee (MREC) of the Ministry of Health Malaysia and the Hulu Selangor District Health Office, Selangor, Malaysia.

RESULTS AND DISCUSSION

A total of 296 patients were approached for this study, out of which 23 patients refused to participate. 273 patients consented and were enrolled in the study. However, certain questions presented, such as the monthly salary and education level, did not achieve a 100% response rate. Socio-demographic characteristics and lifestyle of enrolled patients are presented in Table I.

Table II: Prevalence of consuming at least 1 HDS in the past month (n = 273)

HDS Consumption	Overall	DM
Yes	95 (34.80%)	38 (13.92%)
No	178 (65.20%)	235 (86.08%)

The majority of participants were female Malay Muslims who were already married. Patients were predominantly either working or unemployed, with a monthly salary of less than RM1,500 (USD360), with most possessing primary or secondary level school education.

Table II below reports the prevalence of HDS usage. 95 patients (34.80%) were using at least 1 type of HDS within the past month. 38 of these patients reported using HDS for their DM condition, which accounts for a prevalence of 13.92% among recruited patients. Ethnicity, monthly salary, and physical activity were found to be significantly associated with the active use of HDS. However, none of the studied variables were significantly associated with the active use of HDS for diabetic management purposes.

Table III presents patient-reported expenditure incurred monthly towards purchasing HDS. Median (IQR) expenditure on HDS per month totalled at RM 50 (RM10 – RM123). Median expenditure increased with monthly salary until the RM4000 – RM9000 salary bracket. The highest expense was reported to be RM500, and this was for the purchase of a single product for general well-being (Deer Placenta). Patients who reported no expenses obtained their HDS by harvesting raw herbs from their garden or receiving herbs or products from family or friends.

Based on Supplementary Table A, our study reports that the majority of HDS users consumed only 1 type of HDS (62.1%). Similarly, only 1 type of HDS was consumed among most patients who used it for DM management (84.2%). As shown in Supplementary Table B, a total of 147 HDS were reported to be used among the 95 HDS users, most of which were either self-purchased (74.8%) or home-grown (15.6%).

We reviewed the list of 50 HDS that were reported to be used for DM management purposes among active and past users

Table III: Monthly expenditure associated with the use of HDS stratified according to monthly salary category

Monthly salary	n	Median (RM)	IQR (RM)	Min (RM)	Max (RM)
Overall sample	95	50.00	10.00 – 123.00	0	500.00
< RM1500	48	40.00	3.00 – 117.50	0	290.00
RM1500-4000	32	60.00	16.00 – 124.00	0	500.00
RM4000-9000	7	110.00	10.00 – 124.00	0	450.00
> RM9000	3	100.00	0 - 400.00	0	400.00

Table IV: Univariate and multivariate logistic regression analyses of factors associated with HDS use in general and for T2DM management.

	HDS in general		HDS for T2DM management	
	(Univariate) OR (SE)	(Multivariate) OR (SE)	(Univariate) OR (SE)	(Multivariate) OR (SE)
Age	0.998 (0.0123)		0.969*(0.0145)	0.980 (0.0165)
Weight [b]	1.000 (0.00744)		1.009 (0.00941)	
Ethnicity				
Malay [c]	1(.)	1(.)	1(.)	
Chinese	1.341(0.465)	1.166 (0.441)	0.357 (0.226)	
Indian & Others	0.484*(0.166)	0.456*(0.162)	0.501(0.239)	
Monthly salary [a]	1.760**(0.355)	1.627*(0.347)	1.498(0.373)	
Education [b]	1.422(0.366)		2.540*(0.969)	2.220*(0.893)
Length of disease	1.006(0.0173)		0.979(0.0237)	
Family History	0.835(0.179)		0.755(0.236)	
Smoking	0.985(0.407)		0.689(0.439)	
Alcohol	1.100(0.544)		0.326(0.340)	
Insulin	0.782(0.204)		1.152(0.406)	
Physical activity	1.435*(0.232)	1.452*(0.255)	1.188(0.266)	

OR, Odds ratio; SE, Standard error.
+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
[a] 245 patients responded to this parameter.
[b] 272 patients responded to this parameter.
[c.] Reference category.

(see Supplementary Table C for the full list). Past users were patients who used HDS within the past year, which numbered 12 patients. Not all these patients listed the type of HDS that was used. *Momordica charantia* (bitter gourd) was the most commonly used herb (14%), followed by functional beverages (12%). 10% of HDS were unknown as patients had no knowledge regarding the ingredients or plant extracts used to make the concoction. Moreover, 6% of HDS consisted of dietary supplements that were either untraceable on the internet or had unknown Malaysian product registration status due to their absence in the National Pharmaceutical Regulatory Agency (NPRA) product search web portal. NPRA is Malaysia's regulatory authority for medicinal, supplements, and cosmetic products.

Table IV presents the univariate and multivariate logistic regression analyses conducted to determine factors associated with the use of HDS in general, and HDS specifically for T2DM management To avoid sparse data issues, several categories were recoded. The 'Others' ethnic group had only three respondents and was therefore combined with the Indian ethnic category to form an 'Indian & Others' group. This decision was supported by similar religious or cultural backgrounds between the two groups (see Supplementary Table D). We also collapsed the education level variable into two categories: below secondary education, and secondary education and above. Multivariate logistic regression was conducted using purposeful selection of variables that were significantly associated with HDS use at the 25% significance level in the univariate analysis. In the final model, Indians & Others had a 54.4% lesser likelihood of consuming HDS compared to Malays (OR = 0.456, 95% CI = 0.228 – 0.915). The odds of a patient consuming HDS were 62.7% higher with each successive rise in studied income brackets (OR = 1.627, 95% CI = 1.072 – 2.470). Similarly, the likelihood of a patient consuming HDS increases by 45.2% with each increase in physical activity level (OR = 1.452, 95% CI = 1.029– 2.048). The odds of a patient consuming HDS for T2DM management more than doubled if they had secondary education and above (OR = 2.220, 95% CI = 1.009 – 4.884).

Table V reports the proportion of patients informing healthcare professionals about their HDS usage. Disclosure rates of HDS use to doctors and pharmacists were found to be 16.8% and 7.4% among HDS users, respectively. Among HDS users for T2DM management, 15.8% and 2.6% of them informed their doctor and pharmacist about it, respectively.

Similar reasons behind non-disclosure to both doctors and pharmacists were expressed by patients consuming HDS, as shown in Supplementary Table E & F The two most cited reasons were healthcare professionals never asked patients about their HDS usage, and the perception that disclosure was unimportant.

Supplementary Tables A–F, discussed in the Results section, are provided in Appendix 1 at the end of this article..

DISCUSSION

Our study found that over one-third of individuals with T2DM reported using HDS, with usage associated with ethnicity, income level, and physical activity. Among those who used HDS, a substantial proportion reported using them specifically to manage their diabetes, with educational level being significantly associated with this decision. Our findings also raised concerns as some participants reported using unregistered or unidentified HDS products. Moreover, most users did not disclose their supplement use to their healthcare providers, suggesting a significant communication gap in diabetes management.

Most studies investigating HDS use among patients with diabetes in Malaysia tend to assess it in urban localities alongside other forms of complementary and alternative medicine (CAM), resulting in higher reported usage rates that exceed 50% due to their broader scope and possibly more affluent or educated participants [3, 7, 11]. In contrast, a more comparable local study was conducted in rural Sarawak, East Malaysia, where the use of traditional health supplement products (HSPs) was examined among patients with chronic illnesses, including T2DM. Compared to the present study, they reported a lower prevalence of supplement use, with only 24% of participants actively taking HSPs [22]. This lower rate may be partly due to the study not accounting for the use of herbs consumed as dietary supplements, unlike our current study. Furthermore, their sample comprised a higher proportion of lower-income participants while observing that supplement use was associated with higher household income. These findings align with our study, which also found income level to be significantly associated with HDS use.

From a regional perspective, Putthapiban et al. (2017) examined HDS use among patients with T2DM at a tertiary hospital in urban Bangkok, Thailand, and reported an active usage rate of 28% [23]. In comparison, although only surveying herbal medicine usage, Prasopthum et al. (2022) reported a higher prevalence of 37.5% among T2DM patients attending semi-rural district hospitals in Thailand [8]. Another similar study conducted both in rural and urban health facilities among patients with chronic disease in Thailand also observed similar rates [24]. Although nuanced, there is potentially a greater uptake of HDS in less urbanised regions of Thailand compared to our rural setting in Malaysia. A possible explanation for this difference is that although our study was conducted in a rural region, the surrounding locality is undergoing rapid development through rural-urban transformation initiatives within the state of Selangor, one of Malaysia's wealthiest and most developed states [25]. Increased exposure to urban infrastructure and heightened cost of living due to ongoing rural-urban developments may have influenced HDS usage patterns to closely resemble those observed in urban contexts like Bangkok.

Several studies have reported a notable increase in HDS use during the COVID-19 pandemic. For instance, a Malaysian survey found that 42% of adults used HDS for COVID-19 prevention [26], while similar trends were observed in Saudi Arabia and Indonesia [27, 28]. While these increases were likely driven by pandemic-specific concerns, they may have influenced longer-term attitudes and behaviors toward HDS use. However, whether these patterns persisted post-pandemic remains uncertain. This underscores the need for updated surveys to assess current usage trends among patients with T2DM to trace evolving health-seeking behaviors.

One alarming finding seen during the HDS identification process lies with the discovery of products or herbs which were either unregistered or unknown to the patient. Unregistered or unregulated HDS products are notorious for causing severe or unwanted adverse effects to consumers [29, 30]. These products may be contaminated, adulterated, or contain ingredients that exceed safety levels or contain toxic properties [31-33]. Unknown herbs or products may pose risks of adverse events for similar reasons [34]. Multiple surveys have found that Malaysians in general are ill-equipped with the skills necessary to identify and use HDS responsibly from a regulatory and safety perspective [35-37]. This highlights the need to bolster efforts directed at improving the health literacy of Malaysians via effective educational campaigns regarding safe and responsible HDS usage.

Malay patients with T2DM were more likely to use HDS in this study, a finding that is equally supported by another Malaysian study that examines CAM usage among patients with T2DM [3]. This observation may be attributed to their Islamic faith, which encourages holistic disease management and the use of traditional remedies like olive and honey, as mentioned in the Quran, Sunnah, and Hadith [10, 38, 39]. The NHMS 2015 also supports this finding, showing that many Islamic medical practitioners attribute their use for therapeutic purposes [10].

Patients with at least a secondary education were more likely to use HDS for managing diabetes. While most studies indicate education level as an insignificant factor for overall HDS use [8, 9, 40-42], our finding suggests that higher health literacy may drive the use of HDS for diabetes management in rural areas, possibly due to greater awareness of alternative

therapies, coupled with increased confidence in evaluating health information and making informed decisions about supplement use.

More physically active patients were found to have a higher likelihood of using HDS. While some studies support this finding, others show contrasting results. For example, a prospective cohort study using US National Health and Nutrition Examination Survey data from 1999 to 2018 found that supplement users were more likely to be physically active than non-users (26.8% vs. 19.8%; $p < 0.001$) [43]. However, cross-sectional surveys of patients with T2DM in Thailand found that those using HDS were more likely to be physically inactive [8, 44]. The results of our study may suggest that physically active patients display a more proactive attitude toward managing their disease [45], and hence were more inclined to use HDS.

The majority of our surveyed patients used HDS for general health, while only a small fraction used them to manage their T2DM. However, this contrasts with a local CAM survey conducted across an entire Malaysian state, whereby 40.6% of surveyed T2DM patients used CAM to help manage their condition [7]. The higher rate observed in that study may reflect a broader definition of CAM use, and the inclusion of participants from more urbanized areas where health-seeking behaviors and access to health information may differ.

The overwhelming majority of HDS users surveyed did not disclose their usage of HDS to both doctors and pharmacists. This mirrors the disclosure rates seen in local [14, 22, 46, 47], regional [23], and international studies [9, 48], which ranged from 16.2% to 58%. While the disclosure rate over time was not explicitly studied in this survey, a Malaysian study conducted 13 years prior to our study reported a strikingly similar non-disclosure rate [46]. This suggests that poor disclosure rates remain a long-standing issue in the country that requires urgent attention from Malaysian healthcare providers.

Low disclosure rates of HDS use may occur because patients often downplay its importance, believing it doesn't affect their disease management. This can lead to HDS-related adverse events going unnoticed and complicating treatment. To improve disclosure rates, healthcare providers should encourage proactive discussions about HDS use, as a lack of inquiry is a major reason for non-disclosure [22, 47, 49] Additionally, healthcare providers should adopt adaptive communication strategies, especially in multicultural settings with diverse socioeconomic backgrounds, as differences in terminology and understanding of HDS can affect communication. For instance, a study by Ben-Arye et al. found that including HDS-related keywords during history-taking more than doubled disclosure rates [50]. Furthermore, integrating CAM education into medical training and offering capacity-building courses could also significantly improve healthcare providers' competency and confidence to prompt and address HDS usage among patients [49].

There are several limitations to our study. The findings might only be applicable to the broader local region due to the rapid urbanization of the Hulu Selangor area. Another limiting factor is that data collection was conducted within healthcare facilities, which might have excluded patients who are exclusively on HDS for the management of T2DM and do not seek conventional medical care..

While significant research has been conducted on the prevalence, type, and factors behind HDS use, and the prevalence of non-disclosure rates and their reasons, studies on the impact of remedial actions taken to improve disclosure remain few and far between. Further research on evaluating and optimising existing strategies could be helpful in improving communication between patients and healthcare providers as well as allowing for more holistic management of diabetes.

CONCLUSION

In summary, the use of HDS among T2DM patients in the studied rural region was slightly lower but broadly comparable to rates reported in more developed settings. This suggests that urbanization and socioeconomic development may influence usage patterns even in rural areas. Given the potential risks of HDS use in compromising diabetes management, particularly when involving unknown or potentially harmful products, there is an urgent need to educate and empower patients while strengthening regulatory surveillance of unregistered products in the market. Lastly, taking a proactive, open, and adaptive approach to communicate on HDS usage will allow both patients and healthcare providers to navigate the complexities of multimodal DM treatment in an informed manner.

CONFLICT OF INTEREST

Authors states no conflict of interest.

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APPENDIX

Supplementary Table A: Number of HDS consumed per patient

Number of HDS	Overall HDS users (n=95)	HDS users for T2DM management (n=38)
1	59 (62.1%)	32 (84.2%)
2	24 (25.3%)	5 (13.2%)
3	9 (9.5%)	
4	2 (2.1%)	1 (2.6%)
5	1 (1.0%)	

Supplementary Table B: Prevalence of reported sources for HDS consumed

Source of HDS	n (%)
Self-purchase	110 (74.8)
Homegrown	23 (15.6)
Hospital or clinic pharmacy	6 (4.1)
From neighbour's or friend's garden	4 (2.7)
Harvested from plants growing naturally outside of home	2 (1.4)
Given or bought by a family member	2 (1.4)

Supplementary Table C: Frequency of HDS use for DM management among active and past users

Herbal or Dietary Supplement	n (%)
Momordica charantia	7 (14)
Functional Beverage	6 (12)
Orthosiphon stamineus	4 (8)
Vitamin B12 / Methylcobalamin	4 (8)
Helminthostachys zeylanica	2 (4)
Punica granatum	2 (4)
Clinacanthus nutans	2 (4)
Piper nigrum + *Trigonella foenum-graecum*	1 (2)
Moringa oleifera Lam.	1 (2)
Oenanthe javanica	1 (2)
Centella asiatica	1 (2)
Stevia rebaudiana	1 (2)
Mariposa christia vespertilionis	1 (2)
Andrographis paniculata	1 (2)
Clitoria ternatea	1 (2)
Artocarpus altilis	1 (2)
Gynura procumbens	1 (2)
Murraya koenigii	1 (2)
Abelmoschus esculentus	1 (2)
Flaxseed	1 (2)
Evening Primrose oil	1 (2)
CoEnzyme Q10	1 (2)
Unknown dietary supplement [a]	3 (6)
Unknown (liquid, leaves, plant extract beverage)	5 (10)

[a] Untraceable on the internet or unknown Malaysian product registration status.

Supplementary Table D: Religion of participants by ethnicity

Religion	Ethnicity			
	Malay	Chinese	Indian	Others
Islam	167	0	0	0
Buddhism	0	41	0	0
Hinduism	0	1	56	0
Christianity	0	0	3	1
Sikhism	0	0	0	1
None	0	0	0	1
Unspecified	0	1	1	0

Supplementary Table E Reasons for nondisclosure to doctor among patients consuming HDS

Reason	Frequency (%)
Was never asked	54 (68.3)
Not important	13 (16.4)
Doctor will not agree to it	4 (5.1)
Unsure	2 (2.5)
Just started	2 (2.5)
Traditional remedy	1 (1.3)
Doctor will not understand	1 (1.3)
Friend informed not to disclose	1 (1.3)
Infrequent consumption	1 (1.3)

Supplementary Table F: Reasons for nondisclosure to pharmacist among patients consuming HDS

Reason	Frequency (%)
Was never asked	63 (71.6)
Not important	16 (18.2)
Unsure	5 (5.7)
Just started	1 (1.1)
Traditional remedy	1 (1.1)
Friend informed not to disclose	1 (1.1)
Pharmacist will not agree to it	1 (1.1)