Can J Diabetes 43 (2019) 98–104

Contents lists available at ScienceDirect

Canadian Journal of Diabetes

journal homepage: www.canadianjournalofdiabetes.com

Original Research

# High Proportion of Adults With Type 2 Diabetes and Poor Glycated Hemoglobin Perceived That Their Diabetes Control Was Excellent

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## Key Messages

- This study reaffirmed that health literacy is independent of glycemic control. A small number of patients accurately identified themselves as having poor diabetes control.
- The study also demonstrated that having adequate knowledge and the correct attitude do not translate into proper practice in the management of diabetes.
- These findings suggest that there might be missing components in the relationship between having the knowledge and achieving diabetes control.

ARTICLE INFO

*Article history:*
Received 16 August 2017
Received in revised form
5 June 2018
Accepted 6 June 2018

*Keywords:*
glycated hemoglobin
perception
type 2 diabetes mellitus

ABSTRACT

*Objectives:* As is true for other chronic illnesses, perception of disease control is pivotal to patient empowerment in diabetes care. This study aimed to describe the perception of diabetes control by patients with poor glycated hemoglobin (A1C) levels so as to explore the relationship between perception and various sociodemographic and disease characteristics and to measure the patients' knowledge, attitudes and practices in diabetes care.
*Methods:* A cross-sectional study was made involving 276 patients with type 2 diabetes mellitus. After obtaining informed consent, their sociodemographics, medical histories and most recent available blood investigations were documented. Patients were asked about their perceptions of diabetes control—whether it was excellent, moderate or poor. A Malay-language knowledge, attitudes and practice questionnaire was administered to respondents. Analyses were descriptive and exploratory.
*Results:* The median age of the subjects and the durations of diabetes were 56 (interquartile range, 48–62) years and 8 (interquartile range, 4–13) years, respectively. The median A1C level was 9.5% (interquartile range, 8.3%–11.4%). Despite having poor A1C levels, 28.4% of patients perceived that their diabetes control was excellent; 58.9% perceived it as moderate, and only 12.7% accurately perceived it as poor. A significant number of those with higher education had wrong perceptions, indicating that other factors, such as effective communication, need to be considered. The absence of an association between perception and duration of diabetes suggests that information given over the years did not contribute to patients' understanding of disease control. Younger patients had better knowledge scores. Those with higher education levels had higher quartiles of knowledge and attitude but not practice scores.
*Conclusions:* This study demonstrated discordance between perceived diabetes control and actual A1C levels, which may hinder effective diabetes care.



*Mots clés :*
hémoglobine glyquée
perception
diabète sucré de type 2

RÉSUMÉ

*Objectifs :* Tout comme les autres maladies de longue durée, la perception de lutte contre la maladie est essentielle à l'autonomisation des patients dans les soins du diabète. La présente étude vise à décrire la perception qu'ont les patients ayant de faibles concentrations d'hémoglobine glyquée (A1c) sur la lutte contre le diabète pour étudier la relation entre la perception et les nombreuses caractéristiques

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https://doi.org/10.1016/j.jcjd.2018.06.003

sociodémographiques et pathologiques et pour évaluer les connaissances, les attitudes et les pratiques des patients sur les soins du diabète.
*Méthodes :* Une étude transversale a été réalisée auprès de 276 patients atteints de diabète sucré de type 2. Après avoir obtenu le consentement éclairé de chacun des patients, nous avons recueilli leurs données sociodémographiques, leurs antécédents médicaux et les résultats de leurs analyses sanguines les plus récentes. Nous avons demandé aux patients leur perception sur la lutte contre le diabète, à savoir si elle était excellente, modérée ou médiocre. Les répondants ont rempli un questionnaire en malais sur les connaissances, les attitudes et les pratiques. Les analyses étaient descriptives et exploratoires.
*Résultats :* L'âge médian des sujets et la durée de leur diabète étaient respectivement de 56 (de 48 à 62) et de 8 (de 4 à 13) ans. La concentration médiane de l'A1c était de 9,5 (de 8,3 à 11,4) %. En dépit d'obtenir de faibles concentrations d'A1c, 28,4 % des patients percevaient que la lutte contre le diabète était excellente, 58,9 % la percevaient modérée et seuls 12,7 % la percevaient à juste titre faible. Puisqu'un nombre important de ceux qui possédaient un niveau plus élevé de scolarité avaient une perception erronée, d'autres facteurs tels que la communication efficace doivent être considérés. L'absence d'association entre la perception et la durée du diabète montre que l'information donnée au fil des ans n'a pas contribué à la compréhension qu'avaient les patients sur la lutte contre la maladie. Les patients plus jeunes avaient de meilleurs scores de connaissances. Ceux qui possédaient un niveau plus élevé de scolarité se situaient dans le quartile supérieur des scores de connaissances et d'attitudes, mais non des scores de pratiques.
*Conclusions :* Cette étude a démontré que l'écart entre la perception de lutte contre le diabète et les concentrations actuelles de l'A1c peut nuire à l'efficacité des soins du diabète.


## Introduction

Diabetes mellitus is a worldwide disease affecting 415 million people (1). The largest contributor to this number is the western Pacific region, accounting for 153.2 million people. It is estimated that by the year 2040, there will be more than 640 million people living with diabetes around the world. Malaysia, 1 of the countries of the western Pacific region, has a high prevalence of type 2 diabetes mellitus among those older than 18 years of age, amounting to 17.5%. It is estimated that 4.5 million people in this country have either type 2 diabetes or impaired glucose tolerance (2).

Poor glycemic control is well known to be associated with increased morbidity and mortality. Moreover, it contributes to high global health expenditures, with most countries spending between 5% and 20% of their total health expenditures on diabetes alone, accounting for total health expenditures of USD 673 billion worldwide (1).

Despite advances in various treatments for type 2 diabetes, the majority of patients fail to achieve the American Diabetes Association-recommended glycated hemoglobin (A1C) target of <7% (3). This is true not only in developing countries like Malaysia; in fact, it is a worldwide phenomenon, seen even in developed countries (4). DiabCare Malaysia 2013, a 5-yearly cross-sectional study of the management, control and complications of type 2 diabetes, clearly shows that less than a quarter of patients in Malaysia achieve the target A1C levels, with a mean value of 8.52% (5).

As we move toward patient-centered care in our health-care system, patient involvement in disease management is essential to improving their health and quality of life. Empowering patients to take charge of their health by working together with health-care providers to improve their glycemic control can ultimately lead to better quality of care and more successful outcomes (6). Unfortunately, poor health literacy is common in patients with chronic medical conditions, including type 2 diabetes (7). Studies in Europe and the United Kingdom have consistently shown that patients with diabetes have poor perceptions and understanding of their glycemic control, which subsequently translates into increased diabetes-related complications (8,9).

Similar studies in Asia are scarce, so our present study looked at the perception of diabetes control among patients with poorly controlled type 2 diabetes. Our secondary objective was to explore the association between patients' perceptions of diabetes control and their sociodemographic statuses, especially education levels, disease durations and the presence of micro- and macrovascular complications. We also assessed patients' knowledge, attitudes and practices in diabetes care.

## Methods

This was a cross-sectional study performed in 2 centers (a tertiary referral center and a primary care center) in Kuantan, a city located on the east coast of Malaysia, where Malay ethnicity is the largest ethnic group. Patients in the tertiary referral center were managed by an endocrinologist and received diabetes education from trained educators on a regular basis. In general, all new cases seen at the outpatient department are referred to the diabetes education unit on the first visit and every 3 months subsequently. The frequency of the referral to the diabetes education unit increases as needed, depending on the requirement of individual patients. The diabetes education unit is staffed by 2 diabetes specialist nurses. On the other hand, most patients in the primary care centre were managed by medical officers. Complicated cases were seen by a qualified family physician whereby diabetes education was delivered. There was no dedicated diabetes education unit in the primary care centre. However, there were visiting diabetes-specialist nurses delivering diabetes education to selected patients in the primary care centre.

Potential patients were identified through the clinic's appointment registries. Patients who fulfilled the inclusion and exclusion criteria were invited to participate in this study. We recruited Malaysian patients who were older than 18 years of age, could understand the Malay language and had A1C levels above 7%. We excluded pregnant patients and those who came for unscheduled visits. The sample size was calculated using the OpenEpi sample-size calculator. Based on a previous study reporting 23.7% of subjects' describing their diabetes control as good or excellent despite having poor A1C levels, we determined that a sample size of 278 would achieve a 95% confidence level (10).

Upon obtaining informed consent, the patients' sociodemographic details and medical histories were recorded. Socioeconomic classifications of the cohort were defined by their median household incomes in comparison with the data available from the Department of Statistics Malaysia. The socioeconomic statuses were categorized as high if the median household income was comparable with the top 20%; moderate if comparable with the middle 40%; and low if comparable with the bottom 40% in the 2014 Malaysian Population Household Income Report (11). Anthropometric

measurements included patients' blood pressures and body mass indexes. A1C values and lipid profiles determined within 3 months of the date of interview were recorded from the clinic data. The patients were interviewed, in the Malay language, regarding their perceptions of their diabetes control—whether it was excellent, moderate or poor, without having them refer to their A1C measurements. Their perceptions of diabetes control were taken at face value, without interrogation or questions that would challenge their beliefs. They were also assessed concerning their knowledge, attitudes and practices in the management of diabetes. The knowledge, attitude and practice (KAP) questionnaire was an interview-administered questionnaire conducted in the Malay language. There were 18 items in the knowledge domain and 5 and 7 items in the attitude and practice domains, respectively. A correct response was given a 1, and a wrong response was given a 0. Individual domain scores were the average scores of each domain; the total KAP score was the average score of all domains. The maximum score for each domain and total KAP score was 1.00 (Supplementary Table 1). The validity of the KAP questionnaire's content was reviewed by 2 independent internal medicine specialists. A pilot study performed in a different cohort of patients with diabetes revealed that all domains correlated with the KAP score ($r>0.70$), with an internal consistency of domains (Cronbach alpha) between 0.57 and 0.73 (unpublished data). The interviews were conducted by 6 trained research assistants. Although the researchers were involved in screening the subjects' suitability for recruitment into this study, they were blinded to the exact values of the A1C levels of the subjects during the interviews.

The collected data were analyzed using SPSS v. 23 (IBM, Armonk, New York, United States). The analysis was descriptive and exploratory. Continuous data were analyzed for normality. Non-normally distributed data were summarized using median, 25th and 75th centiles. A comparison between proportions in 2 different groups was made using the chi-square test. For continuous data that were non-normally distributed, a comparison between the medians was made using the Mann-Whitney U test or the Kruskal-Wallis test, where appropriate. The Spearman correlation was determined for the association between 2 non-normally distributed continuous variables. The study was approved by the International Islamic University Malaysia Research Ethics Committee (IREC) (IREC 149 and IREC 150; Ref: IIUM/305/20/4/10/1).

## Results

### *Baseline demography*

A total of 427 patients with type 2 diabetes were screened: 276 patients who had A1C levels above 7% were enrolled in this study, and Figure 1 presents the sociodemographic data. The median age was 56.0 (interquartile range [IQR], 48.0 to 62.0) years, and 56.2% of our patients were female. The majority of the respondents were of Malay ethnicity (82.2%), followed by Chinese (9.8%) and Indian (8.0%); 38.3% of the respondents had completed tertiary education, and 37.5% had completed secondary education. Only a minority had not completed primary education (8.6%) or had no formal education (0.4%). The respondents were of low socioeconomic status, with median monthly incomes of Malaysian ringgit 1,000 (500 to 2,000 RM). Their incomes were lower than the median household income for the bottom 40% of the Malaysian population (11).

The median duration of diabetes was 8.0 (IQR, 4.0 to 13.0) years. The median A1C level was 9.5% (IQR, 8.3% to 11.4%) and the median fasting blood sugar level was 9.7 (IQR, 7.1 to 13.8) mmol/L. The majority of the patients (40.9%) were taking oral antidiabetes agents only, 22.1% of the patients were taking insulin therapy alone, and 36.6% were taking both oral antidiabetes agents and insulin therapy. The median weight was 70.0 (IQR, 61.9 to 80.0) kg, and the median body mass index was 27.6 (IQR, 24.2 to 30.7) kg/m$^2$. The median blood pressure was 134/80 (IQR, 122/72 to 155/87) mmHg. The lipid profile (total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol and triglycerides) is described in Table 1. A total of 56 respondents had recent renal profiles available. The median creatinine level was 89.0 (IQR, 66.5 to 119) µmol/L, and the estimated glomerular filtration rate was 61.4 (IQR, 45.6 to 93.4) mL/min/1.72 m$^2$.

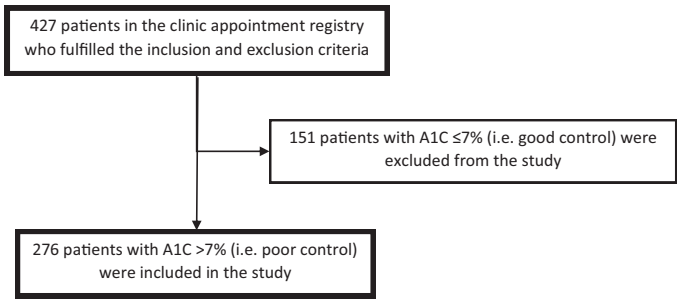


**Figure 1.** Study flow chart: 427 patients who fulfilled the inclusion and exclusion criteria were screened based on the clinic's appointment registry; 151 patients with good glycated hemoglobin (A1C) control, as defined by the American Diabetes Association criteria (i.e. A1C ≤7%) were excluded; 276 patients with poor A1C control (>7%) were included in the study.

In terms of diabetes complications, 48.1% and 57.9% had retinopathy and peripheral neuropathy, regardless of severity; 10.6% of respondents had been diagnosed with ischemic heart disease; 6% of the cohort had had a cerebrovascular accident or transient ischemic attack; 6% had peripheral vascular disease; and 14 patients (6.5%) had had lower-limb amputations resulting from complications of diabetes.

### *Perception of diabetes control*

*Perception of diabetes control and the disease's characteristics.* Despite having a median A1C level of 9.5% and a fasting blood sugar level of 9.7 mmol/L, 58.9% and 28.4% of respondents perceived that their diabetes control was moderate or excellent, respectively. Only 12.7% correctly identified themselves as having poor control of their diabetes (Figure 2). Having said that, patients who perceived themselves as having excellent control of their disease had significantly lower A1C levels (8.9% [IQR, 7.7% to 11.1%]) than those who perceived their control as moderate (9.8% [IQR, 8.5% to 11.3%]) or poor (13.5% [IQR, 9.6% to 18.1%]) ($p=0.002$). Similarly, those who perceived their diabetes control as being excellent had lower fasting blood sugar levels (8.3 [IQR, 7.0 to 10.8] mmol/L) compared to those who perceived their control as being moderate (10.0 [IQR, 7.1 to 13.1] mmol/L) or poor (13.5 [IQR, 9.6 to 18.1] mmol/L) ($p<0.001$) (Supplementary Table 2). It is interesting that there was no significant difference in the duration of diabetes among the 3 groups of respondents. Comparing the 2 health-care centres, 16.3% of patients seen at the tertiary care centre correctly identified themselves as having poor diabetes control, compared to 6.8% of patients from the primary care centre ($p=0.016$). Surprisingly, the usual understanding that insulin therapy is associated with worse diabetes control was not observed in this cohort. In addition to that, the presence of retinopathy, peripheral neuropathy or macrovascular complications did not influence patients' perceptions of diabetes control, except for peripheral vascular disease. However, a higher proportion of those with peripheral vascular disease thought that their blood sugar control was excellent ($p=0.046$) (Supplementary Table 3).

There was no significant difference in terms of weight, body mass index, blood pressure or lipid profile among the 3 groups of

**Table 1**
Baseline demography of respondents and comparison between those ≤55 years of age and those >55 years of age

| | Total | | | Age group | | | | | | p value |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | ≤55 years old | | | >55 years old | | | |
| | Median | 25th percentile | 75th percentile | Median | 25th percentile | 75th percentile | Median | 25th percentile | 75th percentile | |
| Age (years) | 56.00 | 48.00 | 62.00 | | | | | | | |
| Gender (n=276), N (%) | | | | | | | | | | |
| Male | 121 | 43.8 | | 56 | 40.9 | | 65 | 46.8 | | 0.324 |
| Female | 155 | 56.2 | | 81 | 59.1 | | 74 | 52.3 | | |
| Total | 276 | 100.0 | | 137 | 100.0 | | 139 | 100.0 | | |
| Ethnicity (n=276), N (%) | | | | | | | | | | |
| Malay | 227 | 82.2 | | 120 | 87.6 | | 107 | 77.0 | | 0.028† |
| Chinese | 27 | 9.8 | | 7 | 5.1 | | 20 | 14.4 | | |
| Indian | 22 | 8.0 | | 10 | 7.3 | | 12 | 8.6 | | |
| Total | 276 | 100.0 | | 137 | 100.0 | | 139 | 100.0 | | |
| Education (n=256), N (%) | | | | | | | | | | |
| No formal | 1 | 0.4 | | 1 | 0.8 | | 0 | 0.0 | | <0.001† |
| Not completed primary | 22 | 8.6 | | 3 | 2.3 | | 19 | 14.8 | | |
| Completed primary | 39 | 15.2 | | 13 | 10.2 | | 26 | 20.3 | | |
| Completed secondary | 96 | 37.5 | | 46 | 35.9 | | 50 | 39.1 | | |
| Completed tertiary | 98 | 38.3 | | 65 | 50.8 | | 33 | 25.8 | | |
| Total | 256 | 100.0 | | 128 | 100.0 | | 128 | 100.0 | | |
| | Median | 25th percentile | 75th percentile | Median | 25th percentile | 75th percentile | Median | 25th percentile | 75th percentile | |
| Income (RM) | 1,000.00 | 500.00 | 2,000.00 | 1,300.0 | 800.0 | 2,500.0 | 1,000.0 | 500.0 | 1,500.0 | 0.004* |
| Weight (kg) | 70.00 | 61.98 | 80.00 | 72.0 | 62.6 | 82.0 | 68.5 | 58.2 | 77.0 | 0.024* |
| Body mass index (kg/m$^2$) | 27.66 | 24.20 | 30.72 | 27.9 | 24.5 | 31.2 | 26.7 | 24.2 | 30.5 | 0.164 |
| Systolic BP (mmHg) | 134.00 | 122.00 | 155.00 | 130.0 | 120.0 | 148.0 | 136.0 | 125.0 | 159.0 | 0.042* |
| Diastolic BP (mmHg) | 80.00 | 72.00 | 87.00 | 80.0 | 74.0 | 87.0 | 80.0 | 70.0 | 87.0 | 0.348 |
| Duration of diabetes (years) | 8.00 | 4.00 | 13.00 | 5.0 | 3.0 | 10.0 | 10.0 | 6.0 | 18.0 | <0.001* |
| A1C (%) | 9.50 | 8.30 | 11.40 | 10.0 | 8.6 | 11.9 | 9.2 | 8.1 | 11.0 | 0.013* |
| FBS (mmol/L) | 9.70 | 7.10 | 13.18 | 10.5 | 7.2 | 14.7 | 9.2 | 6.8 | 12.9 | 0.045* |
| TC (mmol/L) | 5.20 | 4.37 | 6.20 | 5.3 | 4.4 | 6.3 | 5.2 | 4.3 | 6.2 | 0.778 |
| HDL (mmol/L) | 1.10 | 0.96 | 1.40 | 1.1 | 0.9 | 1.3 | 1.2 | 1.0 | 1.5 | 0.001* |
| LDL (mmol/L) | 3.64 | 2.60 | 4.02 | 3.5 | 2.6 | 3.9 | 3.8 | 2.4 | 4.2 | 0.807 |
| TG (mmol/L) | 1.63 | 1.20 | 2.40 | 1.8 | 1.3 | 2.7 | 1.5 | 1.1 | 2.2 | 0.014* |
| eGFR (ml/min/1.72m$^2$) | 61.41 | 45.63 | 93.34 | 76.1 | 46.4 | 137.4 | 60.8 | 44.2 | 77.1 | 0.703 |
| Creatinine (μmol/L) | 89.00 | 66.50 | 119.00 | 98.0 | 62.0 | 132.3 | 85.0 | 69.3 | 116.8 | 0.341 |
| Treatment (n=276), N (%) | | | | | | | | | | |
| Oral antidiabetic | 113 | 40.9 | | 64 | 46.7 | | 49 | 35.3 | | 0.148 |
| Insulin | 61 | 22.1 | | 29 | 21.2 | | 32 | 23.0 | | |
| Both | 101 | 36.6 | | 43 | 31.4 | | 58 | 41.7 | | |
| Not sure | 1 | 0.4 | | 1 | 0.7 | | 0 | 0.0 | | |
| Total | 276 | 100.0 | | 137 | 100.0 | | 139 | 100.0 | | |
| Diabetes complications‡ (n=216), N (%) | | | | | | | | | | |
| Retinopathy | 104 | 48.1 | | 37 | 35.6 | | 67 | 59.8 | | <0.001† |
| Peripheral neuropathy | 125 | 57.9 | | 57 | 54.8 | | 68 | 60.7 | | 0.380 |
| Ischemic heart disease | 23 | 10.6 | | 7 | 6.7 | | 16 | 14.3 | | 0.072 |
| Cerebrovascular accident/ transient ischemic attack | 13 | 6.0 | | 4 | 3.8 | | 9 | 8.0 | | 0.196 |
| Peripheral vascular disease | 13 | 6.0 | | 7 | 6.7 | | 6 | 5.4 | | 0.577 |
| Amputation | 14 | 6.5 | | 5 | 4.8 | | 9 | 8.0 | | 0.336 |

*A1C*, glycated hemoglobin level; *BP*, blood pressure; *eGFR*, estimated glomerular filtration rate; *FBS*, fasting blood sugar; *HDL*, high-density lipoprotein cholesterol; *LDL*, low-density lipoprotein cholesterol; *RM*, Malaysian ringgit; *TC*, total cholesterol; *TG*, triglycerides.

* Mann-Whitney U test.

† Chi-square test.

‡ Diabetes complications, n=216.

respondents. Although there was no significant difference in creatinine levels among the groups, those who perceived poor control had better estimated glomerular filtration rates than the rest of the cohort (p=0.004). However, age, which is an important factor in determining estimated glomerular filtration rates, was not associated with perceived diabetes control (Supplemetary Table 2).

*Perception of diabetes control and sociodemography.* In terms of gender and ethnicity, no significant difference was found among the groups. Ironically, only 8.2% of those who had completed tertiary education correctly identified themselves as having poor control. On the other hand, 18.2% who had not completed primary education and 20.8% of those who had completed secondary education correctly perceived their diabetes control as poor (Supplementary Table 3).

*Knowledge, attitude and practice scores*

*KAP scores and disease characteristics.* The median scores for the KAP domains in our cohort of patients were 0.70 (IQR, 0.50 to 0.88), 0.78 (IQR, 0.56 to 0.89) and 0.58 (IQR, 0.50 to 0.75), respectively. The median total KAP score was 0.61 (IQR, 0.56 to 0.76). As we can see, the median score of each domain as well as the total KAP scores were higher than 0.50 (maximum attainable score was 1.00). The cohort scored highest in the attitude and knowledge domains but lowest in the practice component.

In our cohort of patients, A1C levels had a negative correlation with attitude scores (Spearman rho=–0.207; p=0.001) and total KAP scores (Spearman rho=–0.125; p=0.038), but we found no correlation with the knowledge and practice scores. There was a positive correlation between duration of diabetes and attitude scores

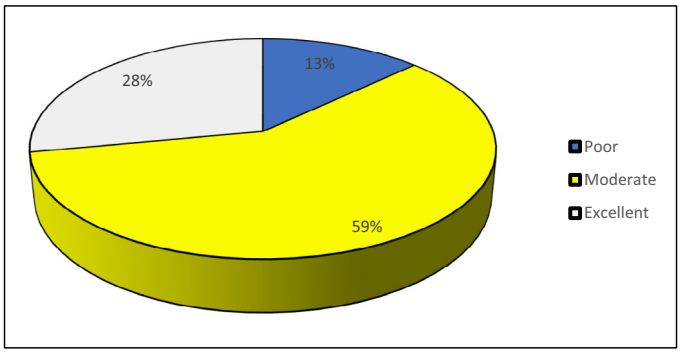


**Figure 2.** Perception of diabetes control by respondents with poor glycated hemoglobin levels (>7%): 28.4% and 58.9% of respondents wrongly perceived that their diabetes control was excellent or moderate, respectively. Only 12.7% of respondents correctly identified themselves as having poor diabetes control.

(Spearman rho=0.124; p=0.04) and total KAP scores (Spearman rho=0.154; p=0.011) but no correlation between duration and knowledge and practice scores. However, fasting blood sugar levels were not associated with either KAP scores or their individual domains (Supplementary Table 4).

*KAP scores and sociodemography.* In terms of sociodemography, only the knowledge score had a negative correlation with age (Spearman rho=–0.173; p=0.004), which translates to younger respondents having better knowledge of diabetes management (Supplementary Table 4). In general, higher education status was associated with higher knowledge scores (p=0.001), attitude scores (p=0.009) and total KAP scores (p<0.001) but not practice scores. Respondents with lower income had lower knowledge scores (p<0.001), attitude scores (p<0.001) and total KAP scores (p<0.001) (Supplementary Table 4).

*Perceptions of diabetes control and KAP scores.* As expected, there was no significant difference in terms of perceived diabetes control among the various quartiles of attitude, practice and total KAP scores. However, it was surprising to find that only a small number of patients whose knowledge scores were in the 2nd and 3rd quartiles perceived their diabetes control as being poor, whereas the majority of respondents in the 4th quartile of the knowledge domain wrongly perceived their diabetes control as being moderate (p=0.030) despite their A1C levels not reaching target (Table 2).

## Discussion

Our study, which aimed to assess our patients' perceptions of their diabetes control compared to their A1C levels, showed a mismatch between these 2 entities. A1C levels are used to reflect blood glucose levels over the past 8 to 12 weeks. It is an objective way to assess glycemic control. Every 1 percentage point increment in A1C level is associated with a significant increment in microvascular complications (12). Similarly, better glycemic control is associated with decreased rates of microvascular complications (13,14). The American Diabetes Association has recommended an individualized glycemic target in patients with type 2 diabetes. However, a reasonable goal for an A1C level in most nonpregnant adults is <7%. Unfortunately, the median A1C level of our patients was far from the recommended target. Despite that, a more worrying fact is that close to 80% of our patients believed that their glycemic control was moderate or excellent, despite median A1C levels of 9.8% and 8.8%, respectively.

Our results echo previous studies that found that health literacy is independent of glycemic control (7,10,15). The poor perception of our patients cannot be attributed solely to a poor understanding of A1C levels. We assessed the patients' general perceptions of their glycemic control. Patients who rated their glycemic control as moderate or excellent had had diabetes for a median duration of 9 and 8 years, respectively. This reflects the poor understanding by patients despite their attendance at regular clinic sessions over many years. We postulate that the differences in perception seen in both centres could be due to the differences in diabetes severity. The majority of patients seen in the tertiary center had more micro- and macrovascular complications compared to the newly diagnosed patients with diabetes who were seen in the primary care setting. The large discordance between perception of diabetes control and actual disease control reflected by A1C levels could be contributed to by other factors, too. Some patients could have perceived their control as being excellent because of their efforts in self-managing their disease, e.g. regular exercise, eating healthfully and being adherent to prescribed medications and follow-up appointments. Unfortunately, such efforts did not translate into optimal A1C results due to other factors, such as underdosing of medications and the natural progression of the disease.

The absence of a positive correlation between duration of diabetes and patients' knowledge and practice scores reflects the minimal impact of the disease's duration on these 2 important aspects. The discordant KAP scores also reflect the inadequacy of diabetes education, which subsequently translates into poor perception by patients of their glycemic control.

In our cohort, education level did not produce the expected perception of control. The poor perception of diabetes control among our patients was not associated with ethnicity or diabetes-related kidney disease either; our analysis did not show any correlation between these confounders. Furthermore, the presence of complications did not influence the perception of diabetes control. The small number of diabetes complications observed in this cohort may have contributed to the statistically nonsignificant association between perceived diabetes control and its complications. The unexpected relationship observed between peripheral vascular disease and perception may have occurred by chance. The other explanation that should be considered is that patients might attribute these complications to other factors, such as comorbidities and adverse effects of medications.

Younger respondents seemed to fare better in knowledge scores, suggesting a better understanding of diabetes knowledge in this group of patients. This may be explained by the fact that the younger population in this cohort was in the higher income group (Table 1), and more of them had completed tertiary education (Table 1). Respondents with higher education levels also showed better knowledge of and attitudes toward diabetes management; however, this did not translate into appropriate practice of diabetes care. This suggests a need for changes in communicating feedback by healthcare providers to patients with regard to the control and care of their diabetes. One way of doing so would be to enhance patients' understanding of glycemic control via more national diabetes-education programs. Other methods include using lay-person terms when explaining A1C and glycemic control to patients as well as using other tools for feedback about glycemic control such as home glucometers. Only when patients can comprehend the severity of their disease can we further empower them for better diabetes self-care.

Our study has a few implications. The wrong perceptions by our patients with diabetes, despite poor control of the disease, may explain why most of them do not achieve the recommended glycemic target, leading to increased risk for diabetes-related complications. Second, more effective and standardized education

**Table 2**
Bivariate analysis between knowledge, attitude, practice scores and several variables

| | Knowledge score | | | | p value | Attitude score | | | | p-value |
|---|---|---|---|---|---|---|---|---|---|---|
| | Q1 | Q2 | Q3 | Q4 | | Q1 | Q2 | Q3 | Q4 | |
| Median age (years) | 50.0 (42.0–57.0) | 46.8 (35.3–57.0) | 48.0 (40.9–55.5) | 44.5 (37.0–53.0) | 0.043* | 44.5 (32.2–56.0) | 47.8 (39.7–56.0) | 50.0 (37.6–57.0) | 49.0 (38.0–53.0) | 0.591 |
| Ethnicity, n (%) | | | | | | | | | | |
| Malay | 49 (77.8) | 50 (80.6) | 70 (85.4) | 58 (84.1) | 0.897 | 25 (83.3) | 90 (84.9) | 51 (78.5) | 61 (81.3) | 0.707 |
| Chinese | 8 (12.7) | 6 (9.7) | 6 (7.3) | 7 (10.1) | | 2 (6.7) | 8 (7.5) | 10 (15.4) | 7 (9.3) | |
| Indian | 6 (9.5) | 6 (9.7) | 6 (7.3) | 4 (5.8) | | 3 (10.0) | 8 (7.5) | 4 (6.2) | 7 (9.3) | |
| Education | | | | | | | | | | |
| No formal | 1 (1.6) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0.001† | 0 (0.0) | 1 (1.0) | 0 (0.0) | 0 (0.0) | 0.009† |
| Did not complete primary | 9 (14.3) | 8 (13.1) | 4 (5.1) | 1 (1.9) | | 5 (16.7) | 12 (12.1) | 3 (4.8) | 2 (3.1) | |
| Completed primary | 15 (23.8) | 11 (18.0) | 12 (15.2) | 1 (1.9) | | 4 (13.3) | 22 (22.2) | 10 (16.1) | 3 (4.6) | |
| Completed secondary | 22 (34.9) | 25 (41.0) | 30 (38.0) | 19 (35.8) | | 12 (40.0) | 38 (38.4) | 22 (35.5) | 24 (36.9) | |
| Completed tertiary | 16 (25.4) | 17 (27.9) | 33 (41.8) | 32 (60.4) | | 9 (30.0) | 26 (26.3) | 27 (43.5) | 36 (55.4) | |
| Duration of diabetes (years) | 7 (3–11) | 6 (3–14) | 10 (5–14) | 7 (4–13) | 0.113 | 6 (3–12) | 7 (4–15) | 7 (3–10) | 10 (5–13) | 0.165 |
| Median A1C (%) | 9.2 (8.3–11.9) | 9.9 (8.6–11.8) | 9.8 (8.4–11.6) | 9.2 (8.1–11.0) | 0.440 | 11.4 (9.0–14.1) | 10.0 (8.3–11.9) | 9.0 (7.8–10.5) | 9.4 (8.6–10.9) | <0.001* |
| Median creatinine (μmol/L) | 91 (68–128) | 63 (48–71) | 99 (77–120) | 118 (82–219) | 0.005* | 81 (56–102) | 82 (63–119) | 100 (75–236) | 104 (65–124) | 0.510 |
| Median eGFR (mL/min/1.72 $m^2$) | 54.1 (39.8–75.7) | 132.1 (81.9–161.0) | 59.9 (47.0–80.8) | 48.1 (33.9–79.2) | 0.003* | 63.2 (52.7–153.1) | 61.5 (41.9–92.4) | 54.3 (30.4–93.2) | 59.1 (48.2–121.4) | 0.747 |
| Perception of diabetes control, n (%) | | | | | | | | | | |
| Poor | 7 (11.1) | 13 (21.0) | 10 (12.2) | 5 (7.4) | 0.030† | 5 (16.7) | 17 (16.0) | 4 (6.2) | 9 (12.2) | 0.230 |
| Moderate | 34 (54.0) | 27 (43.5) | 52 (63.4) | 49 (72.1) | | 14 (46.7) | 56 (52.8) | 44 (67.7) | 48 (64.9) | |
| Excellent | 22 (34.9) | 22 (35.5) | 20 (24.4) | 14 (20.6) | | 11 (36.7) | 33 (31.1) | 17 (26.2) | 17 (23.0) | |
| | Practice score | | | | p value | KAP score | | | | p-value |
| | Q1 | Q2 | Q3 | Q4 | | Q1 | Q2 | Q3 | Q4 | |
| Median age (years) | 45.3 (36.0–56.0) | 51.0 (41.8–57.0) | 48.0 (38.0–53.5) | 48.0 (37.0–56.0) | 0.380 | 50.0 (36.8–57.0) | 46.0 (37.0–57.0) | 48.0 (35.0–53.0) | 48.0 (38.0–53.0) | 0.041* |
| Ethnicity | | | | | | | | | | |
| Malay | 50 (89.3) | 40 (88.9) | 79 (82.3) | 58 (73.4) | 0.209 | 57 (85.1) | 56 (78.9) | 58 (84.1) | 56 (81.2) | 0.747 |
| Chinese | 3 (5.4) | 2 (4.4) | 9 (9.4) | 13 (16.5) | | 4 (6.0) | 10 (14.1) | 5 (7.2) | 8 (11.6) | |
| Indian | 3 (5.4) | 3 (6.7) | 8 (8.3) | 8 (10.1) | | 6 (9.0) | 5 (7.0) | 6 (8.7) | 5 (7.2) | |
| Education | | | | | | | | | | |
| No formal | 1 (1.9) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0.339 | 1 (1.5) | 0 (0.0) | 0 (0.0) | 0 (0.0) | <0.001† |
| Did not complete primary | 6 (11.3) | 7 (16.3) | 5 (5.6) | 4 (5.6) | | 9 (13.4) | 9 (13.0) | 3 (4.7) | 1 (1.8) | |
| Completed primary | 10 (18.9) | 8 (18.6) | 12 (13.5) | 9 (12.7) | | 15 (22.4) | 15 (21.7) | 7 (10.9) | 2 (3.6) | |
| Completed secondary | 16 (30.2) | 12 (27.9) | 36 (40.4) | 32 (45.1) | | 22 (32.8) | 31 (44.9) | 20 (31.3) | 23 (41.1) | |
| Completed tertiary | 20 (37.7) | 16 (37.2) | 36 (40.4) | 26 (36.6) | | 20 (29.9) | 14 (20.3) | 34 (53.1) | 30 (53.6) | |
| Duration of diabetes (years) | 5 (2–13) | 8 (5–14) | 9 (4–13) | 9 (4–15) | 0.202 | 6 (3–13) | 7 (4–13) | 7 (4–13) | 10 (5–15) | 0.704 |
| Median A1C (%) | 9.5 (8.2–11.6) | 9.5 (8.1–11.1) | 9.8 (8.5–11.7) | 9.1 (8.1–11.3) | 0.628 | 9.8 (8.4–12.0) | 10.0 (8.7–12.0) | 9.2 (8.0–10.9) | 9.5 (8.6–12.2) | 0.077 |
| Median creatinine (μmol/L) | 95 (68–124) | 99 (50–128) | 82 (64–117) | 95 (71–113) | 0.996 | 79 (52–104) | 100 (69–120) | 84 (62–129) | 110 (82–187) | 0.409 |
| Median eGFR (mL/min/1.72 $m^2$) | 54.1 (41.9–75.7) | 53.1 (36.8–142.8) | 71.8 (47.7–95.3) | 69.4 (50.4–81.7) | 0.806 | 63.2 (44.0–133.1) | 60.9 (47.2–82.8) | 77.7 (47.6–127.5) | 57.3 (38.0–77.3) | 0.833 |
| Perception of diabetes control | | | | | | | | | | |
| Poor | 10 (17.9) | 4 (8.9) | 11 (11.6) | 10 (28.6) | 0.850 | 10 (14.9) | 12 (16.9) | 6 (8.7) | 7 (10.3) | 0.327 |
| Moderate | 32 (57.1) | 28 (62.2) | 58 (61.1) | 25 (31.6) | | 35 (52.2) | 37 (52.10 | 43 (62.3) | 47 (69.1) | |
| Excellent | 14 (25.1) | 13 (28.9) | 26 (27.4) | 25 (31.6) | | 22 (32.8) | 22 (31.0) | 20 (29.0) | 14 (20.6) | |

*A1C*, glycated hemoglobin; *eGFR*, estimated glomerular filtration rate; *KAP score*, knowledge, attitude, practice score.
* Kruskal-Wallis test.
† Chi-square test.

programs need to be conducted nationwide to further educate our patients about the disease, targeting especially those with lower education levels and elderly patients. Clinicians who manage patients with diabetes also may need regular updates and training in conveying messages and education to patients so as to improve effective feedback to the patients. However, diabetes knowledge is not the only factor in successful diabetes management. Patient empowerment in diabetes self-care is equally important to change their attitudes and practices, enabling them to work alongside their health-care providers to further improve their diabetes control effectively; this will lead to better quality of life for patients and better outcomes.

Our study is limited by the small number of patients as well as by a relatively low-income cohort and a homogeneous convenience sample; hence, it may not be generalizable to the population at large. The other ethnicities of Malaysia (i.e. the Chinese and Indian populations) were not well represented in this study because the population near the tertiary as well as the primary care centres comprised mainly people of Malay ethnicity. Second, the cross-sectional nature of this study precluded the study of any causal relationships among the variables. The KAP questionnaire was not completely validated; however, a pilot study had been performed in a different cohort before the enrollment of this study population. Finally, the interobserver reliability of the interviewers was not assessed. However, they were trained in administration of the questionnaire before the study. They were allowed to read out only the questionnaire to the respondents, without paraphrasing the questions, and standardized responses for clarifications of possible respondent queries were discussed during the training session.

## Conclusions

In conclusion, the mismatch between patients' perceptions of diabetes control shown in our study, combined with studies in other countries, reflects a common phenomenon of poor understanding by the patients of their glycemic control as well as their attitudes toward and practice of diabetes care. More studies are needed to test the effectiveness of communication between health-care providers and patients about diabetes knowledge. Effective education programs are essential to empower patients with knowledge, hence changing their attitudes toward and practices of diabetes management.

## Supplementary Material

To access the supplementary material accompanying this article, visit the online version of *Canadian Journal of Diabetes* at https://www.canadianjournalofdiabetes.com.

## Funding

The study did not receive any funding.

## Author Disclosures

Conflicts of interest: None.

## Author Contributions

MAS came up with the concept idea, designed the study, analyzed the data and wrote the manuscript. AMO collected the data and wrote the manuscript. HHL interpreted the data, wrote and edited the manuscript.

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## Supplementary Materials

**Supplementary Table 1**
Knowledge, Attitude and Practice on management of diabetes interview

| | Questions | Answer | Mark |
|---|---|---|---|
| K1 | Diabetes/kencingmanismerupakankeadaandi mana:<br>*Diabetes mellitus is a condition where:* | **a. Kadar guladalamdarah yang lebihtinggidaripada normal.**<br>b. Kadar guladalamdarah yang lebihrendahdaripada normal.<br>c. Kadar guladalamdarah yang lebihtinggiataulebihrendahdaripada normal.<br>d. Sayatidaktahu<br>**a. *Glucose level in the blood is higher than normal.***<br>b. *Glucose level in the blood is lower than normal.*<br>c. *Glucose level in the blood is either higher or lower than normal.*<br>d. *I do not know.* | **1** □ **0** □ |
| K2 | Sebabutama diabetes/kencingmanisialah:<br>*The main cause of diabetes mellitus is:* | a. Terdapat insulin berlebihandalamdarah<br>**b. Terdapatkekurangan insulin dalamdarah**<br>c. Sayatidaktahu<br>a. There is excessive insulin the blood.<br>**b. There is lack of insulin in the blood.**<br>c. I do not know. | **1** □ **0** □ |
| K3 | Simtom-simtom diabetes/kencingmanisadalah:<br>*Symptoms of diabetes mellitus include:* | a. Bertambahkekerapanmembuang air kecil<br>b. Bertambahdahaga<br>c. Bertambahletih<br>d. Lambatsembuhdariluka<br>**e. Semua di atas**<br>f. Sayatidaktahu<br>*a. Excessive urination.*<br>*b. Excessive thirst.*<br>*c. Lethargy.*<br>*d. Delayed wound healing.*<br>***e. All the above.***<br>f. *I do not know.* | **1** □ **0** □ |
| K4 | Diabetes/kencingmanis, jikatidakdirawat:<br>*Diabetes mellitus, if it is not treated:* | a. Bolehmenyebabkanmasalahmata<br>b. Bolehmenyebabkanmasalahbuahpinggang<br>c. Bolehmenyebabkanlukapada kakiberpanjangan<br>d. Bolehmenyebabkanmasalahjantung<br>**e. Semua di atas**<br>f. Sayatidaktahu<br>a. *May cause visual problems.*<br>b. *May cause kidney problems.*<br>c. *May cause nonhealing wound at the feet.*<br>d. *May cause heart problems.*<br>**e. *All the above.***<br>f. *I do not know.* | **1** □ **0** □ |
| K5 | Cara yang paling tepatuntukmemantau diabetes/kencingmanisialah:<br>*The most appropriate way(s) of monitoring diabetes mellitus is/are by:* | **a. Memeriksaguladalamdarah**<br>b. Memeriksaguladalam air kencing<br>c. Sayatidaktahu<br>***a. Checking blood glucose levels.***<br>*b. Detecting glucose in the urine.*<br>c. *I do not know.* | **1** □ **0** □ |
| K6 | Di kalanganpesakit diabetes/kencingmanis, tekanandarahtinggibolehmeningkatkan:<br>*Among patients with diabetes, hypertension may increase:* | a. Risikoseranganjantung<br>b. Risikoanginahmar<br>c. Risikomasalahmata<br>d. Risikomasalahbuahpinggang<br>**e. Semua di atas**<br>f. Sayatidaktahu<br>a. *The risk of heart attack.*<br>b. *The risk of stroke.*<br>c. *The risk of eye problems.*<br>d. *The risk of kidney failure*<br>**e. *All the above.***<br>f. *I do not know.* | **1** □ **0** □ |
| K7 | Pesakitkencingmanissepatutnyamemeriksatekanandarah:<br>*Patients with diabetes should have their blood pressure checked:* | a. Setahunsekali<br>b. Setiapenambulan<br>**c. Setiaptigabulan**<br>d. Setiapbulan<br>e. Tidakperluperiksasamasekali<br>f. Sayatidaktahu<br>*a. Once a year.*<br>*b. Every 6months*<br>***c. Every 3months.***<br>*d. Every month.*<br>*e. Not necessary.*<br>f. *I do not know.* | **1** □ **0** □ |

(*continued on next page*)

**Supplementary Table 1** (*continued*)

| | Questions | Answer | Mark |
|---|---|---|---|
| K8 | Perubahangayahidup yang perludilakukanolehpesakitkencingmanis:<br>*Lifestyle change(s) that is/are required for patients with diabetes include(s):* | a. Kurangkanberatbadan<br>b. Berhentimerokok<br>c. Berhentipengambilanalkohol<br>**d. Semua di atas**<br>e. Sayatidaktahu<br>*a. Weight reduction.*<br>*b. Stop smoking.*<br>*c. Stop alcohol intake.*<br>***d. All the above.***<br>e. *I do not know.* | **1** □ **0** □ |
| K9 | Pesakit diabetes/kencingmanisperlumemeriksamata:<br>*Patients with diabetes should have their eyes checked:* | **a. Setahunsekali**<br>b. Setiapenambulan<br>c. Tidakperluperiksasamasekali<br>**a. *Once a year.***<br>b. *Every 6months.*<br>c. *Not necessary.* | **1** □ **0** □ |
| K10 | Pemeriksaan air kencingberkalaakanmembantudoktormengesan:<br>*A scheduled urine examination would help the doctor assess:* | a. Keadaanfungsihati<br>**b. Keadaanfungsibuahpinggang**<br>c. Kawalan diabetes/kencingmanis<br>d. Sayatidaktahu<br>*a. Liver function.*<br>***b. Kidney function.***<br>*c. Diabetes control.*<br>d. *I do not know.* | **1** □ **0** □ |
| K11 | Faktorpenting yang membantukawalanguladalamdarahialah:<br>*Important factor(s) that would help blood sugar control include:* | a. Diet yang terancangdanterkawal<br>b. Senamanberjadual<br>c. Ubat<br>**d. Semua di atas**<br>e. Tiada<br>*a. A planned meal.*<br>*b. Scheduled exercise.*<br>*c. Medication.*<br>***d. All the above.***<br>e. *None.* | **1** □ **0** □ |
| K12 | Senaman yang kerapakanmembantu:<br>*Regular exercise would help:* | a. Meningkatkanperjalanandarah<br>**b. Menambah-baiktindakan insulin**<br>c. Sayatidaktahu<br>*a. Increase blood flow.*<br>***b. Improve insulin action.***<br>c. *I do not know.* | **1** □ **0** □ |
| K13 | Makanan yang seimbangtermasuk:<br>*A balanced diet includes:* | a. Sayur-sayuranhijau<br>b. Makanan kaya denganserat<br>c. Rendahgula, minyakdanlemak<br>d. Semua di atas<br>e. Sayatidaktahu<br>*a. Green vegetables.*<br>*b. Food rich in fibre.*<br>*c. Low sugar and fat.*<br>***d. All the above.***<br>e. *I do not know.* | **1** □ **0** □ |
| K14 | Untukpenjagaan kaki yang betul, pesakit diabetes/kencingmanis:<br>*For foot care, patients with diabetes should:* | **a. Perlumemeriksadanmembersih kaki setiaphari**<br>b. Perlumemilihkasutsebaikmungkin<br>c. Perluberkakiayam di dalamdan di luarrumah<br>d. Sayatidaktahu<br>***a. Inspect and clean their feet daily.***<br>*b. Choose the appropriate shoes.*<br>*c. Bare feet inside and outside the home.*<br>d. *I do not know.* | **1** □ **0** □ |
| K15 | Rawatanuntuk diabetes/kencingmanistermasuk:<br>*The treatment(s) for diabetes mellitus include(s):* | a. Antibiotik<br>b. Pemindahandarah<br>**c. Menggantikan insulin**<br>d. Pengambilansayur-sayuranpahit<br>e. Sayatidaktahu<br>*a. Anitbiotics.*<br>*b. Blood transfusion.*<br>***c. Insulin replacement.***<br>*d. Taking bitter vegetables.*<br>e. *I do not know.* | **1** □ **0** □ |

(*continued on next page*)

**Supplementary Table 1** (*continued*)

| | Questions | Answer | Mark |
|---|---|---|---|
| K16 | Diabetes/kencingmanistidakbolehdirawatdengan:<br>*Diabetes mellitus cannot be treated with:* | a. Insulin<br>b. Glibenclamide<br>c. Metformin<br>**d. Antibiotik**<br>e. Sayatidaktahu<br>*a. Insulin.*<br>*b. Glibenclamide.*<br>*c. Metformin.*<br>***d. Antibiotics.***<br>e. *I do not know.* | **1** □ **0** □ |
| K17 | Setelah diabetes/kencingmanisterkawal, ubat-ubatan:<br>*Once diabetes is well controlled, the medication(s):* | a. Bolehdihentikanserta-merta<br>b. Bolehdihentikansetelahsebulan<br>**c. Perluditeruskansepanjanghayat**<br>d. Sayatidaktahu<br>*a. Can be stopped immediately.*<br>*b. Can be stopped after a month.*<br>***c. Need to be continued indefinitely***<br>d. *I do not know.* | **1** □ **0** □ |
| K18 | Bagaimanaandamenanganigejalahipoglisemia?<br>*How would you manage hypoglycemic symptoms?* | **a. Denganmengambilgula**<br>b. Denganmengambilubatkencingmanis<br>c. Denganmengambil insulin<br>d. Sayatidaktahu<br>***a. By taking sugar.***<br>*b. By taking diabetes medication.*<br>*c. By taking insulin.*<br>d. *I do not know.* | **1** □ **0** □ |
| A1 | Adakahandakerapbersenam?<br>*Do you exercise often?*<br><br>Jikaya, berapakerap?<br>*If yes, how frequently?* | **a. Ya**<br>b. Tidak<br>***a. Yes.***<br>*b. No.*<br>a. Seminggusekali<br>b. Sebulansekali<br>**c. 3 kali semingguataulebih**<br>*a. Once a week.*<br>*b. Once a month.*<br>**c. *3 times a week or more.*** | **1** □ **0** □ |
| A2 | Adakahandamengamalkanpemakanan yang terkawaldanterancang?<br>*Do you practice taking planned meals?*<br><br>Jikaya, berapakerap?<br>*If yes, how frequently?* | **a. Ya**<br>b. Tidak<br>***a. Yes.***<br>*b. No.*<br>**a. Setiaphari**<br>b. Seminggusekali<br>c. Sebulansekali<br>d. 3 kali seminggu<br>***a. Every day.***<br>*b. Once a week.*<br>*c. Once a month.*<br>d. *3 times a week.* | **1** □ **0** □ |
| A3 | Adakahandamerasakanbahawadengantertinggalnya pengambilanubatakanmemberikesannegatifter hadapkawalanpenyakitanda?<br>*Do you feel that missing your medication would cause negative effects on your disease control?* | **a. Ya**<br>b. Tidak<br>***a. Yes.***<br>b. *No.* | **1** □ **0** □ |
| A4 | Adakahandapernahmengalamisituasikandungangula dalamdarahlebihrendahdaripada paras normal ("hypoglycemia") apabilaandamengambilubat diabetes/kencingmanisanda?<br>*Have you ever experienced a condition where your blood sugar is lower than normal (hypoglycemia) when you took your diabetes medication?* | a. Ya<br>b. Tidak | **1** □ **0** □ |
| | Jikaya, adakahandapadabila-bila masa mengalamisimtom-simtomberikut?<br>*If yes, do you at any time experience any of these symptoms?* | a. Lemah<br>b. Kekeliruan<br>c. Gangguan visual<br>d. Sayatidaktahu<br>*a. Lethargy.*<br>*b. Confusion.*<br>*c. Visual disturbance.*<br>d. *I do not know.* | |
| | Kerapmengalamihipoglisemiaadalahperkarabiasa.<br>*Having frequent hypoglycemia is acceptable.* | a. Setuju<br>**b. Tidaksetuju**<br>*a. Agree.*<br>**b. *Disagree.*** | |
| A5 | Adakahandaberpendapatbahawaandaperlusentiasa berhubungandengandoktoranda?<br>Do you think you should always be in contact with your doctor? | **a. Ya**<br>b. Tidak<br>***a. Yes.***<br>b. *No.* | **1** □ **0** □ |

(*continued on next page*)

**Supplementary Table 1** (*continued*)

| | Questions | Answer | Mark |
|---|---|---|---|
| P1 | Bila kali terakhirandamemeriksatekanandarahanda?<br>*When was the last time you checked your blood pressure?* | **a. Seminggu yang lalu**<br>**b. Sebulan yang lalu**<br>**c. Tigabulan yang lalu**<br>d. Enambulan yang lalu<br>e. Setahun yang lalu<br>***a. A week ago.***<br>***b. A month ago.***<br>***c. Three months ago.***<br>*d. Six months ago.*<br>e. *A year ago.* | **1** □ **0** □ |
| P2 | Bila kali terakhirandamenjalanipemeriksaanmata?<br>*When was the last time you had an eye examination?* | **a. Sebulan yang lalu**<br>**b. Enambulan yang lalu**<br>**c. Setahun yang lalu**<br>d. Duatahun yang lalu<br>e. Tidakpernahsamasekali<br>***a. A month ago.***<br>***b. Six months ago.***<br>***c. A year ago.***<br>*d. Two years ago.*<br>e. *Never.* | **1** □ **0** □ |
| P3 | Bila kali terakhirandamenjalanipemeriksaan air kencing?<br>*When was the last time you had a urine examination done?* | **a. Sebulan yang lalu**<br>**b. Enambulan yang lalu**<br>c. Setahun yang lalu<br>d. Tidakpernahsamasekali<br>**e. Tigabulan yang lalu**<br>***a. A month ago.***<br>***b. Six months ago.***<br>*c. A year ago.*<br>*d. Never.*<br>**e. *Three months ago.*** | **1** □ **0** □ |
| P4 | Bila kali terakhirandamengunjungidoktoranda?<br>*When was the last time you saw your doctor?* | **a. 3 bulan yang lepas**<br>**b. 6 bulan yang lepas**<br>c. Setahun yang lepas<br>d. Lebihdarisetahun yang lepas<br>***a. 3 months ago.***<br>***b. 6 months ago.***<br>*c. A year ago.*<br>d. *More than a year ago.* | **1** □ **0** □ |
| P5 | Bila kali terakhirpemeriksaanguladalamdarahandadilakukan?<br>*When was the last time you had your blood sugar level checked?* | **a. 3 bulan yang lepas**<br>b. 6 bulan yang lepas<br>c. Setahun yang lepas<br>d. Lebihdarisetahun yang lepas<br>***a. 3 months ago.***<br>*b. 6 months ago.*<br>*c. A year ago.*<br>d. *More than a year ago.* | **1** □ **0** □ |
| P6 | Bila kali terakhirpemeriksaanlemakdalamdarahandadilakukan?<br>*When was the last time you had your blood cholesterol level checked?* | **a. 3 bulan yang lepas**<br>**b. 6 bulan yang lepas**<br>c. Setahun yang lepas<br>d. Lebihdarisetahun yang lepas<br>***a. 3 months ago.***<br>***b. 6 months ago.***<br>*c. A year ago.*<br>*d. More than a year ago.* | **1** □ **0** □ |
| P7 | Adakahandapernahketinggalanmengambilubat diabetes/kencingmanisanda?<br>*Have you ever missed your diabetes medication(s)?*<br><br>Jikaya, berapakerap?<br>*If yes, how frequently?* | a. Ya<br>**b. Tidak**<br>*a. Yes.*<br>**b. *No.***<br><br>a. Kadang-kadang<br>b. Sekurang-kurangnyaseminggusekali<br>c. Sekurang-kurangnyasebulansekali<br>*d. Sometimes.*<br>*e. At least once a week.*<br>f. *At least once a month.* | **1** □ **0** □ |
| | Scoring:<br>Knowledge score=<br>Attitude score=<br>Practice score=<br>Total KAP score = | <br>(K1+K2+K3+K4+K5+K6+K7+K8+K9+K10+K11+K12+K13+K14+K15+K16+K17+K18)/18<br>(A1+A2+A3+A4+A5)/5<br>(P1+P2+P3+P4+P5+P6+P7)/7<br>(Knowledge score + Attitude score + Practice score)/3 | |

*Notes*. The Knowledge, Attitude and Practice on Management of Diabetes interview was conducted in Malay. (The English translation is for the purpose of this publication only.) Correct answers are in boldface. There are 18 questions in the knowledge domain, 5 questions in the attitude domain and 7 in the practice domain. A 1 is given for each correct response, and a 0 is given for each incorrect response. The maximum attainable score is 1.00. The individual domain score is the average of each domain, and the total KAP score is the average of each domain score.

**Supplementary Table 2**
The relationship between perception of diabetes control and several variables

| Variables | Perception | Median | 25th percentile | 75th percentile | p value |
|---|---|---|---|---|---|
| Age (years) | Poor | 52.00 | 45.00 | 61.00 | 0.196 |
| | Moderate | 55.50 | 48.00 | 62.00 | |
| | Excellent | 57.00 | 49.00 | 63.25 | |
| Income (RM) | Poor | 1000.00 | 300.00 | 2000.00 | 0.103 |
| | Moderate | 1000.00 | 600.00 | 2000.00 | |
| | Excellent | 1000.00 | 500.00 | 1575.00 | |
| Weight (kg) | Poor | 65.40 | 59.63 | 74.25 | 0.442 |
| | Moderate | 69.60 | 62.00 | 80.30 | |
| | Excellent | 72.00 | 60.80 | 80.00 | |
| BMI (kg/m$^2$) | Poor | 26.58 | 23.95 | 29.35 | 0.128 |
| | Moderate | 27.98 | 24.22 | 31.88 | |
| | Excellent | 27.19 | 23.66 | 29.96 | |
| Systolic BP (mmHg) | Poor | 130.00 | 120.00 | 146.00 | 0.263 |
| | Moderate | 136.00 | 122.50 | 155.50 | |
| | Excellent | 130.00 | 124.75 | 154.00 | |
| Diastolic BP (mmHg) | Poor | 80.00 | 70.00 | 89.00 | 0.464 |
| | Moderate | 80.00 | 73.00 | 87.00 | |
| | Excellent | 80.00 | 72.00 | 84.50 | |
| A1C (%) | Poor | 11.00 | 9.00 | 12.60 | 0.002* |
| | Moderate | 9.80 | 8.50 | 11.33 | |
| | Excellent | 8.85 | 7.70 | 11.13 | |
| FBS (mmol/L) | Poor | 13.50 | 9.60 | 18.10 | <0.001* |
| | Moderate | 10.00 | 7.10 | 13.10 | |
| | Excellent | 8.25 | 6.95 | 10.83 | |
| TC (mmol/L) | Poor | 5.21 | 4.37 | 6.95 | 0.449 |
| | Moderate | 5.30 | 4.40 | 6.30 | |
| | Excellent | 5.09 | 4.05 | 6.05 | |
| HDL (mmol/L) | Poor | 1.06 | 0.80 | 1.43 | 0.188 |
| | Moderate | 1.20 | 0.95 | 1.42 | |
| | Excellent | 1.10 | 1.00 | 1.31 | |
| LDL (mmol/L) | Poor | 3.64 | 2.66 | 4.46 | 0.959 |
| | Moderate | 3.27 | 2.57 | 4.05 | |
| | Excellent | 3.63 | 2.23 | 4.11 | |
| TG (mmol/L) | Poor | 1.90 | 1.38 | 2.40 | 0.461 |
| | Moderate | 1.60 | 1.20 | 2.36 | |
| | Excellent | 1.66 | 1.20 | 2.48 | |
| Duration of diabetes (years) | Poor | 5.00 | 3.00 | 12.00 | 0.492 |
| | Moderate | 8.00 | 4.00 | 13.00 | |
| | Excellent | 7.50 | 4.00 | 14.00 | |
| eGFR (mL/min/1.72 m$^2$) | Poor | 83.06 | 60.14 | 155.74 | 0.004* |
| | Moderate | 45.79 | 32.21 | 65.08 | |
| | Excellent | 62.58 | 47.45 | 87.38 | |
| Creatinine (μmol/L) | Poor | 69.00 | 50.50 | 112.50 | 0.168 |
| | Moderate | 95.00 | 70.00 | 142.00 | |
| | Excellent | 98.00 | 66.50 | 116.00 | |
| K score | Poor | 0.60 | 0.50 | 0.80 | 0.036* |
| | Moderate | 0.70 | 0.50 | 0.90 | |
| | Excellent | 0.60 | 0.40 | 0.80 | |
| A score | Poor | 0.67 | 0.56 | 0.89 | 0.101 |
| | Moderate | 0.78 | 0.67 | 0.89 | |
| | Excellent | 0.67 | 0.56 | 0.78 | |
| P score | Poor | 0.58 | 0.42 | 0.75 | 0.596 |
| | Moderate | 0.58 | 0.50 | 0.75 | |
| | Excellent | 0.67 | 0.50 | 0.75 | |
| Total KAP | Poor | 0.64 | 0.49 | 0.71 | 0.072 |
| | Moderate | 0.69 | 0.57 | 0.77 | |
| | Excellent | 0.66 | 0.54 | 0.74 | |

*A1C*, glycated hemoglobin; *BMI*, body mass Index; *BP*, blood pressure; *eGFR*, estimated glomerular filtration rate; *FBS*, fasting blood sugar; *HDL*, high-density lipoprotein cholesterol; *K*, knowledge, *A*, attitude, *P*, practice; *LDL*, low-density lipoprotein cholesterol; *TC*, total cholesterol; *TG*, triglycerides.

* Kruskal-Wallis test.

**Supplementary Table 3**
Bivariate analysis between perception of diabetes control and several variables

| | | | Perception | | | Total | p value |
|---|---|---|---|---|---|---|---|
| | | | Poor | Moderate | Excellent | | |
| Center | Primary care | N | 7 | 71 | 25 | 103 | 0.016* |
| | | % | 6.8% | 68.9% | 24.3% | 100.0% | |
| | Tertiary center | N | 28 | 91 | 53 | 172 | |
| | | % | 16.3% | 52.9% | 30.8% | 100.0% | |
| Gender | Male | N | 14 | 67 | 40 | 121 | 0.307 |
| | | % | 11.6% | 55.4% | 33.1% | 100.0% | |
| | Female | N | 21 | 95 | 38 | 154 | |
| | | % | 13.6% | 61.7% | 24.7% | 100.0% | |
| Ethnicity | Malay | N | 31 | 139 | 56 | 226 | 0.503 |
| | | % | 13.7% | 61.5% | 24.8% | 100.0% | |
| | Chinese | N | 1 | 14 | 12 | 27 | |
| | | % | 3.7% | 51.9% | 44.4% | 100.0% | |
| | Indian | N | 3 | 9 | 10 | 22 | |
| | | % | 13.6% | 40.9% | 45.5% | 100.0% | |
| Education | No Formal | N | 0 | 1 | 0 | 1 | 0.023* |
| | | % | 0.0% | 100.0% | 0.0% | 100.0% | |
| | Not completed primary | N | 4 | 12 | 6 | 22 | |
| | | % | 18.2% | 54.5% | 27.3% | 100.0% | |
| | Completed primary | N | 3 | 20 | 16 | 39 | |
| | | % | 7.7% | 51.3% | 41.0% | 100.0% | |
| | Completed secondary | N | 20 | 45 | 31 | 96 | |
| | | % | 20.8% | 46.9% | 32.3% | 100.0% | |
| | Completed tertiary | N | 8 | 69 | 20 | 97 | |
| | | % | 8.2% | 71.1% | 20.6% | 100.0% | |
| Treatment | Oral | N | 13 | 66 | 34 | 113 | 0.225 |
| | | % | 11.5% | 58.4% | 30.1% | 100.0% | |
| | Insulin | N | 8 | 33 | 19 | 60 | |
| | | % | 13.3% | 55.0% | 31.7% | 100.0% | |
| | Both | N | 13 | 63 | 25 | 101 | |
| | | % | 12.9% | 62.4% | 24.8% | 100.0% | |
| | Not sure | N | 1 | 0 | 0 | 1 | |
| | | % | 100.0% | 0.0% | 0.0% | 100.0% | |
| Diabetes complications† | Yes | N | 12 | 66 | 25 | 103 | 0.590 |
| | | % | 11.7% | 64.1% | 24.3% | 100.0% | |
| Retinopathy | No | N | 10 | 79 | 23 | 112 | |
| | | % | 8.9% | 70.5% | 20.5% | 100.0% | |
| Peripheral neuropathy | Yes | N | 17 | 82 | 25 | 124 | 0.125 |
| | | % | 13.7% | 66.1% | 20.2% | 100.0% | |
| | No | N | 5 | 63 | 23 | 91 | |
| | | % | 5.5% | 69.2% | 25.3% | 100.0% | |
| Ischemic heart disease | Yes | N | 1 | 13 | 9 | 23 | 0.101 |
| | | % | 4.3% | 56.5% | 39.1% | 100.0% | |
| | No | N | 21 | 132 | 39 | 192 | |
| | | % | 10.9% | 68.8% | 20.3% | 100.0% | |
| Cerebrovascular accident/ transient ischemic attack | Yes | N | 0 | 11 | 2 | 13 | 0.314 |
| | | % | 0.0% | 84.6% | 15.4% | 100.0% | |
| | No | N | 22 | 134 | 46 | 202 | |
| | | % | 10.9% | 66.3% | 22.8% | 100.0% | |
| Peripheral vascular disease | Yes | N | 2 | 4 | 7 | 13 | 0.046* |
| | | % | 15.4% | 30.8% | 53.8% | 100.0% | |
| | No | N | 20 | 140 | 41 | 201 | |
| | | % | 10.0% | 69.7% | 20.4% | 100.0% | |
| Amputation | Yes | N | 2 | 10 | 2 | 14 | 0.701 |
| | | % | 14.3% | 71.4% | 14.3% | 100.0% | |
| | No | N | 20 | 135 | 46 | 201 | |
| | | % | 10.0% | 67.2% | 22.9% | 100.0% | |

* Chi-square test.
† Diabetes complications, n=215.

**Supplementary Table 4**
Bivariate correlation between KAP scores and various continuous variables

| | | | K score | A score | P score | KAP score |
|---|---|---|---|---|---|---|
| Spearman rho | Age (years) | Correlation coefficient | –0.173† | –0.035 | 0.008 | –0.111 |
| | | p value | 0.004 | 0.564 | 0.901 | 0.065 |
| | Income (RM) | Correlation coefficient | 0.300† | 0.338† | 0.101 | 0.341† |
| | | p value | 0.000 | 0.000 | 0.097 | 0.000 |
| | Weight (kg) | Correlation coefficient | 0.201† | 0.173† | –0.003 | 0.178† |
| | | p value | 0.001 | 0.004 | 0.959 | 0.003 |
| | BMI (kg/m$^2$) | Correlation coefficient | 0.159† | 0.155* | 0.055 | 0.186† |
| | | P value | 0.009 | 0.011 | 0.365 | 0.002 |
| | Systolic BP (mmHg) | Correlation coefficient | 0.050 | 0.120* | 0.103 | 0.123* |
| | | p value | 0.405 | 0.047 | 0.089 | 0.041 |
| | Diastolic BP (mmHg) | Correlation coefficient | 0.048 | 0.104 | 0.102 | 0.114 |
| | | p value | 0.424 | 0.086 | 0.091 | 0.059 |
| | A1C (%) | Correlation coefficient | –0.072 | –0.207† | –0.011 | –0.125* |
| | | p value | 0.230 | 0.001 | 0.859 | 0.038 |
| | FBS (mmol/L) | Correlation coefficient | –0.031 | –0.045 | –0.011 | –0.023 |
| | | P value | 0.614 | 0.474 | 0.856 | 0.717 |
| | TC (mmol/L) | Correlation coefficient | –0.150* | –0.102 | –0.207† | –0.207† |
| | | p value | 0.031 | 0.145 | 0.003 | 0.003 |
| | HDL (mmol/L) | Correlation coefficient | –0.174* | –0.109 | –0.101 | –0.192† |
| | | p value | 0.015 | 0.128 | 0.160 | 0.007 |
| | LDL (mmol/L) | Correlation coefficient | –0.061 | –0.220 | –0.174 | –0.199 |
| | | p value | 0.771 | 0.290 | 0.404 | 0.340 |
| | TG (mmol/L) | Correlation coefficient | -0.034 | 0.041 | –0.084 | –0.021 |
| | | p value | 0.633 | 0.559 | 0.232 | 0.769 |
| | Duration of diabetes (years) | Correlation coefficient | 0.100 | 0.124* | 0.108 | 0.154* |
| | | p value | 0.100 | 0.040 | 0.074 | 0.011 |
| | Creatinine (umol/L) | Correlation coefficient | 0.163 | 0.209 | 0.014 | 0.138 |
| | | p value | 0.240 | 0.129 | 0.921 | 0.318 |
| | eGFR | Correlation coefficient | –0.044 | –0.126 | 0.081 | –0.005 |
| | | p value | 0.750 | 0.363 | 0.562 | 0.969 |

*A1C*, glycated hemoglobin; *BMI*, body mass index; *BP*, blood pressure; *eGFR*, estimated glomerular filtration rate; *FBS*, fasting blood sugar; *HDL*, high-density lipoprotein cholesterol; *LDL*, low-density lipoprotein cholesterol; *KAP score*, knowledge, attitude, practice score; *RM*, Malaysian ringgit; *TC*, total cholesterol; *TG*, triglycerides.
*Note*. All analyses done are non-parametric bivariate correlation.
* Significance level p<0.05.
† Significance level p<0.01.