ORIGINAL ARTICLE

Prevalence of Diabetes Mellitus and its Associated Factors among Adults in Malaysia: Findings from the National Health and Morbidity Survey 2019

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ABSTRACT

INTRODUCTION: Diabetes mellitus (DM) is a major non-communicable health problem in both developed and developing countries, including Malaysia. This study aimed to determine the prevalence of DM and identify associated factors among adults in Malaysia. **MATERIALS AND METHODS:** A nationwide cross-sectional study was conducted in 2019 involving 10,464 respondents. A two-stage stratified sampling design was employed to select a representative sample of adults aged ≥18 years. Data was collected using structured and validated questionnaires administered through face-to-face interviews. Finger-prick fasting blood glucose tests were performed on respondents without a known DM diagnosis. All analyses were weighted to represent the Malaysian adult population. Chi-square tests and multiple logistic regression analyses were used to determine the associations between DM and the associated factors, with a significance level set at 0.05. **RESULTS:** The overall weighted prevalence of DM was 18.3% (n=2629). Higher prevalence was observed among individuals aged ≥60 years (41.5%), of Indian ethnicity (31.4%), physically inactive individuals (22.5%), obese individuals (27.1%), those with hypertension (36.0%), and those with high cholesterol levels (30.4%). Logistic regression identified age, ethnicity, obesity, hypertension, and cholesterol levels as significant factors associated with DM. **CONCLUSION:** The prevalence of DM among Malaysian adults remains high. Targeted strategies focusing on high-risk groups, particularly older adults, individuals of Indian ethnicity, those with obesity, hypertension, and dyslipidaemia, are important to reduce the national diabetes burden.

Keywords
Prevalence, Diabetes, Adults, Factors, Malaysia

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INTRODUCTION

Diabetes is a prioritised non-communicable (NCD) disease due to its significant public health problem all over the world, including in Malaysia. The World Health Organisation (WHO) states that 830 million people worldwide have diabetes, especially in low or middle-income countries. Diabetes is a major contributor to serious health complications, including blindness, kidney failure, heart attacks, strokes, and lower limb amputations. In 2021 alone, diabetes and diabetes-related kidney disease were responsible for more than 2 million deaths worldwide. Additionally, elevated blood glucose levels accounted for approximately 11% of all cardiovascular-related deaths.

The WHO's 2019 Global Health Estimates state that seven of the top ten causes of death worldwide are NCDs.[2]

In Malaysia, the National Health and Morbidity Survey (NHMS) in 2006[3] showed that the prevalence of diabetes mellitus (DM) was 11.6%. This figure increased to 15.2% and 17.5% in NHMS 2011[4] and NHMS 2015[5], respectively. The increase in the prevalence of overweight and obesity in people may be one of the factors contributing to the rise in diabetes.[6]

The increasing prevalence of diabetes from year to year around the world has raised concerns among many parties, especially those involved in the field of healthcare. According to the International Diabetes Federation (IDF),

in 2021 estimated that approximately 537 million adults (20-79 years) are living with diabetes worldwide, and the number is expected to rise to 643 million by 2030 and 783 million by 2045[7]. More worryingly, data shows that nearly 1 in 2 (240 million) adults with diabetes are undiagnosed.[8] Untreated diabetes has a significant relationship with morbidity and mortality and can lead to microvascular (retinopathy, neuropathy, and nephropathy) and macrovascular (heart attack, stroke, and peripheral vascular) complications.[9]

Recent evidence indicates that a diet high in saturated fats and added sugars is significantly associated with increased risk of type 2 diabetes, whereas dietary patterns rich in whole grains, fruits, and vegetables are protective.[10] In addition to lifestyle factors, genetic predisposition plays a crucial role in the pathogenesis of type 2 diabetes, particularly through its influence on beta-cell function and glucose metabolism.[11] Other studies also showed certain socio-demographics to be associated with diabetes, such as gender, age, higher Body Mass Index (BMI), and co-morbidities, such as hypertension.[12]

Although previous NHMS cycles (2006, 2011, 2015) have documented the rising prevalence of diabetes in Malaysia, these surveys provided limited analysis of sociodemographic determinants and lacked detailed stratification by clinical risk factors such as obesity, hypertension, and cholesterol. Furthermore, earlier studies did not explore associations using a fully adjusted multivariable model based on the latest national dataset.

This study aims to address these gaps by providing updated prevalence estimates of DM and a more comprehensive assessment of associated factors among the adult population in Malaysia using nationally representative data from NHMS 2019.

MATERIALS AND METHODS

Data collection

The NHMS 2019 was a cross-sectional nationwide survey conducted by the Institute for Public Health, Ministry of Health Malaysia. NHMS 2019 implemented a multi-stage stratified sampling design proportionate to the population size throughout all states in Malaysia, covering both urban and rural areas. The target population was residents of all non-institutional living quarters (LQs) in Malaysia for at least two weeks before data collection.

This survey used structured and validated bilingual questionnaires (in Bahasa Malaysia and English), and it was administered by trained interviewers. The data collection team conducted face-to-face interviews using mobile devices with a system developed specially for this data collection.[13] Completed questionnaires were sent to the data management team through the NHMS server in the Institute of Public Health whenever there was an internet connection. Quality control checks were performed (especially on the respondent ID, outliers, or incorrect data).

Dependent variable

The fasting blood glucose measurement was performed on finger-prick blood samples from respondents using the CardioChek® PA Analyzer portable blood test system. Only respondents who claimed to be non-diabetic were tested for glucose levels. For this study, a respondent was classified as having DM when the respondent self-reported it or was told to have diabetes by a doctor or assistant medical officer, or had a fasting capillary blood glucose (FBG) of ≥ 7 mmol/L.

Independent variables

This survey involved structured and validated questionnaires that covered information on general household, socio-demographic, and specific health problems. The categorical variables that were considered were "sex" (male, female), "age group" (18-39, 40-59, 60 & above), "residence" (urban, rural), "ethnic" (Malay, Chinese, Indian, other indigenous, others), "education level" (no formal education, primary school education, secondary school education, tertiary education, unclassified), "marital status" (single, married, widow/ widower/divorcee) and "occupational status" (working, not working). Meanwhile, in the section on specific health problems, we've included "physical activity" (active, inactive, "obesity" (non-obese, obese), "blood pressure

status" (normotensive, hypertensive), and "cholesterol status" (normal cholesterol, high cholesterol).

Trained research assistants did the clinical anthropometric measurements while qualified nurses took the finger-prick biochemistry tests. Informed consent was obtained from all the respondents before the questionnaire was administered. All followed the protocol for blood glucose intake and blood pressure measurements.

This survey used blood pressure assessments of respondents using the Omron Japan Model HEM-907. Three readings were taken from each respondent, and an average of the second and third readings was computed for the findings. Respondents were considered hypertensive if their average systolic blood pressure was ≥140 mmHg and /or diastolic blood pressure ≥90 mmHg or were self-reported hypertensive.

The cholesterol level of respondents was measured using a finger-prick method with the CardioChek® portable blood test system. A validated and calibrated HemoCue® Machine Hb 201+ was used to measure haemoglobin level, and respondents were considered high cholesterol if they had a total cholesterol of 5.2mmol/L or more.

The weight of respondents was measured in kilograms using a digital weighing machine, Tanita Personal Scale HD 319, and height was measured in centimetres using SECA Stadiometer 213. Both tools had also been validated and calibrated before the survey was conducted. BMI was calculated as weight divided by height squared. Respondents with a BMI of 30.0 kg/m2 or more were classified as obese.

The physical activity level of respondents was assessed using the short form of the International Physical Activity Questionnaire (IPAQ). Respondents were classified as physically active if they achieved a minimum combination of vigorous-intensity, moderate-intensity, and walking activities of 600 metabolic equivalent of task (MET) minutes/week.[14]

Statistical Analysis

Data were entered, cleaned, and analysed using SPSS (Statistical Package for Social Science) Version 20 (SPSS, Chicago, IL, USA). Descriptive statistics were calculated to describe the data as frequencies and percentages. All analyses were weighted using sample weights provided by the Department of Statistics Malaysia (DOSM) to ensure that the estimates were representative of the Malaysian adult population. Crude and adjusted odds ratios (ORs) were calculated with 95% confidence intervals (CIs) and standard deviations (SDs). Pearson's chi-square test was used to determine the association between categorical variables.

Multiple logistic regression analysis was performed to identify factors associated with DM while controlling for potential confounders. Variable selection was based on significant changes in the -2 log-likelihood ratio. The outcome variable was DM, and the predictor variables included age group, ethnic group, education level, marital status, occupational status, physical activity level, obesity, blood pressure status, and cholesterol status. Adjusted odds ratios (aORs) and 95% confidence intervals (CIs) were estimated. Statistical significance was set at a P value <0.05.

RESULTS

Socio-demographic characteristics of the study respondents

The total number of respondents to the DM questionnaire was 10,472. The proportion of female respondents was slightly higher, comprising 54.3% of the total sample. Based on age, respondents aged 18-39 made up 41.3%, and the majority of the respondents (60.9%) were from the urban population. Respondents who were Malays were the majority ethnic group with 64.8%, followed by Chinese (12.7%) and other indigenous groups (10.3%). More than 60.0% of respondents had received either a primary or secondary school education. Nearly 70.0% of respondents were married, and more than 50.0% of respondents were still employed (Table I).

Table I: Socio-demographic characteristics of the respondents (N= 10,472)

Socio-demographic characteristic	N	%
Gender		
Male	4785	45.7
Female	5687	54.3
Age group (mean, sd): (45.6, 16.9)		
18-39	4322	41.3
40-59	3697	35.3
60 & above	2453	23.4
Residence		
Urban	6380	60.9
Rural	4092	39.1
Ethnic group		
Malay	6787	64.8
Chinese	1327	12.7
Indian	662	6.3
Other indigenous	1078	10.3
Others	618	5.9
Education level		
No formal education	644	6.2
Primary school education	2379	22.8
Secondary school education	4969	47.6
Tertiary education	2425	23.2
Unclassified	31	0.3
Marital status		
Single	2186	20.9
Married	7154	68.3
Widow/widower/divorcee	1132	10.8
Occupation status		
Working	5944	56.8
Not working	4520	43.2

Prevalence of diabetes mellitus by socio-demographic characteristics

The prevalence of DM in this study was 18.3% (95% CI: 17.08, 19.58). There were differences in the various age groups, ethnic groups, education status, marital status, occupational status, physical activity, obesity, status of hypertension and cholesterol. However, gender and rural/ urban status were not important factors in this study.

Factors associated with diabetes mellitus

The risk factors identified using the logistic regression model based on sociodemographic and health characteristics were like those identified using the fully adjusted model. There was a positive association between older age groups and the risk of DM. The risk of DM was significantly higher in individuals aged 40-59 years [aOR 1.95(95% CI: 1.68,2.27)] and 60 years old and above [aOR 2.68 (95% CI: 2.23,3.20)]. In addition, the risk of DM was significantly associated with ethnic groups [Malays: aOR1.77 (95% CI: 1.50,2.09) and Indians: aOR 3.02 (95% 2.38, 3.83)], educational level [no formal education: aOR 1.37 (95% CI: 1.07, 1.76) and secondary education: aOR1.20 (95 CI: 1.04, 1.38)], marital status (married: aOR 1.79 (95% CI: 1.49, 2.16)] and widow/widower/divorced: aOR1.83 (95 CI: 1.45, 2.31)], physically inactive: aOR 1.21 (95% CI: 1.07,1.36)], obese: aOR1.63 (95% CI: 1.45,1.83)], hypertensive: aOR 2.19 (95% CI: 1.95, 2.45) and high cholesterol: aOR 1.93 (95% CI: 1.73,2.15)]. No significant associations were found for gender, residence (rural/ urban), and occupational status.

Table II: Prevalence of Diabetes Mellitus Among Adults Aged ≥18 Years by Sociodemographic and Clinical Characteristics

Demographic Characteristics	Diabetes Mellitus			
	count	Prevalen (%)	% (95 CI) Lower	Upper
National	2629	18.3	17.08	19.58
Gender				
Male	1191	18.2	16.63	19.90
Female	1438	18.4	16.99	19.89
Age group				
18-39	438	8.4	7.16	9.75
40-59	1129	25.3	23.27	27.47
60 & above	1062	41.5	38.54	44.55
Residence				
Urban	1519	18.3	16.8	19.8
Rural	1110	18.3	16.48	20.4
Ethnic group				
Malay	1868	21.6	20.02	23.17
Chinese	276	15.1	25.85	37.53
Indian	250	31.4	25.85	37.53
Other indigenous	160	11.6	9.15	14.62
Others	75	8.8	6.21	12.21
Education level				
No formal education	231	28.7	23.10	34.94
Primary school education	795	23.9	21.14	26.98
Secondary school	1196	18.1	16.59	19.77
Tertiary education	399	12.7	10.76	14.85
Unclassified	3	4.8	1.21	17.18
Marital status				
Single	195	7.7	6.27	9.53
Married	1975	21.3	19.74	22.94
Widow/widower/divorcee	459	33.2	29.27	37.30
Occupation status				
Working	1166	14.5	13.06	16.01
Not working	1461	24.9	23.23	26.65
Physical activity				
Active	1799	16.8	15.49	18.23
Inactive	796	22.5	20.26	24.81
Obesity				
Non-Obese	1702	16.0	14.76	17.38
Obese	747	27.1	24.31	30.05
Blood pressure status				
Normotensive	916	10.7	9.54	12.04
Hypertensive	1713	36.0	33.84	38.16
Cholesterol status				
Normal cholesterol	839	10.9	9.62	12.22
High cholesterol	1790	30.4	28.48	32.42

Note: Values represent the prevalence of diabetes mellitus in the general population, not proportions within the diabetic subgroup. Weighted analysis was applied to reflect national population estimates.

Table III: Factors associated with diabetes mellitus (using multiple logistic regression)

Risk Factors	Simple Logistic Regression		Multiple Logistic	
	Crude OR (95% CI)	p-value	adjusted Odds Ratio (aOR)*	p-value
Gender				
Male	1.00	-	-	-
Female	1.02 (0.94, 1.12)	0.629	-	-
Age group				
18-39	1.00		-	
40-59	3.99 (3.45, 4.40)	<0.00	1.95 (1.68, 2.27)	<0.00
60 & above	6.76 (5.96, 7.68)	<0.00	2.68 (2.23, 3.20)	<0.00
Residence				
Rural	1.19 (1.09,1.31)	<0.00	-	-
Urban	1.00		-	-
Ethnic group				
Chinese	1.00		-	-
Malays	1.45 (1.25,1.67)	<0.00	1.77 (1.50, 2.09)	<0.00
Indians	2.31 (1.88,2.84)	<0.00	3.02 (2.38, 3.83)	<0.00
Other Bumiputra	0.66 (0.54, 0.82)	<0.00	0.82 (0.64, 1.04)	0.103
Others	0.53 (0.40, 0.70)	<0.00	0.92 (0.68, 1.26)	0.616
Education level				
No formal education	2.84 (2.34, 3.45)	<0.00	1.37(1.07,1.76)	0.012
Primary education	2.55 (2.22, 2.93)	<0.00	1.18 (0.99,1.40)	0.061
Secondary education	1.61 (1.42, 1.83)	<0.00	1.20 (1.04,	0.012
Tertiary education	1.00		-	-
Marital status				
Single	1.00	-	-	-
Married	3.89 (3.33, 4.54)	<0.00	1.79 (1.49, 2.16)	<0.00
Widow/widower/	6.95 (5.75, 8.39)	<0.00	1.83 (1.45, 2.31)	<0.00
Occupation status				
Working	1.00	-	-	-
Not working	1.96 (1.79, 2.14)	<0.00	-	
Physical activity level				
Active	1.00	-	-	-
Inactive	1.39 (1.26, 1.54)	<0.00	1.21 (1.07, 1.36)	0.002
Obesity				
Non-Obese	1.00		-	-
Obese	1.86 (1.68, 2.07)	<0.00	1.63 (1.45, 1.83)	<0.00
Blood pressure status				
Hypertensive	4.38 (3.99, 4.81)	<0.00	2.19 (1.95, 2.45)	<0.00
Normotensive	1.00		-	
Cholesterol status				
Normal cholesterol	1.00		-	
High cholesterol	3.40 (3.10,3.74)	<0.00	1.93 (1.73, 2.15)	<0.00

*Backward likelihood ratio multiple logistic regression was applied. Multicollinearity and interaction were checked and not detected. The Hosmer–Lemeshow test (p = 0.074), classification table (overall correctly classified percentage = 76.9%), and receiver operating characteristic (ROC) curve (77.0%) indicated acceptable model fitness.

DISCUSSION

In this cross-sectional survey, we provide information about the associated factors of diabetes mellitus (DM) among adults in Malaysia. The prevalence of DM in the current study was found to be high at 18.3% (95% CI: 17.08, 19.58), which means that 1 in 5 Malaysians has DM. The prevalence from our survey is highest compared to studies conducted in other countries, including China (13%), Indonesia (10.8%), Thailand (11.6%), Singapore (14.7%), Nepal (8.5%), and Brazil (7.5%).[15,16,17]

However, when compared to countries in the Arab World, the prevalence studies are lower in Malaysia: e.g. the Kingdom of Arabia at 31.6%, Oman at 29.0%, Kuwait at 25.4%, and Bahrain at 25.0%.[17] The International Diabetes Federation's (IDF) 10th edition of the Diabetes Atlas reported that 537 million adults worldwide were living with diabetes in 2021, a figure projected to rise to 783 million by 2045. Even more concerning is the fact that approximately 240 million people, around 44.7% of all adults with diabetes, remain undiagnosed and unaware of their condition.[18]

The high prevalence of DM among Malaysian adults could be partly due to a lack of awareness of the necessity of health screening at an earlier age and of early diabetes symptoms. Another issue that prevents Malaysians from getting screened for diabetes is the high patient load in public primary healthcare facilities.[19] Population increase, population ageing, growing urbanisation, rising obesity and physical inactivity rates, particularly seen in developing and developed nations, could all be contributing factors.

Based on Table II, the prevalence of DM rose with age and was substantially more significant (41.5%) in people 60 years and older. Furthermore, based on Table III, our findings reveal that age was the one factor that showed the highest effect on the risk of DM. This finding is similar to findings in other studies in Saudi Arabia, Kenya and Vietnam, where the disease has become more common among the elderly,[20,21,22] which showed that further age-related glucose intolerance is related to decreased insulin sensitivity and decreased β-cell function.[23] This is most likely brought on by an ageing population's increased propensity to gain weight, loss of muscle mass, and being engaged in less physical activity. It is known that cells in the body are more resistant to insulin when there is a greater abundance of fatty tissue.[24]

This study shows a high prevalence of DM among Malaysian Indians, followed by Malays and Chinese. This pattern has been consistently observed in previous NHMS cycles, including NHMS 2011[4] and 2015[5], where Indian respondents also had the highest prevalence rates. In the current analysis, Indian ethnicity was associated with a more than threefold increased risk of DM (aOR: 3.02, 95% CI: 2.38-3.83), while Malay ethnicity also showed a significantly elevated risk (aOR: 1.77, 95% CI: 1.50-2.09) compared to the Chinese population.

Several factors may contribute to this ethnic disparity. There is growing evidence of genetic susceptibility to insulin resistance and central adiposity within South Asian populations, especially Indians, which may further elevate diabetes risk.[25] As for Malays, dietary habits, increasing urbanisation, and rising obesity rates are likely contributing factors. In contrast, the relatively lower prevalence among Chinese Malaysians may be linked to healthier dietary patterns, greater health awareness, and possibly more proactive health-seeking behaviours.[26] These findings underscore the importance of culturally tailored diabetes prevention strategies that consider ethnic-specific risk profiles in the Malaysian context.

Table II's data indicate that married and widow/widower/ divorced individuals have a greater frequency of DM than single individuals. The result in Table III shows that married individuals are 1.79 times more likely to have DM; meanwhile, widow/widower/ divorced individuals are 1.83 times more likely to have DM compared to single individuals. Economic stability often changes with marital transitions. Widowed individuals may experience financial constraints due to the loss of a partner's income, impacting their ability to access healthcare and maintain a healthy lifestyle. Economic hardships have been associated with higher diabetes prevalence.[27]

Regarding educational attainment, based on Table II, a higher prevalence was observed in those without formal education, followed by those with primary education. There was a statistically significant association between education status and DM. Lower awareness and fewer opportunities for prevention and control may be linked to lower education levels, but not higher education. However, the current study is unlike earlier studies that found no connection.[28] Further research is needed to confirm the association between DM and education level.

According to the findings in this study, obese people had a higher risk of DM. The results showed that the risk of DM was 1.63 times higher in obese individuals. A recent meta-analysis provides evidence of the strong association between obesity and type 2 diabetes mellitus (T2DM). The study highlights that obesity is the most significant risk factor for the development and progression of T2DM, with excess adiposity leading to insulin resistance and β-cell dysfunction. Recent studies have elucidated the mechanisms by which abdominal fat accumulation contributes to insulin resistance. Excess visceral adipose tissue releases elevated levels of free fatty acids (FFAs) into the bloodstream, which can impair the insulin signalling pathways in the liver and muscle tissues, leading to decreased insulin sensitivity. Additionally, adipocytes secrete pro-inflammatory cytokines such as interleukin-6 (IL-6) and tumour necrosis factor alpha (TNF-α), which further disrupt insulin action by interfering with insulin receptor signalling and promoting systemic inflammation.[30]

The present study found that the risk of DM was 1.21 times higher among inactive individuals. Recent research underscores a significant inverse relationship between physical activity and the risk of developing T2DM. A 2025 population-based cohort study found that higher levels of physical activity across various domains were independently associated with a lower risk of T2DM.[31] Notably, individuals who combined high physical activity with an anti-inflammatory diet experienced an even greater reduction in diabetes risk.[32]

According to our study, respondents with hypertension had a 2.19-fold increased risk of having DM. Similar findings were reported in a study by Pakistan[33] and Ethiopia.[34] Hypertension and T2DM frequently co-occur due to shared pathophysiological mechanisms such as insulin resistance, endothelial dysfunction, chronic inflammation, and activation of the renin-angiotensin-aldosterone system (RAAS).[35] These conditions are also driven by overlapping risk factors, including obesity, physical inactivity, and unhealthy dietary patterns, contributing to their high rate of co-occurrence.[36] Similarly, these relationships significantly raise the risk of cardiovascular problems as a result of insulin resistance.[37] In older people, high blood pressure doubles the risk of developing diabetes.[38]

Our results also showed respondents with high cholesterol had a 1.19-fold increased risk of having DM. This finding aligns with recent research indicating that dyslipidaemia,

particularly elevated levels of low-density lipoprotein cholesterol (LDL-C) and small dense LDL-C, is significantly associated with an increased risk of developing T2DM. For instance, a 2024 large-scale multicentre retrospective cohort study in China found a nonlinear positive association between estimated small dense LDL-C levels and the risk of developing DM, suggesting that even modest elevations in certain cholesterol subtypes can substantially impact diabetes risk.[39]

Improving Diabetes Awareness in the Malaysian Population

In order to improve diabetes awareness in Malaysia, efforts undertaken must address existing gaps in knowledge dissemination, risk perception, and accessibility to screening services, especially among high-risk populations. While the National Strategic Plan for Non-Communicable Diseases (NSP-NCD) 2016-2025 outlines broad goals for NCD awareness, implementation on the ground remains fragmented and limited in reach.

One key area for enhancement is the integration of diabetes risk communication into routine community health activities led by *Klinik Kesihatan* and KOSPEN volunteers. Currently, KOSPEN's focus is primarily on general lifestyle advice. Expanding its scope to include personalised diabetes risk assessment and targeted messaging, particularly in communities with a high proportion of Indian or older adult populations, can increase its impact. Additionally, many community health promoters lack culturally tailored materials in different languages and dialects (Tamil, Mandarin, and indigenous languages), which can be addressed to improve engagement.

Secondly, Malaysia lacks a nationwide, easily accessible digital diabetes risk calculator, unlike Singapore's "Diabetes Risk Assessment Tool"[40] or the UK's "Know Your Risk" tool by Diabetes UK.[41] A locally adapted version hosted on MySejahtera, or the Ministry of Health's website, could allow individuals to self-assess their risks and receive tailored advice or be prompted to undergo screening at the nearest clinics.

Thirdly, school-based diabetes education is currently minimal and often limited to general health promotion weeks. Embedding structured diabetes awareness content into the *Pendidikan Jasmani dan Kesihatan* (PJPK) syllabus, beginning from lower secondary school, can instil early awareness, particularly targeting students with family histories of DM.

Additionally, the use of religious platforms and Friday Mosque khutbahs,[42] as has been successfully done for vaccination and smoking cessation awareness,[43] can be adapted in Malaysia for DM. This approach would help reach older males, a group often under-screened despite being at higher risk.

Lastly, while workplace health screenings are encouraged, they are not mandated or standardised across the public or private sector. Incentivising employers, through tax benefits or HRDF-linked programmes, to conduct annual diabetes risk assessments and provide follow-up education could close this gap, particularly among sedentary office workers.

In summary, improving diabetes awareness in Malaysia will require not only strengthening existing programmes but also adopting best practices from successful regional models, improving community outreach, and embedding structured risk communication across schools, workplaces, and digital platforms.

This study has several notable strengths. Firstly, this study utilises data from the NHMS 2019, a large-scale, population-based survey with high response rates and robust sampling design, ensuring national representativeness of the adult population in Malaysia. The use of trained interviewers, structured and validated bilingual questionnaires, and standardised data collection protocols has enhanced the reliability and consistency of the information gathered. Additionally, objective clinical measurements such as fasting blood glucose, blood pressure, and anthropometric indicators were incorporated alongside self-reported data, reducing sole reliance on subjective reporting. The application of sample weights provided by the Department of Statistics

Malaysia further strengthens the generalisability of the findings. Finally, the study's analytical approach, including the use of multivariable logistic regression, allowed for the comprehensive identification of independently associated risk factors for DM, offering valuable insight for targeted public health interventions.

This study has several limitations. Although NHMS 2019 was a nationally representative survey, the analysis was constrained by the limited number of variables available on potential risk factors for undiagnosed DM. In addition, the study relied partly on self-reported data, which may be subject to recall bias and underreporting, particularly regarding medical history and lifestyle behaviours. The cross-sectional design also limits the ability to establish causal relationships between the identified risk factors and DM. Furthermore, obesity classification in this study was based on WHO criteria (BMI ≥30 kg/m^2), in line with previous NHMS methodologies. However, we acknowledge that this may underestimate obesity-related risks among Asian populations, for whom lower BMI thresholds are recommended in the 2023 Malaysian Clinical Practice Guidelines (CPG) on obesity.

CONCLUSION

In Malaysia, the number of people with diabetes mellitus increased significantly in 2019. The findings of this study indicate that age, ethnicity, educational attainment, marital status, degree of physical activity, obesity, blood pressure, and cholesterol are significantly associated with diabetes mellitus. Awareness programs and interventions on diabetes need to be improved, especially related to behavioural change as a strategy for the prevention and control of diabetes and its complications. The public must be made more aware of the significance of early diabetic screening, particularly among individuals 60 years of age and older and among high-risk populations, to prevent more severe complications and lessen the burden of this disease.

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CONFLICT OF INTEREST

The authors declare no competing interests.

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INSTITUTIONAL REVIEW BOARD (ETHIC COMMITTEE)

This study obtained ethical approval from the Medical Research and Ethics Committee of the Ministry of Health Malaysia and was registered in the National Medical Research Registry, bearing registration number NMRR-18 -3085-44207. Informed consent was obtained from all the respondents before the questionnaire was administered.

CONSENT FOR PUBLICATION

Not applicable

AVAILABILITY OF DATA AND MATERIALS

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

AUTHORS' CONTRIBUTIONS

HI oversaw all aspects of the study and was also involved in the writing of the manuscript. TAS was involved in supervising nationwide data collection and contributed significantly to the writing of the manuscript. TGRL was involved in data collection and writing. WSRH contributed to the data analysis and writing, NLAM were involved in the data collection and writing of the manuscript, MFMY was involved in cleaning the raw data and data analysis and contributed to manuscript writing.

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