Original article
Poor Glycemic Control: Prevalence and Risk Factors Among Patients with Type 2 Diabetes Mellitus in Northeast State of Peninsular Malaysia
Hafizuddin Awang1, Siti Mariam Ja’afar1, Nurul Adhiyah Wan Ishak2, Muhamad YusofZaina2, Abdul Mukmin Mohamed Aminuddin2, Zawiyah Dollah2

Abstract:
Background: Poor glycemic control remains an on-going public health concern worldwide. With the increasing prevalence of diabetes mellitus in Malaysia, good control of blood glucose level is paramount to avert life-long complications of diabetes mellitus. Hence, this study aimed to determine the prevalence of poor glycemic control and its associated factors to assist clinicians in achieving good glycemic control among diabetic patients.

Materials and Methods: A comparative cross-sectional study between groups of good glycemic control and poor glycemic control patients was conducted among type 2 diabetes mellitus (T2DM) patients who fulfilled study criteria in Pasir Puteh district, Kelantan, a northeast state of Peninsular Malaysia. Eligible samples registered in the National Diabetes Registry from 1st January 2019 until 31st December 2019 were recruited into the study. Descriptive statistics, simple and multiple logistic regressions were used for data analysis.

Results: The prevalence of patients with poor glycemic control in Pasir Puteh district was 79.6% (95% CI: 0.78, 0.81). Multivariable analysis using multiple logistic regression revealed age, duration of diabetes, cigarette smoking, presence of hypertension and presence of dyslipidaemia were the significant factors associated with poor glycemic control among T2DM patients in Pasir Puteh district with an adjusted odds ratio (AOR) of 0.93 (95%CI:0.91, 0.94; p<0.001), AOR 1.19 (95%CI:1.14, 1.25; p<0.001), AOR 2.75 (95%CI:1.52, 4.97; p=0.001), AOR 2.19 (95%CI:1.32, 3.62; p=0.002) and AOR 2.16 (95%CI:1.45, 3.21; p<0.001) respectively.

Conclusion: This study provided important criteria for clinicians to improve management of diabetes mellitus and optimize glycemic control based on the pinpointed significant risk factors.

Keywords: Type 2 diabetes mellitus, poor glycemic control, associated factors, Kelantan, Malaysia.

Introduction
Diabetes mellitus is one of non-communicable diseases that developed over a long period of time. It is a condition when one has an elevated blood sugar levels with disruption of carbohydrate, fat and protein metabolism. It may be due to failure of pancreas to excrete insulin (type 1) or inability of body cells to react to insulin (type 2). It also could happen during pregnancy due to hormonal changes (gestational diabetes). Worldwide, the prevalence of type 2 diabetes mellitus (T2DM) is more than 6% across all continents. World Health Organization (WHO) in their work on Global Report on Diabetes has illustrated trend of diabetes prevalence. Across all class of income group countries, high income group has shown small range of increment compared to lower, lower-middle and upper-middle income group. Nonetheless, countries across all income group has shown an increasing trend since 1980,
with upper-middle income group has the highest prevalence in 2014 at more than 8%.

In Malaysia, a National Health Morbidity Survey (NHMS) conducted in 2015 found that 17.5% of adults aged 18 years and above has T2DM with 8.3% are known to have diabetes while 9.2% are previously undiagnosed with diabetes. Percentage of those who were unknown to have diabetes is higher than those who were diagnosed might suggest low health seeking behavior among Malaysian that may be contributed by low awareness of diabetes or low accessibility to quality healthcare. Late diagnosis of diabetes mellitus may contribute to poorly controlled diabetes and therefore, might increase risk for complications in diabetes such as retinopathy, nephropathy and cardiomyopathy.

In diagnosing diabetes mellitus, glycated hemoglobin (HbA1c) is used as the gold standard measurement. HbA1c test tells the average level of blood sugar over the past 2 to 3 months. According to Malaysia’s Clinical Practice Guideline on Management of Diabetes Mellitus, HbA1c of > 6.3% is used to diagnose diabetes mellitus. For those who are newly diagnosed, at younger age, no cardiovascular complication, has low risk of hypoglycemia and has longer life expectancy, the targeted HbA1c is between 6.0 – 6.5%. While those who has comorbidities (such as coronary disease, heart failure, kidney failure and liver dysfunction), prone to hypoglycemia and has shorter life expectancy, an HbA1c range of 7.1 – 8.0% is aimed. Those who are not in both categories, the target A1c is 6.6-7.0%. Therefore, patients with an HbA1c level of more than the range in the individualized group is considered to have poor glycemic control.

Factors that are associated with poor glycemic control are modifiable and non-modifiable factors such as younger age (<50 years old), female, overweight, longer duration of diagnosis, had more diabetic complications, hypertension and dyslipidemia. Therefore, it is important to manage diabetes as a whole by tackling modifiable risk factors such as overweight and obesity. Timely treatment of patients with poor glycemic control is critical to prevent its dangerous complications. Besides, uncontrolled diabetes mellitus is highly associated with increased susceptibility to certain infections such as tuberculosis and skin infections due to impaired host immunity. Knowing the predisposing factors for poor glycemic control can be effective in controlling diabetes mellitus and avert the life-long complications. Therefore, this study is aimed to estimate the prevalence of patients with poor glycemic control and determine its associated factors among T2DM patients in Pasir Puteh district, Kelantan.

Materials and Methods

From 15th December 2019 until 15th January 2020, we conducted a comparative cross-sectional study in eight primary healthcare facilities in the district of Pasir Puteh, Kelantan, a northeast state of Peninsular Malaysia. The clinics involved were Pasir Puteh Health Clinic, Selising Health Clinic, Cherang Ruku Health Clinic, Jeram Health Clinic, Gaal Health Clinic, Banggol Pak Esah Health Clinic, Gong Kulim Health Clinic and Sungai Petai Health Clinic.

The reference populations were all T2DM patients in Pasir Puteh district, and the study samples were all T2DM patients who fulfilled study inclusion and exclusion criteria in the eight selected health clinics. The inclusion criteria were T2DM patients who actively underwent diabetes clinic follow-up for at least 3 visits at any of the eight recruited health clinics until 31st December 2019. T2DM patients who died or lost to diabetes clinic follow-up were excluded from the study.

The sample size was calculated for each variable of associated factors for poor glycemic control among T2DM patients using power and sample size calculation software, as well to compare two independent proportions. The largest estimated sample for each group was 341 using the proportion of patients with good glycemic control by the factor of hypertension (0.34), an estimated proportion of 0.24, 5% type 1 error, 80% power and additional of 10% missing data. Therefore, the total sample size required is 682 T2DM patients.

Data were collected from National Diabetes Registry; an online database for diabetes mellitus
under the governance of Ministry of Health Malaysia\textsuperscript{18}, and recorded in patient’s pro forma. The retrieved information for independent variables included socio-demographic characteristics (age, gender) and clinical characteristics (duration of diabetes mellitus; cigarette smoking status; presence of comorbidities such as hypertension and dyslipidaemia; presence of diabetic complications such as retinopathy, nephropathy, diabetic foot ulcer, cerebrovascular disease and cardiovascular disease). The dependent variable was the diabetic control status either good control or poor control of diabetes mellitus. The HbA1c level of patients which served as indicator of glycemic control status was retrieved from the Dynamic Management System, an online database for clinical laboratory findings. In this study, good glycemic control is defined as HbA1c level \(\leq 6.5\%\). Meanwhile, HbA1c level beyond 6.5\% is considered as poor glycemic control\textsuperscript{7}. In this study, hypertension in diabetic patient is defined as systolic blood pressure of >140 mmHg and/or diastolic blood pressure of >90 mmHg\textsuperscript{7}. Dyslipidaemia in diabetic patient is defined as levels of either LDL>2.6mmol/L, HDL≤1.0 mmol/L, or triglycerides ≥1.7mmol/L\textsuperscript{7}.

**Statistical Analysis**

We used SPSS Statistics (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp) for data entry and analysis. Descriptive statistics with mean and standard deviation (SD), frequency and percentages were calculated. Simple and multiple logistic regression analysis were used to determine factors associated with poor glycemic control among T2DM patients. All significant variables with a p-value <0.25 from univariable analysis and clinically important variables were chosen for multiple logistic regression analysis. A p-value<0.05 was considered statistically significant.

**Results**

From the National Diabetes Registry, as of 31st December 2019, there were a total of 1780 diabetic patients who fulfilled the study criteria in Pasir Puteh primary healthcare facilities. The prevalence of patients with poor glycemic control were 79.6\% (95\% Confidence Interval (CI): 0.78, 0.81) or 1417 out of 1780 patients. Out of 1780 patients, 341 samples were randomly selected for each of the comparison group in accordance to sample size calculation.

Socio-demographically, the mean (±SD) age for T2DM patients with poor glycemic control was 59.87 (±9.77) years old. Majority of T2DM patients with poor glycemic control were female and non-smoker. As for duration of diabetes since diagnosis, the mean (±SD) duration for T2DM patients with poor glycemic control was 7.42 (±5.22) years.

As for complications in T2DM patients, majority of those with poor glycemic control had no retinopathy, no nephropathy, no diabetic foot ulcer, no cerebrovascular disease and no cardiovascular disease. For comorbidities, majority of patients with poor glycemic control had hypertension and dyslipidaemia. Details are summarized in Table 1.

In the univariable analysis, age, duration of diabetes, smoking status, presence of nephropathy, hypertension and dyslipidaemia were the statistically significant and clinically important factors selected for multivariable analysis. Details are summarized in Table 2.

Multivariable analysis using multiple logistic regression revealed age, duration of diabetes, cigarette smoking, presence of hypertension and presence of dyslipidaemia were the significant factors associated with poor glycemic control among T2DM patients in Pasir Puteh district with an adjusted odds ratio (AOR) of 0.93 (95\%CI:0.91, 0.94; p<0.001), 1.19 (95\%CI:1.14, 1.25; p<0.001), 2.75 (95\%CI:1.52, 4.97; p=0.001), 2.19 (95\%CI:1.32, 3.62; p=0.002) and 2.16 (95\%CI:1.45, 3.21; p<0.001) respectively. Details are shown in Table 3.

**Discussion**

The prevalence of patients with poor glycemic control in Pasir Puteh district was 79.6\% (95\% CI: 0.78, 0.81) which is higher than the prevalence reported by Eid, Mafauzy (2003) among T2DM patients on follow up at Hospital Universiti Sains Malaysia, Kubang Kerian, Kelantan which was 73\%\textsuperscript{19}. Besides, a study in one of the health clinics in Sarawak also reported lower prevalence of patients with poor glycemic control which was only 38\% out of 1031 patients on diabetic clinic follow up\textsuperscript{20}. Similarly, another local study done in
Tampin district, Negeri Sembilan reported lower prevalence of poor glycemic control (66.4%) in relative to our finding21. Due to high prevalence of patients with poor glycemic control in Pasir Puteh district in relative to other studies of local settings, it justified the need for our inferential study to be done to delve the risk factors for poor glycemic control in the setting of Pasir Puteh district.

Age is one of the significant factors associated with poor glycemic control in this current study. It is found that older patient has lower risk of having poor glycemic control (AOR: 0.93; 95%CI: 0.91, 0.94; p<0.001). It is congruent to another local nationwide study in 2015 which reported that young-old and middle-old age group was a significant predictor of poor glycemic control as compared to those of age beyond 80 years old22. Studies from other international settings reported similar findings23,24. A South Korean study has found important factors that influenced older adult’s view on glycemic control. Through qualitative exploration, they found that older adults considered ‘positive attitude and self-confidence’ are important in achieving good glycemic control besides technical coaching from medical staff25. Therefore, empowering the elderly to self-manage their health condition could be a turning point in management of diabetes. Detailed information must be given to them such as advices on healthy diet, physical activity and medication compliance.

Duration of diabetes mellitus plays a substantial role as well. We found that patient with longer duration of diabetes has higher risk of having poor glycemic control (AOR: 1.19; 95%CI: 1.14, 1.25; p<0.001). Similar finding was observed in another local study in the state of Johor, Malaysia26. Longer T2DM duration is related to progressive loss of pancreatic beta cell function which subsequently will cause poor glycemic control regardless of treatment regime27. Besides that, it is also postulated that “metabolic memory” plays important role in the development of macro- and microvascular complication in later life28. Those who has longer episode of hyperglycemia has poorer outcome. Hyperglycemia will lead to oxidative stress that causes harm to endothelial epithelium of blood vessels. If the insult left uninterrupted, the damage to the endothelium will be irreversible. Therefore, intensive intervention at early stage of disease has protective effect to the development of complications24,28,29.

We also found significant association between cigarette smoking with poor glycemic control. Patient who smoke cigarette has 2.75 higher odds of having poor glycemic control. This finding is similar with a Swedish study which reported cigarette smoking is independently associated with poor glycemic control30. An Australian study had suggested that there is an association between cigarette smoking and diabetes. Those who is a carrier of C-allele gene in CYP1A1 enzyme (a detoxification enzymes of polycyclic aromatic hydrocarbons (PAH) which is a toxin component produced by cigarette smoking) and who is also a smoker, has more than two times the risk of having diabetes. This enzyme not only detoxify PAHs but also plays a role in intracellular oxidative metabolism. When the enzyme is affected by the toxins from cigarette smoking, it could lead to disturbances in intracellular oxidative metabolism that further affect insulin-related metabolic abnormalities. When the enzyme is affected by the toxins from cigarette smoking, it could lead to disturbances in intracellular oxidative metabolism that further affect insulin-related metabolic abnormalities in diabetes31. Therefore, cigarette smoking could disturb CYP1A1 enzyme function and hence further affecting the control of diabetes.

Apart from that, our study found that patients with dyslipidaemia were more likely to have poor glycemic control (AOR: 2.16; 95%CI: 1.45, 3.21; p<0.001 respectively). Similarly, a study in Montenegro reported that low level of high-density lipoprotein cholesterol (HDL-c) was found to be the independent predictor of higher HbA1c (AOR: 0.44, 95%CI: 0.20–0.67, p=0.039), and increase in HDL-c by 1 mmol/L reduced the probability of higher HbA1c by 56%32. It is postulated that lipid-related genetic loci may affect glycemic metabolism, suggesting potentially causal relationship between genetically determined low HDL-c or high triglycerides levels and increased risk of T2DM33. Interestingly, a study done in a Malaysian teaching hospital found that hypertensive patients with dyslipidaemia who were prescribed statin showed higher A1c levels regardless of diabetes status34. Therefore, focus should be given to diabetic patients who are on statin. If controlling glucose level in these patients is difficult, it is best to replace statin with other lipidlowering medications to achieve better glycemic control.
Another statistically significant determinant for poor glycemic control was presence of hypertension in which hypertensive patients were more prone to have poor glycemic control (AOR: 2.19; 95%CI: 1.32, 3.62; p=0.002). This finding is consistent with few studies which also echoed the association of hypertension with glycemic control\textsuperscript{22,35}. Hypertension and T2DM usually co-exist. The prevalence of hypertension in T2DM is higher than that in the general population. At the age of 75 around 60% of patients with T2DM are hypertensive\textsuperscript{36}. The pathophysiological mechanisms explaining the association between blood pressure and incidence of T2DM are not clearly understood, but several postulations were proposed. High blood pressure was shown to induce microvascular dysfunction, which may contribute to the pathophysiology of diabetes development and impairment in blood glucose control\textsuperscript{37}. Besides, endothelial dysfunction which is related to insulin resistance is also strongly linked with hypertension, and biomarkers of endothelial dysfunction were found to be independent predictors of impaired blood glucose regulation\textsuperscript{38}.

**Limitation of the study:** As for the study limitation, we did not include family history of T2DM and diabetic treatment regime as part of the studied factors. These two factors are among the well-known significant predictors for poor glycemic control as reported by few Malaysian studies previously\textsuperscript{21,39,40}. 

**Conclusion and Recommendations**

In conclusion, poor glycemic control among T2DM patients is quite prevalent in Pasir Puteh district. Younger age, longer duration of diabetes mellitus, cigarette smoking, presence of hypertension and dyslipidaemia were the significant risk factors for poor glycemic control. Hence, it is recommended that focus on diabetic care and education should be given to all groups of patients, not necessarily to elderly group only as our study reported that younger population was more prone towards poor glycemic control. Our study also revealed the link between longer duration of diabetes with poorer glycemic outcome, thus, it is imperative for us to manage diabetes optimally for patients who are diagnosed with diabetes mellitus at a very young age as they will have diabetes for quite a long time. Diabetes educators or counselors in clinics should educate young diabetic patients on the importance of medication adherence and healthy lifestyle in order to achieve good glycemic control.

Besides that, all diabetic patients who smoke cigarette should be referred to Quit Smoking Clinic to help them with cigarette smoking cessation. Smoking cessation would reduce the likelihood of getting poor glycemic control among T2DM patients. Co-morbidities in diabetic patients such as hypertension and dyslipidaemia should be controlled optimally. Equal priority should be given to both blood glucose control and co-morbidities during follow-up session as failure to optimize blood pressure and lipid level would lead to failure in glycemic control. Blood pressure should be monitored regularly during each diabetes follow-up session while lipid levels should be checked every 6 months in diabetic patients to achieve optimal management of co-morbidities and good glycemic control\textsuperscript{7}.

**Conflict of interest:** None declared. The authors have no financial, consultative, institutional, and other relationships that might lead to bias or conflict of interest.

**Disclosure statement:** The authors declare no conflicts of interest.

**Ethical approval issue:** This study was approved by the Medical Review and Ethical Committee from National Institute of Health, Ministry of Health Malaysia NMRR-19-3530-52294.

**Individual authors contribution:** Conception-H.A., S.M.J, Z.D.; Writer-H.A., S.M.J.; Data collection and/or processing-H.A., S.M.J., N.A.W.I., M.Y.Z., A.M.M.A.; Supervision-Z.D.; Analysis and/or Interpretation-H.A., S.M.J.

**Funding statement:** This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

**Acknowledgement:** The authors would like to thank the Director General of Health Malaysia for allowing us to use the secondary data from National Diabetes Registry. Our gratitude also goes to staffs at Non-Communicable Diseases (NCD) Unit, Pasir Puteh District Health Office for their assistance during data collection.
Table 1: Socio-demographic and clinical characteristics of T2DM patients in accordance to glycemic control outcomes (n=682).

| Characteristics          | Poor glycemic control (n=341) | Good glycemic control (n=341) |
|--------------------------|-------------------------------|-------------------------------|
| Frequency (%)            |                               |                               |
| Age (years)*             | 59.87 (±9.77)                 | 64.87 (±10.60)                |
| Duration of diabetes (years)* | 7.42 (±5.22)                 | 4.83 (±4.22)                 |
| Gender                   |                               |                               |
| Male                     | 97 (28.4)                     | 98 (28.7)                     |
| Female                   | 244 (71.6)                    | 243 (71.3)                    |
| Cigarette smoking        |                               |                               |
| No                       | 289 (84.8)                    | 315 (92.4)                    |
| Yes                      | 52 (15.2)                     | 26 (7.6)                      |
| Retinopathy              |                               |                               |
| Absent                   | 325 (95.3)                    | 331 (97.1)                    |
| Present                  | 16 (4.7)                      | 10 (2.9)                      |
| Nephropathy              |                               |                               |
| Absent                   | 291 (85.3)                    | 307 (90.0)                    |
| Present                  | 50 (14.7)                     | 34 (10.0)                     |
| Diabetic foot ulcer      |                               |                               |
| Absent                   | 336 (98.5)                    | 339 (99.4)                    |
| Present                  | 5 (1.5)                       | 2 (0.6)                       |
| Cerebrovascular disease  |                               |                               |
| Absent                   | 337 (98.8)                    | 335 (98.2)                    |
| Present                  | 4 (1.2)                       | 6 (1.8)                       |
| Cardiovascular disease   |                               |                               |
| Absent                   | 334 (97.9)                    | 333 (97.7)                    |
| Present                  | 7 (2.1)                       | 8 (2.3)                       |
| Hypertension             |                               |                               |
| Absent                   | 54 (15.8)                     | 79 (23.2)                     |
| Present                  | 287 (84.2)                    | 262 (76.8)                    |
| Dyslipidaemia            |                               |                               |
| Absent                   | 75 (22.0)                     | 133 (39.0)                    |
| Present                  | 266 (78.0)                    | 208 (61.0)                    |

*Mean (±SD)

Table 2: Factors associated with poor glycemic control among T2DM patients in Pasir Puteh district by simple logistic regression (n=682).

| Factors                          | β     | S.E.   | Wald statistics (df) | Crude OR (95% CI) | p-value |
|----------------------------------|-------|--------|-----------------------|-------------------|---------|
| Age (years)                      | -0.05 | 0.008  | 36.40 (1)             | 0.95 (0.93, 0.97) | <0.001  |
| Duration of diabetes (years)*    | 0.12  | 0.02   | 43.43 (1)             | 1.13 (1.09, 1.17) | <0.001  |
| Gender                           |       |        |                       |                   |         |
| Male                             |       |        |                       | 1.00 (0.73, 1.41) | 0.932   |
| Female                           |       |        |                       |                   |         |
| Cigarette smoking                |       |        |                       |                   |         |
| No                               |       |        |                       |                   |         |
| Yes                              |       |        |                       |                   |         |
| Retinopathy                      |       |        |                       |                   |         |
| Absent                           |       |        |                       |                   |         |
| Present                          |       |        |                       |                   |         |
| Nephropathy                      |       |        |                       |                   |         |
| Absent                           |       |        |                       |                   |         |
| Present                          |       |        |                       |                   |         |
| Diabetic foot ulcer              |       |        |                       |                   |         |
| Absent                           |       |        |                       |                   |         |
| Present                          |       |        |                       |                   |         |
| Cerebrovascular disease          |       |        |                       |                   |         |
| Absent                           |       |        |                       |                   |         |
| Present                          |       |        |                       |                   |         |
| Cardiovascular disease           |       |        |                       |                   |         |
| Absent                           |       |        |                       |                   |         |
| Present                          |       |        |                       |                   |         |
| Hypertension                     |       |        |                       |                   |         |
| Absent                           |       |        |                       |                   |         |
| Present                          |       |        |                       |                   |         |
| Dyslipidaemia                    |       |        |                       |                   |         |
| Absent                           |       |        |                       |                   |         |
| Present                          |       |        |                       |                   |         |
Table 3: Factors associated with poor glycemic control among T2DM patients in Pasir Puteh district by multiple logistic regression (n=682).

| Factors                | β     | S.E. | Wald statistics (df) | Adjusted OR (95% CI) | p-value |
|------------------------|-------|------|----------------------|----------------------|---------|
| Age (years)            | -0.08 | 0.01 | 64.13 (1)            | 0.93 (0.90, 0.94)    | <0.001* |
| Duration of diabetes (years) | 0.18  | 0.02 | 60.42 (1)            | 1.19 (1.14, 1.25)    | <0.001* |
| Cigarette smoking      |       |      |                      |                      |         |
| No                     |       |      |                      | 1.00                 |         |
| Yes                    | 1.01  | 0.30 | 11.11 (1)            | 2.75 (1.52, 4.97)    | 0.001*  |
| Nephropathy            |       |      |                      |                      |         |
| Absent                 |       |      |                      | 1.00                 |         |
| Present                | -0.33 | 0.29 | 1.34 (1)             | 0.72 (0.41, 1.26)    | 0.717   |
| Hypertension           |       |      |                      |                      |         |
| Absent                 |       |      |                      | 1.00                 |         |
| Present                | 0.78  | 0.26 | 9.31 (1)             | 2.19 (1.32, 3.62)    | 0.002*  |
| Dyslipidaemia          |       |      |                      |                      |         |
| Absent                 |       |      |                      | 1.00                 |         |
| Present                | 0.77  | 0.20 | 14.32 (1)            | 2.16 (1.45, 3.21)    | <0.001* |

*p-value <0.05

No multicollinearity and no interaction found.

Hosmer Lemeshow test, p-value=0.174

Classification table 70% correctly classified.

Area under Receiver Operating Characteristics (ROC) curve was 76.6%.
References:

1. Fatin A, Alina T. Proportion of women with history of gestational diabetes mellitus who performed an oral glucose test at six weeks postpartum in Johor Bahru with abnormal glucose tolerance. Malaysian Family Physician. 2019;14(3):2-9.

2. Roglic G. WHO Global report on diabetes: A summary. International Journal of Noncommunicable Diseases. 2016;1(1):3.

3. Chan YY, Lim KK, Lim KH, Teh CH, Kee CC, Cheong SM, et al. Physical activity and overweight/obesity among Malaysian adults: findings from the 2015 National Health and morbidity survey (NHMS). BMC Public Health. 2017;17(1):733.

4. Beagley J, Guargiguata L, Weil C, Motala AA. Global estimates of undiagnosed diabetes in adults. Diabetes research and clinical practice. 2014;103(2):150-60.

5. Lotfy M, Adeghate J, Kalasz H, Singh J, Adeghate E. Chronic complications of diabetes mellitus: a mini review. Current Diabetes Reviews. 2017;13(1):3-10.

6. Sato A. Indicators of glycemic control--hemoglobin A1c (HbA1c), glycated albumin (GA), and 1, 5-anhydroglucitol (1, 5-AG). Rinshobyori The Japanese Journal of Clinical Pathology. 2014;62(1):45-52.

7. Ministry of Health. Clinical Practice Guidelines. Management of Type 2 Diabetes Mellitus. 5th ed. Malaysia: Ministry of Health; 2015 December 2015.

8. Siddiqui FJ, Avan BI, Mahmud S, Nanan DJ, Jabbar A, Assam PN. Uncontrolled diabetes mellitus: Prevalence and risk factors among people with type 2 diabetes mellitus in an Urban District of Karachi, Pakistan. Diabetes research and clinical practice. 2015;107(1):148-56.

9. de Pablos-Velasco P, Parhofer KG, BradleyC, Eschwege E, Gönder-Frederick L, Maheux P, et al. Current level of glycemic control and its associated factors in patients with type 2 diabetes across Europe: data from the PANORAMA study. Clinical Endocrinology. 2014;80(1):47-56.

10. Ishak NAW, Awang H, Aziz RA, Abdullah AJ, Bahari N. Prevalence And Determinants For Insulin Therapy Refusal Among Type 2 Diabetes Mellitus Patients In Primary Healthcare Facilities In East Coast Region Of Peninsular Malaysia. International Journal of Public Health and Clinical Sciences. 2019;6(2):160-71.

11. Awang H, Husain NRN, Abdullah H. Pediatric tuberculosis in a Northeast state of Peninsular Malaysia: Diagnostic classifications and determinants. Oman Medical Journal. 2019;34(2):110-117.

12. Awang H, Husain NRN, Abdullah H. Chest radiographic findings and clinical determinants for severe pulmonary tuberculosis among children and adolescents in Malaysia. Russian Open Medical Journal. 2019;8(2).

13. Peleg AY, Weeraratna T, McCarthy JS, Davis TM. Common infections in diabetes: pathogenesis, management and relationship to glycaemic control. Diabetes/metabolism Research and Reviews. 2007;23(1):3-13.

14. Awang H, Raub N, Alias ANA, Rahman NAA, Dollah Z. Predictors of Tuberculosis Relapse in Pasir Puteh District, Kelantan: A Case-Control Study. International Journal of Public Health and Clinical Sciences. 2020;6(6):133-47.

15. Awang H, Ja’afar SM, Ishak NAW, Dollah Z. Determinants of Neonatal Jaundice Among Newborns in Pasir Puteh District, Kelantan. International Journal of Public Health and Clinical Sciences. 2020;6(6):109-122.

16. Dupont WD, Plummer Jr WD. Power and sample size calculations: a review and computer program. Controlled Clinical Trials. 1990;11(2):116-28.

17. Khattab, M., Khader, Y. S., Al-Khawaldeh, A., & Ajlouni, K. Factors associated with poor glycemc control among patients with type 2 diabetes. Journal of Diabetes and its Complications. 2010; 24(2), 84-89.

18. Feisul MI, Azmi S. National Diabetes Registry Report 2009-2012 Malaysia: Non-Communicable Disease Section, Disease Control Division, Ministry of Health Malaysia; 2013 [Available from: http://www.moh.gov.my/moh/resources/Penerbitan/Rujukan/NCD/Diabetes/National_Diabetes_Registry_Report_Vol_1_2009_2012.pdf.

19. Eid M, Mafauzy M, Faridah A. Glycaemic control of type 2 diabetic patients on follow up at Hospital UniversitiSains Malaysia. The Malaysian Journal of Medical Sciences: MJMS. 2003;10(2):40.

20. Wong J, Rahimah N. Glycaemic control of diabetic patients in an urban primary health care setting in Sarawak: the Tanah Puteh Health Centre experience. Med J Malaysia. 2004;59(3):411-7.

21. Wan Hamdzan WFF, Juni MH, Salmiah M, Azuhairi A, Zairina A. Factors Associated With Glycemic Control Among Type 2 Diabetes Mellitus Patients. International Journal of Public Health and Clinical Sciences. 2016;3(3):89-102.

22. Sazlina S-G, Mastura I, Cheong AT, Mohamad AB, Jamaiyah H, Lee PY, et al. Predictors of poor glycaemic control in older patients with type 2 diabetes mellitus.
23. Ali MK, McKeever Bullard K, Imperatore G, Barker L, Gregg EW. Characteristics associated with poor glycemic control among adults with self-reported diagnosed diabetes—National Health and Nutrition Examination Survey, United States, 2007–2010. MMWR Morb Mortal Wkly Rep. 2012;61(2):32-7.

24. Crowley MJ, Holleman R, Klamerus ML, Bosworth HB, Edelman D, Heisler M. Factors associated with persistent poorly controlled diabetes mellitus: clues to improving management in patients with resistant poor control. Chronic Illness. 2014;10(4):291-302.

25. Choi S, Song M, Chang SJ, Kim S-a. Strategies for enhancing information, motivation, and skills for self-management behavior changes: a qualitative study of diabetes care for older adults in Korea. Patient Preference and Adherence. 2014;8:219.

26. Mahmood M, Daud F, Ismail A. Glycaemic control and associated factors among patients with diabetes at public health clinics in Johor, Malaysia. Public Health. 2016;135:56-65.

27. UK Prospective Diabetes Study Group. UK Prospective Diabetes Study 16: overview of 6 years’ therapy of type II diabetes: a progressive disease. Diabetes. 1995;44(11):1249-58.

28. Ihnat M, Thorpe J, Ceriello A. Hypothesis: the ‘metabolic memory’, the new challenge of diabetes. Diabetic Medicine. 2007;24(6):582-6.

29. Juarez DT, Sentell T, Tokumaru S, Goo R, Davis JW, Mau MM. Peer Reviewed: Factors Associated With Poor Glycemic Control or Wide Glycemic Variability Among Diabetes Patients in Hawaii, 2006–2009. Preventing Chronic Disease. 2012;9.

30. Nilsson P, Gudbjörnsdottir S, Eliasson B, Cederholm J, Register SCotSND. Smoking is associated with increased HbA1c values and microalbuminuria in patients with diabetes—data from the National Diabetes Register in Sweden. Diabetes &Metabolism. 2004;30(3):261-8.

31. Wang XL, Greco M, Sim AS, Duarte N, Wang J, Wilcken DE. Effect of CYP1A1 MspI polymorphism on cigarette smoking related coronary artery disease and diabetes. Atherosclerosis. 2002;162(2):391-7.

32. Klisic A, Kavaric N, Jovanovic M, Zvrko E, Skerovic V, Scepanovic A, Medin D, Ninic A. Association between unfavorable lipid profile and glycemic control in patients with type 2 diabetes mellitus. J Res Med Sci. 2017;22:122.

33. Qi Q, Liang L, Doria A, Hu FB, Qi L. Genetic predisposition to dyslipidemia and type 2 diabetes risk in two prospective cohorts. Diabetes. 2012;61(3):745-52.

34. Liew SM, Lee PY, Hanafi NS, Ng CJ, Wong SSL, Chia YC, et al. Statins use is associated with poorer glycaemic control in a cohort of hypertensive patients with diabetes and without diabetes. Diabetology &Metabolic Syndrome. 2014;6(1):53.

35. Toh MPHS, Wu CX, Leong HSS. Association of younger age with poor glycemic and cholesterol control in Asians with type 2 Diabetes Mellitus in Singapore. Journal of Endocrinology and Metabolism. 2011;1(1):27-37.

36. Hypertension in Diabetes Study Group. I. Prevalence of hypertension in newly presenting type 2 diabetic patients and the association with risk factors for cardiovascular and diabetic complications. J Hypertens. 1993;11:309-17.

37. FeihlFo, Liaudet L, Waeber B, Levy BI. Hypertension: a disease of the microcirculation? Hypertension. 2006;48(6):1012-7.

38. Meigs JB, Hu FB, Rifai N, Manson JE. Biomarkers of endothelial dysfunction and risk of type 2 diabetes mellitus. Jama. 2004;291(16):1978-86.

39. Abdullah NA, Ismail S, Ghazali SS, Juni MH, Kadir H, Shahr NRRA. Predictors of Good Glycemic Controls Among Type 2 Diabetes Mellitus Patients in Two Primary Health Clinics, Kuala Selangor. Malaysian Journal of Medicine and Health Sciences. 2019;15(Suppl 3):58-64.

40. Ahmad NS, Islahudin F, Paraikadathathu T. Factors associated with good glycemic control among patients with type 2 diabetes mellitus. Journal of Diabetes Investigation. 2014;5(5):563-9.