



Poor Glycaemic Control and its Associated Factors among Type 2 Diabetes Mellitus Patients in Southern Part of Peninsular Malaysia: A Registry-based Study

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Abstract

BACKGROUND: Type 2 diabetes mellitus (T2DM) is a growing global health concern that is likely to reach a pandemic level by 2030 and is one of the leading causes of death globally. Recently, T2DM has been causing an increase in premature mortality including in developing countries.

AIM: This study aimed to determine the prevalence and the factors associated with poor glycaemic control among T2DM patients in Segamat, Malaysia.

METHODS: The study population was selected from the National Diabetic Registry database between June 2019 and September 2020 which included a total of 3100 patients. General and clinical information were retrieved from the registry. Glycaemic control was categorized as good (HbA1c \leq 6.5%) or poor (HbA1c $>$ 6.5%). Univariable and multivariable logistic regression were performed to assess the factors of poor glycaemic control.

RESULTS: More than half (59.2%) of the patients had poor glycaemic control. As high as, 55.1% of older patients (\geq 60 years old) had poorer glycaemic control. Most patients with poor glycaemic control (62.0%) were obese. Multiple logistic regression analysis revealed that age (\geq 60 years old), ethnicity (Malay and Indian), more than 10 years of diabetes, obesity, early diabetes onset before 40 years, and dyslipidemia were associated with poor glycaemic control.

CONCLUSION: These findings can provide the necessary guidance for the stakeholders in identifying T2DM patients at risk of poor glycaemic control so that early preventive measures and organized care can be provided for the patients.

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Introduction

Type 2 diabetes mellitus (T2DM) is one of the most common metabolic disorders worldwide. It is a severe, and long-term disease characterized by an elevated glucose level in the blood. The disorder arises from the failure of the body to generate an adequate amount of insulin or to efficiently utilize the insulin [1]. The prolonged state of hyperglycemia will eventually result in multiple organ damage, leading to disabling and multi systems complications such as cardiovascular diseases, neuropathy, nephropathy, and retinopathy [2]. The prevalence of T2DM is rising at a faster rate in low- and middle-income countries than in high-income countries, with the Eastern Mediterranean and the South East Asian region recorded the highest prevalence [3].

Similarly, Malaysia is not spared of the same diabetic epidemic. The National Health and Morbidity Survey 2019 revealed an increasing trend of diabetes and hypercholesterolemia. The prevalence of diabetes

increased from 11.2% in 2011 to 13.4% in 2015 and 18.3% in 2019. The prevalence of hypercholesterolemia also increased from 35.1% in 2011 to 47.7% in 2015 [4]. There was a small dip to 38.1% in 2019 [4]. Cardiovascular and circulatory diseases, a common complication among diabetic patients, contributed to 34.8% of deaths nationwide [5]. Hence, with the increasing prevalence of diabetes in Malaysia, good glycaemic control is crucial to prevent lifelong complications of diabetes mellitus (DM) [6].

Despite significant advances in diagnosis and management, numerous patients still have not achieved targeted glycaemic control. It may be caused by the paucity of information available to patients on the importance of practicing diabetes self-care, as well as the lack of intervention strategies by health-care practitioners [7]. Although T2DM is often associated with an ageing population, a few studies showed that the onset of DM is shifting toward the younger population. Early onset of T2DM is defined as a patient who is diagnosed with T2DM before the age of 40 as compared to the usual onset of T2DM at 40 years old

and above [8]. Many studies reported that individuals with early onset of T2DM were at a higher risk of developing vascular complications than individuals with late-onset diabetes [9], [10]. In view of multiple complications among T2DM patients, these conditions will further compromise their productivity and quality of life [11].

Worldwide, many countries face similar challenges in the management of T2DM, including the maintenance of glycemic control [12]. This alarming situation triggered the need for the relevant stakeholders to take prompt actions in tackling this problem, knowing the predisposing factors for poor glycemic control can be effective in controlling DM and avert lifelong complications [6]. Until now, there have been limited studies done specifically in Segamat, Malaysia in identifying the related factors that contribute to poor glycemic control by using existing data from the registry. Hence, the main aim of this study was to identify factors associated with poor glycemic control among patients with T2DM in Segamat, Malaysia.

Methods

Study design and sampling methods

A cross-sectional survey was conducted to evaluate the glycemic control of T2DM patients and associated factors at 10 primary health-care facilities in the district of Segamat, Johor from December 2020 to May 2021 using secondary data from the National Diabetic Registry (NDR) database. Johor is the second biggest city state in Malaysia. It located is in the Southern part of Malaysia. All newly registered patients with T2DM and the patients receiving follow-up care from June 2019 to September 2020 were identified from the NDR. The study population comprised of patients aged ≥ 18 years old with a confirmed diagnosis of DM at participating sites. The inclusion criteria were T2DM patients who underwent diabetes clinic follow-up at least once at any of the 10 health clinics. Exclusion criteria included T2DM patients who died, patients who were lost to follow-up, and patients whose data in the registry were insufficient.

Sample size

The sample size was calculated using the Kish-Leslie formula (1965) [13]. According to this Kish-L formula, whereby, sample size, $n = (Z^2 PQ)/d^2$; Z is 1.96 (standard normal deviation at 95% confidence interval); the prevalence of poor glycemic control among T2DM in Johor is adapted from a study by Mahmood *et al.* 2016 which was 68% [14]. Q is 1-P, $Q = 1 - 0.68$; therefore, $Q = 0.32$; d is the maximum error allowed between the

estimated prevalence of the problem in the population; thus, $d = 5\%$ (95% confidence interval); $n = (Z^2 PQ)/d^2$; $n = (1.96)^2 \times (0.68 \times 0.32)/(0.05)^2$; hence, the minimum sample size required was 334 respondents.

From the NDR, we were able to extract 4457 subjects, and a total of 3100 subjects were selected for analysis after removing all missing data. A simple randomized sampling was applied to select the subjects from the T2DM patients in the Segamat district who fulfilled the inclusion criteria. Data on age, gender, ethnicity, body mass index (BMI), waist circumference, the date of diagnosis, duration of T2DM, comorbidities (hypertension and dyslipidemia), latest HbA1C level, pharmacological treatment, and the presence of diabetes-related complications (retinopathy, nephropathy, ischemic heart disease, cerebrovascular disease, and diabetic foot ulcer) were extracted from the NDR.

Variables

In this study, the dependent variable was glycemic control. According to Malaysian Clinical Practice Guideline for T2DM, HbA1c level was used as an indicator for glycemic control [15]. HbA1c $> 6.5\%$ was considered as poor glycemic control and HbA1c $\leq 6.5\%$ was considered as good glycemic control [15]. On the other hand, independent variables included demographic factors such as age, ethnicity, and gender. Other independent variables in this study were the onset of diabetes, the duration of diabetes, BMI, diabetes-related complications (diabetic foot ulcer, amputation, retinopathy, and nephropathy), and comorbidities (hypertension, ischemic heart disease, and dyslipidemia). BMI was categorized as normal ($< 25 \text{ kg/m}^2$), overweight ($\geq 25 \text{ kg/m}^2$), or obese ($\geq 30 \text{ kg/m}^2$) [15]. Systolic blood pressure $\geq 130 \text{ mmHg}$ or diastolic blood pressure $\geq 80 \text{ mmHg}$ on each of two successive readings obtained by the physicians was indicated as hypertension. Fasting blood glucose and waist circumference were treated as continuous data.

Statistical methods

In this study, data were analyzed using the Statistical Package for the Social Sciences version 23 (IBM Corp, NY, USA). Data such as age group, BMI, the onset of diabetes, and others were categorized and presented as proportion and percentage. Continuous variables such as waist circumference and fasting blood glucose were presented as mean and standard deviation. Pearson's Chi-square test was used to determine the association between categorical independent variables. Statistical significance was taken as $p < 0.05$ and confidence interval 95%. Simple and multiple logistic regression were applied to determine the factors associated with poor glycemic control among T2DM patients in Segamat, Malaysia.

Results

The sociodemographic characteristics of the participants are presented in Table 1. The most of the participants were ≥ 60 years old (67.6%), females (73.9%), and Malays (60.2%). Overall, 59.2% of the participants had poor glycemic control. The proportion of participants diagnosed with diabetes after 40 years old was 90.5%, while 42.9% of them had been diagnosed with the disease for more than 10 years. The mean and standard deviation for fasting blood glucose and waist circumference among the participants were 7.9 ± 3.45 mmol/L and 92.8 ± 12.38 cm, respectively. A total of 46.9% of them were obese and 36% were overweight. A total of 61.0% had a systolic blood pressure of ≥ 130 mmHg, and 32.7% had a diastolic blood pressure of ≥ 80 mmHg. The most common

Table 1: Sociodemographic and clinical characteristics of the T2DM patients in Segamat, Malaysia (n = 3,100)

Sociodemographic characteristics	Frequency (f)/(Mean \pm SD)	Percentage
Age (years old)		
<60	1005	32.4
≥ 60	2095	67.6
Gender		
Male	809	26.1
Female	2291	73.9
Race		
Malay	1865	60.2
Chinese	793	25.6
Indian	428	13.8
Others	14	0.4
Duration of diabetes (years)		
<10	1770	57.1
≥ 10	1330	42.9
Diabetes onset		
Early onset (<40 years old)	294	9.5
Usual onset (≥ 40 years old)	2806	90.5
Hypertension		
Yes	2598	83.8
No	502	16.2
Dyslipidemia		
Yes	2453	79.1
No	647	20.9
Ischemic heart disease		
Present	253	8.2
Absent	2847	91.8
BMI Classification		
Underweight	75	2.4
Normal	455	14.7
Overweight	1117	36.0
Obese	1453	46.9
HbA1c		
$\leq 6.5\%$	1266	40.8
$> 6.5\%$	1834	59.2
Systolic blood pressure		
<130mmHg	1210	39.0
≥ 130 mmHg	1890	61.0
Diastolic blood pressure		
<80mmHg	2086	67.3
≥ 80 mmHg	1014	32.7
Fasting blood glucose (mmol/L)	7.904 \pm 3.45	
Waist circumference (cm)	92.77 \pm 12.38	
Retinopathy		
Absent	2793	90.1
Present	307	9.9
Diabetic foot ulcer		
Absent	3056	98.6
Present	44	1.4
Nephropathy		
Absent	2648	85.4
Present	452	14.6
Amputation		
Absent	3072	99.1
Present	28	0.9
Metformin		
Yes	2685	86.6
No	415	13.4
Insulin		
Yes	924	29.8
No	2176	70.2

*Data are mean \pm SD, or f (%), T2DM: Type 2 Diabetes mellitus, BMI: Body mass index.

comorbidity was hypertension (83.8%), followed by dyslipidemia (79.1%) and ischemic heart disease (8.2%). Furthermore, nephropathy accounted for the most prevalent diabetes-related complication (14.6%), followed by retinopathy (9.9%), and diabetic foot ulcer (1.4%). A small proportion of respondents (0.9%) had undergone amputation of the affected limb. The majority of the participants (86.6%) were on metformin, whereas 29.8% were on subcutaneous insulin.

Table 2 shows the association between sociodemographic factors and glycemic control among T2DM patients in Segamat, Malaysia. The significant factors associated with glycemic control among the participants were age, ethnicity, duration of diabetes, diabetes onset, and BMI. Comorbidity and disease complications significantly associated with glycemic control were dyslipidemia and retinopathy.

Multiple logistic regression was used. No multicollinearity was detected and no significant interaction was noted. Hosmer Lemeshow test shows $p = 0.571$. The classification table shows 73% correctly classified.

Table 2: Bivariable analysis to identify factors associated with glycemic control among T2DM patients in Segamat, Malaysia

Variables	Glycemic control		χ^2	p-value
	Poor (HbA1c > 6.5)	Good (HbA1c \leq 6.5)		
Age (years old)				
<60	680 (67.7)	325 (32.3)	44.475	<0.001*
≥ 60	1154 (55.1)	941 (44.9)		
Gender				
Male	458 (56.6)	351 (43.4)	2.942	0.088
Female	1376 (60.1)	915 (39.9)		
Race				
Malay	1155 (61.9)	710 (38.1)	55.848	<0.001*
Chinese	383 (48.3)	410 (51.7)		
Indian	287 (67.1)	141 (32.9)		
Others	9 (64.3)	5 (35.7)		
Duration of diabetes (years)				
<10	924 (52.8)	836 (47.2)	69.787	<0.001*
≥ 10	900 (67.7)	430 (32.3)		
Diabetes onset				
Early onset (<40 years old)	227 (77.2)	67 (22.8)	43.797	<0.001*
Usual onset (≥ 40 years old)	1607 (57.3)	1199 (42.7)		
Systolic blood pressure				
<130mmHg	716 (59.2)	494 (40.8)	0.834	0.361
≥ 130 mmHg	1118 (59.2)	772 (40.8)		
Diastolic blood pressure				
<80mmHg	1231 (59.0)	855 (41.0)	0.058	0.809
≥ 80 mmHg	603 (59.5)	411 (40.5)		
Hypertension				
Yes	1522 (72.3)	1076 (27.7)	2.217	0.137
No	312 (75.1)	190 (24.9)		
Dyslipidemia				
Yes	1492 (60.8)	961 (39.2)	13.440	<0.001*
No	342 (52.9)	305 (47.1)		
Ischemic heart disease				
Present	149 (58.9)	104 (41.1)	0.112	0.928
Absent	1685 (59.2)	1162 (40.8)		
BMI classification				
Underweight	27 (36.0)	48 (64.0)	34.670	<0.001*
Normal	232 (51.0)	223 (49.0)		
Overweight	675 (60.4)	442 (39.6)		
Obese	899 (62.0)	552 (38.0)		
Retinopathy				
Absent	1635 (58.5)	1158 (41.5)	4.517	0.034*
Present	199 (64.8)	108 (35.2)		
Diabetic foot ulcer				
Absent	1802 (59.0)	1254 (41.0)	3.40	0.065
Present	32 (72.7)	12 (27.3)		
Nephropathy				
Absent	1561 (59.0)	1087 (41.0)	0.335	0.563
Present	273 (60.4)	175 (39.6)		
Amputation				
Absent	1813 (59.0)	1259 (41.0)	2.934	0.087
Present	21 (87.0)	7 (13.0)		

*Significant at $P < 0.05$, T2DM: Type 2 Diabetes mellitus, BMI: Body mass index.

In Table 3, the significant factors of poor glycaemic control based on multivariable logistic regression were age, ethnicity, diabetes onset, duration of diabetes, BMI, and dyslipidemia. Patients ≥60 years old had 1.72 higher odds (95% Confidence interval [CI]: 1.43–2.07) to have poor glycaemic control compared to other age group. Indian patients had 1.97 higher odds (95% CI: 1.53–2.54) and Malay patients had 1.58 higher odds (95% CI: 1.33–1.89) of having poor glycaemic control compared to other ethnicities. Those diagnosed with DM for more than 10 years also had 1.83 higher odds (95% CI: 1.57–2.14) of having poor glycaemic control. Similarly, patients who were diagnosed with T2DM before 40 years old had 1.59 higher odds (95% CI: 1.08–2.35) of poor glycaemic control. In addition, patients who were obese and overweight had 1.38 and 1.26 higher odds of poor glycaemic control, respectively, compared to those with normal body weight. Other than that, patients with dyslipidemia also showed 1.30 higher odds (95% CI: 1.08–1.56) of having poor glycaemic control.

Discussion

In this study, the prevalence of T2DM patients with poor glycaemic control in the Segamat was 59.2%. However, another study in northern part of Malaysia reported a high prevalence of poor glycaemic control, that is, 79.6% [16]. The variation of the prevalence of poor glycaemic control may be due to different place of the study and the instrument being used. The factors associated with poor glycaemic control in this study were age, ethnicity, duration of diabetes, the onset of diabetes, BMI (overweight and obese), and dyslipidemia. In terms of the sociodemographic characteristics, 55.1% of T2DM patients within the age more than 60 years

old had poor glycaemic control. A previous survey of 706 participants also reported a similar outcome whereby 63% of the patients above 60 years old showed poor glycaemic control [14]. The condition is possible due to the progressive loss of function of the pancreatic β-cells among T2DM patients [17].

Malay and Indian ethnicities had higher odds of poor glycaemic control. Malaysia is a multi-ethnic country comprising of three main ethnic groups: Malay, Indian, and Chinese. Our finding echoed a study in which Malay and Indian T2DM patients were found to have significantly poorer glycaemic control than Chinese patients [7]. Their susceptibility to T2DM and diabetes-related complications may differ due to their underlying socioeconomic status that affects access to health-care services [18]. Abdullah *et al.* also reported that T2DM patients of Malay and Indian ethnicities had a higher level of insulin resistance than their Chinese counterparts [19]. Apart from that, patients who were diagnosed with T2DM for more than 10 years were also associated with poor glycaemic control in this study. In the previous literature, patients with diabetes for more than 10 years were found to have higher risk of poor glycaemic control [19]. The duration of T2DM is closely linked to disease progression [20]. A longer duration of diabetes often leads to poor glycaemic control due to the continuing loss of function of the pancreatic β-cells [17]. Moreover, with a longer life expectancy, DM patients are increasingly afflicted with new complications such as infections, physical, and cognitive impairment [21].

T2DM among the young population is increasingly prevalent and significantly impacts individual and health-care service delivery. The glycaemic control of early onset patients (<40 years old) was shown to be poorer than older patients. This result is consistent with a study conducted in China in which patients with early onset T2DM had poorer glycaemic control as indicated by increased HbA1c when compared with patients with

Table 3: Simple and multiple logistic regression to identify poor glycaemic control among T2DM patients in Segamat, Malaysia

Variables	Simple Logistic Regression			Multiple Logistic Regression		
	Crude OR (95% CI)	X ² stat.(df)	p-value	Adjusted OR (95% CI)	X ² stat.(df)	p-value ^a
Age (years old)						
<60	1			1		
≥60	1.226 (1.457–1.998)	21.581	<0.001*	1.719 (1.426–2.073)	32.223	<0.001*
Ethnic						
Malay	1.741 (1.473–2.059)	21.012	<0.001*	1.581 (1.325–1.886)	25.822 ^b	<0.001 ^{ba}
Indian	2.179 (1.705–2.784)	37.107	<0.001*	1.967 (1.525–2.537)	27.088 ^b	<0.001 ^{ba}
Others	0.795 (0.306–2.068)	1.361	0.243	0.782 (0.625–1.235)	1.546 ^b	0.227 ^b
Chinese	1			1		
Duration of diabetes (years)						
<10	1			1		
≥10	1.873 (1.616–2.172)	10.132	<0.001*	1.833 (1.573–2.136)	60.283	<0.001*
Diabetes onset						
Early onset (<40 years old)	2.528 (1.906–3.353)	41.373	<0.001*	1.593 (1.082–2.345)	98.476	0.007*
Usual onset (≥40 years old)	1			1		
BMI classification						
Underweight	0.547 (0.326–0.897)	1.597	0.206	0.568 (0.335–0.964)	4.402 ^b	0.228 ^b
Normal	1			1		
Overweight	1.468 (1.179–1.828)	11.750	0.007*	1.263 (1.026–1.554)	6.040 ^b	0.014 ^{ba}
Obese	1.565 (1.266–1.935)	17.140	<0.001*	1.381 (1.125–1.705)	7.535 ^b	0.006 ^{ba}
Dyslipidemia						
Yes	1.385 (1.163–1.648)	13.380	<0.001*	1.299 (1.082–1.558)	21.682	0.004*
No	1			1		
Retinopathy						
Yes	1.521 (1.176–1.967)	10.221	0.034*	1.220 (0.935–1.593)	2.149	0.143
No	1			1		

BMI: Body mass index, *Significant at P < 0.05, T2DM: Type 2 Diabetes mellitus, OR: Odds ratio, CI: Confidence interval, LR: ^aLikelihood Ratio, ^bWald Test.

late onset T2DM [22]. Individuals with early onset DM are usually more reluctant to visit the hospital because they have self-perceived confidence in their health and are not concerned about their diet, subsequently resulting in poor glycemic control and diabetes-related complications [14], [9]. As early onset T2DM is prevalent globally, screening programs and intervention plans should also target younger adults [23].

Furthermore, this study identifies a significant positive association between being overweight or obese and poor glycemic control. This situation could be attributed to the fact that these patients often have higher dietary intakes, especially food rich in carbohydrate content and of high glycemic index. As a result, their fat storage increases, lead it even harder for them to control their glycemic levels [24]. Obesity also reduces insulin sensitivity and predisposes individuals to have increased waist circumference and increased visceral adiposity [25]. Patients with higher serum triglyceride levels often had poor glycemic control [26]. In our study, patients with dyslipidemia were higher risk to have poor glycemic control. The link between poor glycemic control and hyperlipidemia identified in this study is consistent with the previous literature [16]. It is hypothesized that free fatty acids may induce subclinical inflammation, which brings to insulin resistance and β -cells dysfunction and leads to an increased risk of T2DM [27].

However, there are several limitations in this study. First, some clinical and non-clinical variables that can affect T2DM management outcomes such as compliance to treatment and self-care behaviors, physical activity as well as family history were not measured in the study. This is because there are only a few variables or limited variables in the National Diabetes Registry. Despite so, this study managed to identify important factors associated with poor glycemic control among the local population. This study varies from others in that the sample population was focused to a clinical setting, and the sample size was quite large. The NDR constitutes more than 90% of the patients seeking treatment at the primary care level [23]. Hence, the findings could be used as guidance at the district level in revising the existing diabetes management strategies and intervention plans, especially at the level of primary care. The interventions need to be focused based on related factors that were identified in this study. Primary prevention is crucial in terms of preventing the occurrence of T2DM among communities.

Conclusion

In summary, age group ≥ 60 years old, Indian and Malay ethnicities, duration of diabetes more than 10 years, diabetes onset before 40 years old, BMI

(overweight, obesity), and dyslipidemia were the factors that identified have association with poor glycemic status in this study. Health-care professionals should pay more attention to these at-risk groups. Thus, there is a need to customize the various aspects of diabetic care and diabetes education toward achieving targeted glycemic control. The other approach is to evaluate the patients as whole, tailored the glycemic goals individually, and educate on a healthy lifestyle are required to achieve these objectives. For future improvement, it is suggested that the NDR provides and add more data or information to the registry, such as income status, educational level, physical activity level, diet history, and family history. The recommended data can facilitate the assessment of the outcome of management of T2DM at the primary care level in the future.

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