ORIGINAL ARTICLE

Prevalence of metabolic associated fatty liver disease (MAFLD) and its associated factors among type 2 diabetes mellitus (T2DM) in primary care settings in Kuantan, Pahang

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ABSTRACT

Introduction: Metabolic associated fatty liver disease (MAFLD) is a common comorbidity in type 2 diabetes mellitus (T2DM) and is associated with adverse hepatic and metabolic outcomes. Early detection in primary care is limited by restricted access to imaging, highlighting the need for practical non-invasive screening tools. This study aimed to determine the prevalence of MAFLD using the Fatty Liver Index (FLI) and identify associated factors among T2DM patients in Kuantan, Pahang.

Materials and Methods: A cross-sectional study was conducted among T2DM patients aged ≥18 years selected through systematic random sampling from primary care clinics. Sociodemographic and clinical data were obtained from interviews and medical records. FLI, calculated using BMI, waist circumference, triglycerides, and gamma-glutamyl transferase, was used to estimate hepatic steatosis, with MAFLD defined as FLI ≥60. Data were analysed using SPSS version 29, and multiple logistic regression was used to identify independent predictors.

Results: Among 430 participants, MAFLD prevalence was 51.2% (n=220). Patients with MAFLD were younger (56.4 vs. 61.5 years, p<0.001), had shorter diabetes duration (6 vs. 8 years, p=0.011), and poorer glycaemic control (HbA1c ≥7%: 64.5% vs. 48.2%, p<0.001). Prevalence was highest among Indians (61.9%), followed by Malays (53.7%) and Chinese (35.1%) (p=0.008). Multivariable analysis demonstrates younger age (AOR=0.974; 95% CI: 0.956–0.992) and poor glycaemic control (AOR=2.016; 95% CI: 1.326–3.065) were independently associated with MAFLD.

Conclusion: MAFLD prevalence was high among T2DM patients in primary care. Younger age and poor glycaemic control were independently associated with MAFLD. Routine FLI screening may support early identification of high-risk patients and timely intervention.

KEYWORDS:
Fatty Liver Index; MAFLD; Type 2 Diabetes Mellitus; Prevalence; Malaysia

INTRODUCTION

Metabolic associated fatty liver disease (MAFLD) is a clinically defined condition characterised by hepatic steatosis alongside metabolic dysfunction, such as overweight/obesity, dyslipidaemia, or type 2 diabetes mellitus (T2DM). This redefinition, transitioning from the previous non-alcoholic fatty liver disease (NAFLD) framework, emphasises inclusion based on metabolic criteria rather than solely excluding alcohol or other liver diseases.[1] The change was endorsed by the Asian Pacific Association for the Study of the Liver (APASL) and national societies, including the Malaysian Society of Gastroenterology and Hepatology (MSGH).[2,3]

In 2023, an international consensus introduced the term metabolic dysfunctional associated steatotic liver disease (MASLD) to standardise nomenclature and replace NAFLD.[4,5] MASLD is defined as hepatic steatosis occurring in the presence of at least one cardiometabolic risk factor, excluding significant alcohol intake and other liver diseases. Given the close alignment between the concepts of MAFLD and MASLD, the MAFLD framework remains clinically relevant and was therefore adopted in the present study.

Beyond terminology, the clinical and public health burden of metabolically driven fatty liver disease is substantial. Globally, MAFLD affects more than 1 billion individuals. In the population with T2DM, meta-analyses indicate that nearly 65% have MAFLD, putting them at a heightened risk for advanced fibrosis, cirrhosis, hepatocellular carcinoma, and cardiovascular mortality.[6–9] In Malaysia, the National Health and Morbidity Survey (NHMS) 2023 reported a national MAFLD prevalence of 28.2%, with higher rates observed among urban and overweight adults.[9,10] Recent evidence from 2020 to 2025 further demonstrates a substantial burden among high-risk Malaysian populations, including hemodialysis cohorts and hospital-based T2DM patients, where MAFLD prevalence ranges from 43% to 45%, and 22–26% meet criteria for advanced fibrosis.[11,12] Despite these concerning trends, there remains a paucity of local data describing the burden of MAFLD specifically within primary care settings, where most T2DM patients receive long-term follow-up and where opportunities for early detection are greatest.

This article was accepted: 14 March 2026
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Thus, this study was conducted to determine the prevalence of MAFLD and its associated factors among patients with T2DM attending government primary care clinics in Kuantan, Pahang. By examining the burden of MAFLD in a real-world primary care population, this study aims to strengthen local epidemiological evidence and inform targeted screening strategies to support earlier identification of high-risk individuals.

MATERIALS AND METHODS

Population, Setting and Sample Size Calculation

This cross-sectional study was conducted from April 2024 to April 2025 at government health clinics in Kuantan, Pahang. The inclusion criteria comprised Malaysian citizens aged 18 years and older with a diagnosis of T2DM, registered in the National Diabetes Registry (NDR) and attending routine follow-up at least twice yearly. Individuals with known chronic liver diseases such as hepatitis B or C, autoimmune hepatitis, Wilson's disease, hepatocellular carcinoma, or decompensated liver failure were excluded. Pregnant women, individuals who consume alcohol and vulnerable populations, including prisoners or aggressive respondents, were excluded.

The required sample size was determined to be 430, calculated based on an expected prevalence of 63.2% for MAFLD among T2DM patients from a previous study in China.[13] This calculation was made with a 95% confidence interval, a precision of 5%, and a 20% allowance for non-response. Simple random sampling was used to select respondents from the five clinics with high T2DM burden. Patients were randomly selected from the NDR using Excel to minimise selection bias.

Data Collection and Study Instruments

Data was collected using a structured, interviewer-administered questionnaire and validated measurement tools. The questionnaire covered socio-demographic information (age, sex, ethnicity, education, household income), clinical history (duration of diabetes, smoking status), and physical activity using the validated Malay short-form International Physical Activity Questionnaire (IPAQ-M). Anthropometric measurements, including weight, height, body mass index (BMI), and waist circumference (WC), were obtained using standard SECA equipment to ensure accuracy and consistency. Venous blood samples were obtained for routine diabetes monitoring (HbA1c, fasting lipid profile, and liver function tests), with gamma-glutamyl transferase (GGT) explicitly measured for this study. Fatty liver status was determined using the FLI, which incorporates WC(cm), BMI (kg/m²), GGT (U/L), and triglycerides (mg/dL). The formula is as follows:

$$FLI = \frac{(e0.953\times\ln(TG)+0.139\times BMI+0.718\times\ln(GGT)+0.053\times WC-15.745)}{(1+e0.953\times\ln(TG)+0.139\times BMI+0.718\times\ln(GGT)+0.053\times WC-15.745)} \times 100$$

An FLI score ≥60 was used to indicate steatosis in this study. FLI was chosen for its practicality and suitability for large-scale screening in primary care, where imaging modalities such as ultrasonography or transient elastography are not routinely available. In ultrasound-based validation studies, this cut-off showed good diagnostic performance, with a sensitivity of 80.3%, specificity of 87.3%, and substantial agreement with ultrasonography (κ=0.65).[14,15]

Data Analysis

All data were analysed using SPSS version 29. Descriptive statistics were used to summarise socio-demographic, clinical, and biochemical characteristics. Continuous variables were reported as mean ± standard deviation (SD) or median (interquartile range, IQR), while categorical variables were presented as frequencies and percentages. Bivariate analyses were conducted to examine associations between MAFLD and potential predictors. Multiple logistic regression was performed to identify independent factors associated with MAFLD, and adjusted odds ratios with 95% confidence intervals were reported. A p-value < 0.05 was considered statistically significant.

RESULTS

Sociodemographic and clinical characteristics of respondents. Four hundred thirty adults with type 2 diabetes mellitus in Kuantan, Pahang, were included in this study. The general characteristics of the respondents at baseline are presented in Table I. Most respondents were female (59.5%, n=246) with a mean age of 58.89 years, and the majority were Malay (72.3%, n=311). The median duration of diabetes was 7 years (IQR: 10), and anthropometric measurements indicated a high prevalence of obesity (mean BMI 28.7 kg/m²; mean waist circumference 91.36 cm). More than half had secondary education (52.3%, n=225), and most were from the B40 income group (82.3%, n=354). Most of the respondents were non-smokers (87.7%, n=377) and had low physical activity (54.4%, n=234).

Table II illustrates 56% of respondents had HbA1c levels ≥7%, indicating poor glycaemic control. The median ALT was 31 U/L (IQR: 20), while mean AST and GGT levels were 22.36 U/L (SD=10.001) and 41.14 U/L (SD=37.162), respectively. Although triglyceride (mean 129.53 mg/dL, SD=72.99) and HDL cholesterol levels (mean 56.55 mg/dL, SD=18.51) were generally favourable, LDL cholesterol remained high (mean 104.43 mg/dL, SD=44.42).

Prevalence of Metabolic Associated Fatty Liver Disease (MAFLD) among Type 2 Diabetes Mellitus (T2DM) patients.

Figure 1 presents the prevalence of metabolic associated liver disease (MAFLD) among type 2 diabetes mellitus (T2DM) patients attending primary care settings in Kuantan, Pahang. In this study, 51.2% (n=220) of the respondents were detected to have MAFLD. This finding indicates the prevalence of MAFLD was notably high in this population.

Factors associated with Metabolic Associated Fatty Liver Disease (MAFLD) among T2DM patients.

In Table III, the bivariate analysis identified several factors associated with MAFLD. Respondents with MAFLD were significantly younger than the non-MAFLD group (56.4 vs. 61.4 years, p < 0.001). Ethnicity was also a significant factor (p=0.008), with Indians exhibiting the highest prevalence (61.9%, n=26). MAFLD was additionally associated with a

Table I: Sociodemographic characteristics of respondents

Variable	n (%)
Age (years)	Mean = 58.89, SD = 0.575
Male	174 (40.5%)
Female	256 (59.5%)
Race	
Malay	311 (72.3%)
Chinese	77 (17.9%)
Indian	42 (9.8%)
Duration of DM (years)	Median = 7.0, IQR = 10
BMI (Kg/m²)	Mean =28.79, SD = 6.444
Waist Circumference (cm)	Mean = 91.36, SD = 19.449
Education Level	
Primary School	112 (26.0%)
Secondary School	225 (52.3%)
College/University	93 (21.6%)
Household Income	
B40 (<RM3,900/month)	354 (82.3%)
M40 (RM3,900–RM7,599/month)	60 (14.0%)
T20 (>RM7,599/month)	16 (3.7%)
Smoking Status	
Yes	53 (12.3%)
No	377 (87.7%)
Physical Activity Level	
Low	234 (54.4%)
Moderate	147 (34.2%)
High	49 (11.4%)

SD: standard deviation; IQR: interquartile range

Table II: Clinical parameters of respondents

Variables	n (%)
HbA1c (%)	
HbA1c <7%	189 (44.0%)
HbA1c ≥7%	241 (56.0%)
ALT (U/L)	Median = 31.00, IQR = 20
AST (U/L)	Mean = 22.36, SD = 10.001
GGT (U/L)	Mean = 41.14, SD = 37.162
Triglyceride (mg/dl)	Mean = 129.525, SD = 72.988
HDL (mg/dl)	Mean = 56.546, SD = 18.510
LDL (mg/dl)	Mean = 104.430, SD = 44.422

SD: standard deviation; IQR: interquartile range

shorter duration of diabetes (p=0.011) and poor glycaemic control, with 58.9% (n=142) of individuals with HbA1c ≥7% affected (p < 0.001).

The multivariable logistic regression analysis (Table IV) shows age and glycaemic control remained independently associated with MAFLD after adjustment for potential confounders. Increasing age was inversely associated with MAFLD (AOR=0.974, p=0.005), indicating a higher likelihood of MAFLD among younger patients with T2DM. In contrast, poor glycaemic control (HbA1c ≥ 7%) was associated with approximately a two-fold increase in the odds of MAFLD (AOR=2.016, p=0.001).

DISCUSSION

In this study, 51.2% of respondents had MAFLD, accounting for half of the T2DM patients in Kuantan, Pahang. This finding highlights a considerable metabolic burden within the local diabetic population and reflects the emerging recognition of MAFLD as the hepatic manifestation of metabolic dysfunction. The high prevalence observed in our setting underscores the need for heightened awareness and early screening for MAFLD in primary care, where most diabetic patients receive long-term follow-up and lifestyle counselling.

Compared with our observed prevalence, recent evidence suggests the global burden of MAFLD is generally lower, with a pooled adult prevalence of around 38–39%.[4,6,16–18] However, when comparing with the individuals with T2DM specifically, published prevalence figures tend to be substantially higher than in the general population. A recent meta-analysis reported a global prevalence of MAFLD among T2DM of approximately 65.33%, with the highest prevalence in the Eastern European region.[17] Moreover, K. E. Chan et al. (2022) also reported that patients with diabetes have nearly four times higher odds of developing MAFLD compared to non-diabetics (OR 3.80; 95% CI 2.65–5.43).[19] Our study reaffirmed the previous findings that patients with diabetes mellitus have a higher risk of getting MAFLD. The prevalence of MAFLD in our cohort was 51.2%, substantially higher than

Table III: Factors associated with MAFLD among Type 2 Diabetes Mellitus patients in primary care settings in Kuantan, Pahang

	Non-MAFLD (n=210)	MAFLD (n=220)	MAFLD (%)	p-value (2-sided)
Age	m:61.5±11.13	m:56.4±12.13	-	<.001*
Gender				0.434
Female	129	127	57.7%	
Male	81	93	42.3%	
Race				0.008*
Malay	144	167	75.9%	
Chinese	50	27	12.3%	
Indian	16	26	11.8%	
Educational Status				0.488
Primary School	60	52	23.6%	
Secondary School	105	120	54.5%	
College/University	45	48	21.8%	
Household Income				0.602
B40 (<RM3900/Month)	173	181	82.3%	
M40(RM3900RM7599/Month)	31	29	13.2%	
T20 (> RM 7599/Month)	6	10	4.5%	
Smoking Status				0.254
No	188	189	85.9%	
Yes	22	31	14.1%	
Physical Status				0.620
Low	111	123	55.9%	
Moderate	72	75	34.1%	
High	27	22	10.0%	
Duration of DM	8.00 (IQR:4-16)	6.00 (IQR: 3 -10.75	-	0.011*
HbA1c status				<0.001*
HbA1c <7%	111	78	35.5%	
HbA1c ≥7%	99	142	64.5%	

IQR: interquartile range; m: mean; * significant p-value<0.05

Table IV: Multiple logistic regression predicting associated factors of MAFLD among T2DM patients

Predictor	B	Wald	AOR	95% CI	p-value
Age (years)	–0.026	7.813	0.974	0.956 – 0.992	0.005*
Race (overall)	—	4.251	—	—	0.119
Chinese vs Malay	–0.477	2.938	0.620	0.359 – 1.071	0.086
Indian vs Malay	0.305	0.757	1.356	0.683 – 2.694	0.384
Duration of DM (years)	–0.030	3.799	0.970	0.941 – 1.000	0.051
HbA1c ≥7% (vs <7%)	0.701	10.750	2.016	1.326 – 3.065	0.001*

AOR: Adjusted odd ratio; CI: confidence interval; * significant at p- value <0.05

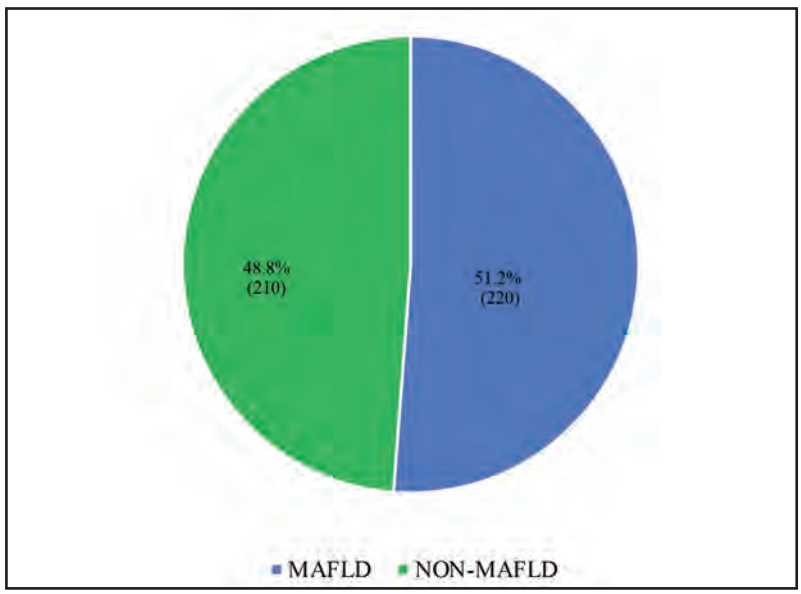

Fig. 1: Prevalence of metabolic associated fatty liver disease (MAFLD) among type 2 diabetes mellitus (T2DM) in primary care settings in Kuantan, Pahang (N= 430)

the 28.2% reported in the general Malaysian population. This finding is particularly noteworthy, as our respondents exhibited more favourable metabolic profiles, including a lower average BMI (27.04 kg/m² vs national 32.5 kg/m²), triglyceride levels (129.53 mg/dL vs national 165.63 mg/dL), as were their liver enzymes: ALT (31.00 vs. national 41.07), AST (22.36 vs. national 29.68), and GGT (41.14 vs. national 62.33). However, glycaemic control was suboptimal, with 56% of participants having HbA1c ≥7%, compared with a national mean of 6.04%. As our cohort consisted exclusively of patients with T2DM, a recognised high-risk group for fatty liver disease, the elevated prevalence observed was expected.9 The coexistence of T2DM and MAFLD has important clinical implications, as it significantly increases the risk of advanced liver fibrosis, cardiovascular disease, and renal complications. Poor glycaemic control may further accelerate hepatic steatosis and fibrosis progression through worsening insulin resistance and metabolic dysfunction.[17,20,21] These findings highlight the importance of incorporating early MAFLD screening and timely metabolic optimisation into routine primary care diabetes management to reduce future hepatic and systemic complications.

In this study, multivariable logistic regression analysis demonstrated that age and glycaemic control were independently associated with MAFLD among patients with T2DM. Notably, MAFLD was more prevalent among younger adults with T2DM, with a mean age of 56.4 years. While earlier population-based studies have consistently shown that MAFLD becomes more common with advancing age, more recent diabetic cohorts demonstrate an emerging shift whereby MAFLD increasingly affects younger individuals.[13,22–25] Similar observations have emerged in Malaysia, where MAFLD patients were nearly a decade younger than the global average but experienced a higher burden of metabolic comorbidities.[9] Our findings were consistent with this emerging trend, as each 1-year increase in age was associated with a 2.6% reduction in the odds of MAFLD (AOR 0.974; 95% CI 0.956–0.992; p-value=0.005). This shift toward younger-onset MAFLD among T2DM patients likely reflects earlier development of metabolic risk factors, rising early-onset diabetes, and prolonged lifetime exposure to hyperglycaemia and dyslipidaemia. Such early metabolic derangement accelerates hepatic fat accumulation and fibrosis progression. In contrast, older patients may represent a survivor group or may have progressed to more advanced liver disease, where steatosis becomes less detectable using FLI. For future T2DM populations, this trend is concerning as it increases the lifetime risk of advanced liver disease, cardiovascular complications, and long-term healthcare burden, underscoring the need for earlier screening and tighter metabolic control in primary care.

Poor glycaemic control further compounded this risk. Individuals with HbA1c ≥7% had almost twice the odds of developing MAFLD (AOR 2.016; 95% CI 1.326–3.065; p-value=0.001), highlighting the key role of persistent hyperglycaemia in driving hepatic steatosis. Pathophysiologically, prolonged elevation in glucose levels exacerbates insulin resistance, stimulates de novo lipogenesis, increases hepatic free fatty acid influx, and promotes inflammatory liver injury. Similar associations have been demonstrated across other diabetic cohorts, where higher HbA1c levels were consistently observed among MAFLD cases compared to non-MAFLD T2DM patients and international evidence has reinforced the strong link between sustained hyperglycaemia and disease severity.[22,26–29] Taken together, the combination of younger age and poor glycaemic control suggests a shift towards a more metabolically aggressive form of MAFLD in T2DM patients, underscoring the importance of early metabolic intervention to reduce hepatic injury and prevent future progression.

Other demographic factors, including gender and race, did not show a significant association with MAFLD in this study. Despite reports of higher MAFLD prevalence among males with T2DM, we found no significant sex differences, indicating a high metabolic burden in both genders. Although Indian ethnicity in Malaysia is associated with higher visceral fat and cardiometabolic risk, it lost significance after adjustments. This implies that metabolic disturbances have a greater impact than ethnic background on liver fat accumulation after diabetes develops. Apart from that, longer diabetes duration showed a borderline inverse association with MAFLD (AOR 0.970; p=0.051), which contrasts with recent evidence linking prolonged diabetes with greater hepatic steatosis and fibrosis.[12,30] This finding is likely affected by the high rate of poor blood sugar control in our group, as over half of the participants had an HbA1c level of 7% or higher. Chronic hyperglycemia is a stronger driver of hepatic fat accumulation than diabetes duration. The limited range of diabetes duration in our study may have limited our ability to detect a clear association, likely explaining the weaker association between diabetes duration and MAFLD in our cohort compared with previous studies.

Physical activity, smoking, socioeconomic status, and education were not significantly associated with MAFLD in our study, differing from previous research. Earlier studies consistently reported that lower physical activity and smoking increase the risk of NAFLD/MAFLD.[31–33] This difference might be attributable to limitations of the IPAQ questionnaire, which relies on self-reported data and may overlook key differences. Similarly, smoking lost its significance after adjustments, despite its known role in promoting hepatic steatosis and fibrosis.[8,34] The more pronounced influence of metabolic factors, particularly adiposity and HbA1c, may have overshadowed the effects of these lifestyle factors. Nonetheless, physical inactivity and smoking remain critical determinants of metabolic health. Therefore, lifestyle counselling should continue to be emphasised in routine diabetes care. Additionally, socioeconomic status and education were not associated with MAFLD in our cohort, in contrast to studies that have linked higher income or urban living to a greater risk and lower education to a lower risk.[24,35,36] The possible reason for these findings is the relatively similar urban population served by primary care clinics in Kuantan. Modern eating habits, easy access to high-calorie foods, and sedentary lifestyles are common across all income and education levels, which may reduce the usual differences seen between socioeconomic groups. As a result, the absence of significant differences in demographic, lifestyle, or socioeconomic factors likely reflects the strong influence of overall metabolic burden in individuals with T2DM.

The findings from this study have important implications for diabetes care in Malaysian primary care settings. The high burden of MAFLD among individuals with T2DM, together with the strong influence of poor glycaemic control, highlights the need for earlier screening and more aggressive metabolic intervention before fibrosis and liver-related complications develop. Screening for fatty liver disease should not rely solely on liver enzymes, as many patients with MAFLD may have normal ALT levels. Instead, simple non-invasive tools such as the FLI, abdominal obesity measures, and routine metabolic profiling can be incorporated into routine diabetes follow-up assessments, particularly among younger patients with poor HbA1c control who already demonstrate significant metabolic risk. These findings are especially relevant in Malaysia, given rapid urbanisation, increasingly sedentary lifestyles, and widespread access to energy-dense foods and sugary beverages, which may help explain the lack of significant socioeconomic differences observed in our cohort. In line with the 2023 international consensus, the Malaysian Society of Gastroenterology and Hepatology has adopted the term MASLD to emphasise the central role of metabolic dysfunction in fatty liver disease. Our findings further support this concept, as poor glycaemic control emerged as a major contributor to fatty liver disease among patients with T2DM. Integrating this understanding into routine diabetes care may facilitate earlier identification of high-risk individuals and enable timely intervention to reduce progression to fibrosis, cirrhosis, and other metabolic complications.[39]

This study provides insight into MAFLD among patients with T2DM in primary care, where most long-term diabetes management occurs. The use of the FLI, based on routinely available parameters, supports its practicality for large-scale screening. However, the study has several limitations including steatosis was assessed using FLI without imaging confirmation, and the intermediate range (FLI between 30–59) may underestimate prevalence. In addition, the single-district primary care setting may limit generalisability. Future longitudinal studies incorporating imaging modalities and fibrosis assessment, including transient elastography and FIB-4, are recommended.

CONCLUSION

MAFLD was highly prevalent among patients with T2DM in Kuantan, reflecting a substantial local metabolic burden. Younger age and poor glycaemic control were independently associated with MAFLD, underscoring the importance of early screening and proactive metabolic optimisation. Integrating MAFLD assessment into routine diabetes care within primary care settings is crucial to mitigate the growing dual burden of diabetes and fatty liver disease in Malaysia.

FUNDING

This study was financially supported by the Family Medicine Specialist Association Research Grant and the Malaysian Society of Gastroenterology and Hepatology Research Fund.

ETHICAL APPROVAL

This study was approved by the Research and Ethical Committee of the researchers' institution (IREC number 1073) and NMMR (NMRR ID-24-00035-876 (IIR)). All respondents had given their written consent. Those who refused to participate received the same standard of care as those who agreed.

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