Research Square

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# Pattern of macronutrients intake among type-2 diabetes mellitus (T2DM) patients in Malaysia

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# Abstract

**Background**: The incidence of type 2 diabetes mellitus (T2DM) is rising rapidly in Malaysia. Modifying dietary intake is key to both the prevention and treatment of T2DM. This study aims to investigate the pattern of macronutrient intake among T2DM patients in Malaysia.

**Methods**: This study was carried out on adults aged between 35 and 70 years, residing in urban and rural Malaysian communities. A series of standardised questionnaires was used to assess the sociodemographic information, dietary intake and physical activity level of 15,353 respondents who provided informed consent to participate in this study. Blood sampling (finger prick test) and physical examination were performed to obtain blood glucose and anthropometric data, respectively. The Chi-square test was used to assess differences in the trends of macronutrient intake among T2DM groups.

**Results**: The total number of participants diagnosed with T2DM in this study was 2,254. Of these, 453 (20.1%) were newly diagnosed, 1,156 (51.3%) were diagnosed for ≤ 5 years and 645 (28.6%) were diagnosed for > 5 years. The majority of the T2DM patients consumed carbohydrate and protein in the recommended proportions. Compliance with the recommended carbohydrate intake (50–65% of Total Energy Intake (TEI)) was 19.1%, 52.2% and 28.7% among the newly diagnosed, diagnosed for ≤ 5 years and diagnosed for > 5 years groups, respectively. Compliance with the recommended protein intake (10–20% of TEI) among these groups was 20.5%, 51.9% and 27.6%, respectively. Although the differences among groups were not significant, the majority of the T2DM patients consumed fat in amounts higher than the recommended proportion (> 30% of TEI).

**Conclusions**: The pattern of dietary intake among T2DM patients in this study showed moderate consumption of carbohydrate and protein, coupled with high fat intake. Compliance with the Recommended Nutrient Intake (RNI) was satisfactory for both carbohydrate and protein but not for fat. The pattern indicated a preference for fat rather than protein when carbohydrate intake was restricted. Further research regarding the specific types of carbohydrate, protein and fat consumed is necessary to understand the effect of these macronutrients on T2DM in Malaysia. The high proportion of newly diagnosed T2DM patients (20.1%) in this study indicates that there is a lack of awareness among the general population regarding T2DM.


# Introduction

The global prevalence of diabetes mellitus is estimated to rise from 9.3% (463 million cases) in 2019 to 10.2% (578 million) by 2030 and 10.9% (700 million) by 2045 [1, 2]. Meanwhile, the prevalence of diabetes mellitus in South East Asia is predicted to rise from 8.8% (88 million) in the year 2019 to 9.7% (115 million) by 2030 and 11.3% (153 million) by 2045 [2]. Type 2 diabetes mellitus (T2DM) is the most common type of diabetes, comprising 90% of all cases of diabetes worldwide [2]. It is a metabolic disorder that arises either when the pancreas is incapable of producing enough insulin or when the body uses the insulin ineffectively [1, 3]. The prevalence of T2DM has been escalating rapidly in developing

countries such as Malaysia [3]. The National Health and Morbidity Surveys (NMHS) in Malaysia reported an increase in T2DM prevalence from 15.2% in 2011 to 18.3% in 2019 [4, 5]. Meanwhile, the NHMS also reported that the prevalence of newly diagnosed T2DM cases (amongst those not known to have T2DM) in Malaysia increased from 8.0% in 2011 to 8.9% in 2019 [4, 5]. This group has the same risk of developing complications of diabetes as already-diagnosed T2DM patients. Newly diagnosed T2DM patients are more prone to developing T2DM complications at a later stage due to uncontrolled glucose levels [6]. T2DM is associated with both unmodifiable factors (age and genetics) and modifiable risk factors (obesity and dietary intake) [1].

Modification of dietary intake is key to both the prevention and treatment of T2DM [7]. The Nutrition Division of the Ministry of Health, Malaysia, has been promoting healthy eating practices among the Malaysian population to facilitate a higher quality of life. The healthy eating campaign included advocacy for the food pyramid guideline and the recent healthy meal intake guide of ‘quarter quarter half’ plate portions [8]. These campaigns were derivatives of the macronutrient guideline provided by the Malaysian Recommended Nutrient Intake (RNI). The RNI suggested that the general macronutrient requirements for an adult were 50–65% of total energy intake (TEI) from carbohydrate, 10–20% of TEI from protein and the remaining 25–35% of TEI from fat [9]. The Malaysian Adult Nutrition Survey (MANS) has shown that total carbohydrate intake decreased from 59% of TEI in 2003 to 55% in 2014, while the total protein and fat intake increased from 14–16% and 27–29%, respectively, for the same years [10, 11].

Studies have previously been conducted in different settings to assess the dietary intake of T2DM patients in Malaysia [12–14]. However, these studies did not address dietary intake among newly diagnosed T2DM patients. Therefore, this study aimed to investigate the pattern of macronutrient (carbohydrate, protein and fat) intake among Malaysian adults with newly diagnosed and already-diagnosed T2DM.

## Methodology

# Design of the Prospective Urban and Rural Epidemiological (PURE) study

The PURE study has been described in previous literature [15–17]. It is a large-scale, international study of the incidence, mortality and risk factors associated with non-communicable diseases, which includes individuals from urban and rural communities in 21 countries, including Malaysia. The PURE study is coordinated by the Population Health Research Institute (PHRI), Hamilton, Ontario, Canada. The Malaysian arm of the study is coordinated by two public universities, namely Universiti Kebangsaan Malaysia (UKM) and Universiti Teknologi MARA (UiTM). This study has enrolled 15,353 Malaysian individuals since 2007, and follow-up data collection is ongoing until 2030. Participants were recruited from selected urban and rural areas of Malaysia that represent the heterogeneity of the national population in terms of social and economic factors. The feasibility of carrying out long-term follow-up was also considered in study site selection.

Sampling was executed by reaching out to the community leaders of the purposively selected study locations, which included all 14 states of Malaysia. Once agreement from the community leaders was obtained, a health screening program was implemented. Prior to recruitment, individuals from the community health screening program were asked about their interest in participating in the study. Interested individuals were followed up through home visits. Individuals aged between 35 and 70 years and living in the same household were also invited as study participants. Written informed consent was obtained after participants understood the provided study information and their rights as study participants.

To ensure standardised methods of data collection, research assistants were trained with comprehensive operation manuals, videos and workshops. Data were transferred electronically to the project office and coordinating centre at PHRI for quality control.

# Measurements

Participants were defined as having T2DM if they reported having been diagnosed with T2DM or had a glucose level of ≥ 7 mmol/L (fasting blood glucose) or ≥ 11.1 mmol/L (non-fasting blood glucose) [18]. The measurement of blood glucose was recorded as fasting blood sugar when the participants fasted for at least 8 hours prior to the test. The non-fasting blood sugar test was carried out for participants who did not fast prior to blood collection. The GlucoSure Plus blood glucose monitor was used to measure participants' blood glucose levels. Participants were defined as newly diagnosed if they had never been diagnosed with T2DM but had an elevated blood glucose level at the baseline study. Those who were already diagnosed were stratified into either the diagnosed for ≤ 5 years or diagnosed for > 5 years group. The grouping was based on the number of years from diagnosis to the time of baseline data collection.

Participants' habitual food intake was recorded using a validated food frequency questionnaire (FFQ). Participants reported the usual portion size of each food item in the FFQ and the average frequency of consumption. Then, macronutrients in terms of total energy, carbohydrate, protein and fat intake were calculated based on the Malaysian food composition and US Department of Agriculture food composition databases, with reference to nutrient databases containing the recipes of mixed dishes [19]. Participant dietary intake was stratified into three groups according to the RNI for Malaysians [9]. The recommended proportions of carbohydrate, protein and fat in the TEI were 50–65%, 10–20% and 25–30%, respectively [9].

Information on demographics, personal and family medical history, and active or passive smoking status was extracted from the validated PURE questionnaire and physical activity levels were assessed using the International Physical Activity Questionnaire (IPAQ) [16, 19, 20]. Demographic characteristics included age (rounded to the nearest year of birth), gender, race (Malay or non-Malay), marital status (single, married or divorced), education level (none, primary, secondary or tertiary) and employment status (yes or no). The residency area (urban or rural) was based on local government-gazetted areas. Rural areas were defined as areas occupied by less than 150 residents per square kilometre. Height and weight were

measured using a portable stadiometer and the TANITA (BC-558 Ironman®) segmental body composition analyser, respectively. Body mass index (BMI) was derived by dividing weight by height squared. A BMI of ≥ 30 kg/m$^2$ was categorised as obese and a BMI of < 30 kg/m$^2$ as non-obese.

The participants were asked whether they had been diagnosed with hypertension as comorbidity. Family medical history of T2DM and hypertension was defined as the occurrence of these comorbidities in at least one family member (father, mother or siblings) as reported by the participant. Active smoking status was categorised into current smokers and former tobacco smokers who had quit within the previous year, while inactive smoker was those who had never smoked. Passive smokers included those who had been exposed to environmental tobacco smoke at least once a week for the previous year. Physical activity level was considered low if it was < 600 Metabolic Equivalent (MET) min/week and high if it was ≥ 600 MET min/week.

A total of 15,352 participants completed the personal medical history assessment of T2DM. Of these, 2,254 participants were diagnosed with T2DM without missing data on years of being diagnosed, age, gender and obesity. Finally, a total of 1,718 participants completed the FFQs.

# Statistical analysis

The data were analysed using SPSS version 26. Chi-square test was used to assess differences in the T2DM groups according to the following variables: carbohydrate intake, protein intake, fat intake, age, gender, obesity status, race, marital status, education level, employment status, geographical classification of residency, participant comorbidities, family history of comorbidities, smoking status and physical activity level. The results were reported as frequencies and percentages, and a *p*-value of < 0.05 was considered significant.

# Results

The total number of participants diagnosed with T2DM in this study was 2,254. Of these, 453 (20.1%) were newly diagnosed, 1,156 (51.3%) were diagnosed for ≤ 5 years and 645 (28.6%) were diagnosed for > 5 years. Table 1 shows the general characteristics of this study population. There were significant differences among the three groups according to the following variables: age, obesity, education level, residency, participant comorbidity of hypertension, family history of diabetes and hypertension, and active and passive smoking behaviour. Meanwhile, the three groups had similar patterns of gender, race, marital status, employment status and physical activity level.

Table 1
General characteristics of T2DM patients (n = 2,254)

| | **Newly diagnosed** | **Diagnosed ≤ 5 years** | **Diagnosed > 5 years** | ***p* value** |
|---|---|---|---|---|
| Demographic characteristics | | | | |
| Age (year) | | | | **< 0.001*** |
| 35–40 | 51 (38.6) | 60 (45.5) | 21 (15.9) | |
| 41–50 | 153 (28.3) | 292 (54.0) | 96 (17.7) | |
| 51–60 | 152 (17.1) | 460 (51.8) | 276 (31.1) | |
| 61–70 | 97 (14.0) | 344 (49.6) | 252 (36.4) | |
| Gender | | | | 0.829 |
| Male | 196 (19.5) | 519 (51.7) | 289 (28.8) | |
| Female | 257 (20.6) | 637 (51.0) | 356 (28.5) | |
| Obesity | | | | **< 0.001*** |
| Yes | 134 (32.1) | 187 (44.7) | 97 (23.2) | |
| No | 319 (17.4) | 969 (52.8) | 548 (29.8) | |
| Race | | | | 0.089 |
| Malay | 423 (20.4) | 1069 (51.5) | 583 (28.1) | |
| Non-Malay | 28 (16.0) | 85 (48.6) | 62 (35.4) | |
| Marital Status | | | | 0.050 |
| Single | 7 (20.6) | 16 (47.1) | 11 (32.4) | |
| Married | 419 (20.9) | 1013 (50.6) | 570 (28.5) | |
| Separated | 27 (12.4) | 126 (58.1) | 64 (29.5) | |
| Education level | | | | **0.001*** |
| None | 41 (20.4) | 107 (53.2) | 53 (26.4) | |
| Primary | 160 (16.9) | 474 (50.1) | 313 (33.1) | |
| Secondary | 185 (22.1) | 438 (52.4) | 213 (25.5) | |
| Tertiary | 67 (25.1) | 135 (50.6) | 65 (24.3) | |
| Employment Status | | | | 0.605 |
| Yes | 235 (20.9) | 573 (50.8) | 319 (28.3) | |

| | Newly diagnosed | Diagnosed ≤ 5 years | Diagnosed > 5 years | *p* value |
|---|---|---|---|---|
| No | 212 (19.2) | 577 (52.2) | 317 (28.7) | |
| Residency | | | | **< 0.001*** |
| Urban | 176 (16.4) | 553 (51.5) | 345 (32.1) | |
| Rural | 277 (23.5) | 603 (51.1) | 300 (25.4) | |
| Participants' comorbidities | | | | |
| Hypertension | | | | **< 0.001*** |
| Yes | 102 (8.2) | 712 (57.0) | 436 (34.9) | |
| No | 351 (35.0) | 444 (44.2) | 209 (20.8) | |
| Family history comorbidities | | | | |
| Diabetes | | | | **< 0.001*** |
| Yes | 88 (9.9) | 509 (57.0) | 296 (33.1) | |
| No | 364 (26.9) | 642 (47.4) | 348 (25.7) | |
| Hypertension | | | | **0.001*** |
| Yes | 138 (16.1) | 471 (55.1) | 246 (28.8) | |
| No | 314 (22.6) | 680 (48.9) | 397 (28.5) | |
| Lifestyle | | | | |
| Active smoker | | | | **0.044*** |
| Yes | 106 (20.9) | 279 (54.9) | 123 (24.2) | |
| No | 347 (20.2) | 861 (50.0) | 513 (29.8) | |
| Passive smoker | | | | **0.012*** |
| Yes | 154 (21.7) | 377 (53.2) | 178 (25.1) | |
| No | 239 (19.3) | 611 (49.3) | 390 (31.5) | |
| Physical activity | | | | 0.837 |
| Low | 141 (19.7) | 372 (52.1) | 201 (28.2) | |
| High | 286 (20.8) | 702 (51.1) | 386 (28.1) | |
| * significant at $p < 0.05$ | | | | |

Table 1

The Chi-square analysis showed that there were significant differences in carbohydrate intake and protein intake among the three groups of T2DM patients (Table 2). Most of the T2DM patients consumed appropriate proportions of carbohydrate (50–65% of TEI) and protein (10–20% of TEI). However, the three groups had a similar pattern of fat intake, although the majority of the T2DM patients consumed higher amounts of fat than the recommended level.

Table 2
Proportion of carbohydrate intakes among T2DM patients (n = 1718).

| **Dietary intake (% from TEI)** | **Newly diagnosed** | **Diagnosed ≤ 5 years** | **Diagnosed > 5 years** | **p-value** |
|---|---|---|---|---|
| Carbohydrate intake | | | | **0.002*** |
| < 50 | 109 (19.7) | 291 (52.6) | 153 (27.7) | |
| 50–65 | 200 (19.1) | 545 (52.2) | 300 (28.7) | |
| > 65 | 42 (35.0) | 50 (41.7) | 28 (23.3) | |
| Protein intake | | | | **0.007*** |
| < 10 | 8 (53.3) | 7 (46.7) | 0 (0) | |
| 10–20 | 288 (20.5) | 728 (51.9) | 388 (27.6) | |
| > 20 | 55 (18.4) | 151 (50.5) | 93 (31.1) | |
| Fat intake | | | | 0.145 |
| < 25 | 89 (23.9) | 177 (47.5) | 107 (28.7) | |
| 25–30 | 106 (18.2) | 304 (52.1) | 174 (29.8) | |
| > 30 | 156 (20.5) | 405 (53.2) | 200 (26.3) | |
| *significant at $p < 0.05$ | | | | |

Table 2

## Discussion

# Basic characteristics of T2DM patients

The Chi-square analysis showed significant differences between the three groups of T2DM patients according to the following variables: age, obesity, education level, geographical classification of residency, participant comorbidity of hypertension, family history of diabetes and hypertension, and smoking status. A majority of the newly diagnosed T2DM patients were between 41 and 50 years, whereas most participants in the already-diagnosed groups were between 51 and 60 years of age. These findings were comparable with those of the NHMS, which reported that the prevalence of newly

diagnosed T2DM was highest among 45–49-year-old Malaysian adults [4]. This result also indicates that participants in the age group of 51–60 years with a time since T2DM diagnosis > 5 years were primarily diagnosed when they were between 41 and 50 years old.

A study done by Mafauzy et al. reported that 72% of T2DM patients were obese, which reflects the imbalance between energy intake and expenditure [21–23]. In the present study, participants with obesity were most common among those who were diagnosed for ≤ 5 years compared to the other two groups. The percentage was slightly higher in the group diagnosed for ≤ 5 years (44.7%) than among newly diagnosed participants (32.1%). Interestingly, obesity prevalence decreased from 44.7–23.2% in participants who were diagnosed for ≤ 5 years and > 5 years, respectively. According to a Malaysian report, obese persons were recommended to reduce their initial weight by 5–10% over a period of 6 months [23]. To achieve this goal, medical nutrition therapy (MNT) was provided via individualised nutritional recommendations for T2DM patients with obesity [23]. Thus, obesity prevalence among T2DM patients in the newly diagnosed group was higher (42%) compared to the already-diagnosed groups of ≤ 5 years and > 5 years (19.3% and 17.7%, respectively).

This study found that newly diagnosed T2DM was most common among those who received secondary education (40.8%). In comparison, already-diagnosed participants in the ≤ 5 years and > 5 years groups mostly received primary education (41.0% and 48.9%, respectively). Our finding contradicts that of the NHMS, which reported that the prevalence of both newly diagnosed and known T2DM was higher among those without a formal education [4]. In terms of geographical classification of residency, newly diagnosed participants and those already diagnosed for ≤ 5 years more commonly resided in rural areas (61.1% and 52.1%, respectively). Meanwhile, the majority of participants who were diagnosed for > 5 years were urban residents (53.5%). The NHMS also reported that newly diagnosed T2DM was more common in rural compared to urban areas (10.2% vs 8.5%) [4]. In contrast, the prevalence of known T2DM was higher in urban than in rural areas (9.7% vs 8.2%) [4].

Our results showed that patients already diagnosed with T2DM for ≤ 5 years and > 5 years both had a notably higher prevalence of hypertension comorbidities (57.0% and 34.9%, respectively), compared to newly diagnosed participants (8.2%). Increased comorbidities would increase the risk of complications such as cardiovascular disease and impact the management of comorbidities, long-term survival and the health care system [6]. Other than that, a family history of comorbidities (diabetes and hypertension) was most common among participants who were already diagnosed for ≤ 5 years. This is because comorbidities are heritable [24]. The results of the present study showed that active and passive smoking status were significantly different among the three T2DM groups. Smoking behaviours have been reported as risk factors contributing to T2DM [25].

# Pattern of macronutrient intake among T2DM patients

The Chi-square analysis showed significant differences among the three groups of T2DM patients in terms of carbohydrate and protein intake. Compliance with the recommended carbohydrate intake (50–65% of TEI) among the newly diagnosed, ≤ 5 years and > 5 years groups was 19.1%, 52.2% and 28.7%,

respectively. Similarly, carbohydrate consumption of < 50% of TEI among the newly diagnosed, ≤ 5 years and > 5 years groups was 19.7%, 52.6% and 27.7%, respectively. Meanwhile, T2DM patients who consumed carbohydrate at proportions > 65% of TEI were most common among the group diagnosed for ≤ 5 years (41.7%).

Compliance with the recommended protein intake (10–20% of TEI) among the newly diagnosed, ≤ 5 years and > 5 years groups was 20.5%, 51.9% and 27.6%, respectively. Similar patterns were observed for a protein intake of > 20% of TEI among the newly diagnosed, ≤ 5 years and > 5 years groups (18.4%, 50.5% and 31.1%, respectively). In addition, very few T2DM patients consumed protein in amounts less than the recommended proportions. Although the differences were not significant, the majority of the T2DM patients consumed amounts of fat higher than the recommended proportion (> 30% of TEI).

A previous study conducted at the outpatient clinic of the University of Malaya Medical Centre reported that the mean proportions of carbohydrate, protein and fat consumed by T2DM patients were 56.9%, 14.7% and 28.4% of TEI, respectively [12]. Another study by Chin et al. found that the mean proportions of carbohydrate, protein and fat consumed by T2DM patients were 60.0%, 16.0% and 24.0% of TEI, respectively [14]. To compare the results of this study with previous studies reporting on the dietary intake of T2DM patients who were receiving treatment in a healthcare facility, the mean macronutrient intake among T2DM patients in this study was computed, combining the results of those who were diagnosed for ≤ 5 and > 5 years (Table 3). As shown in Table 3, the present study found that the mean carbohydrate intake among T2DM patients was lower than in previous studies (51.9% vs 56.9% and 60.0% of TEI) [12, 14]. Conversely, the mean intake of protein (17.7% of TEI) and fat (30.4% of TEI) among T2DM patients in this study was higher compared to the previous studies [12, 14]. The mean proportions of macronutrients consumed by participants in this study were found to be within the range recommended in the clinical practice guidelines for the nutritional management of T2DM patients (Table 3) [18].

Table 3
Comparison of mean proportion intake among T2DM patients between this study and previous studies conducted in Malaysia.

| **Dietary intake (% from TEI)** | **Present study (n = 1,367)** | **Moy & Suriah (n = 196)** | **Chin et al. (n = 210)** | **CPG guideline** |
|---|---|---|---|---|
| Carbohydrate | 51.9 | 56.9 | 60 | 45–60 |
| Protein | 17.7 | 14.7 | 16 | 15–20 |
| Fat | 30.4 | 28.4 | 24 | 25–35 |

Table 3

Overall, the results of this study showed that T2DM patients largely adhered to a moderate carbohydrate and protein intake but had a high fat intake (Table 2 and Table 3). This pattern contradicted a review by Hussein et al., which concluded that Malaysian diabetics were more prone to consuming high amounts of

carbohydrate and fat [23]. The differences may be because the former study included only already known T2DM patients, while this study included both newly diagnosed and already-diagnosed T2DM categories. Several studies have highlighted that the general dietary intake recommendations based on macronutrients were not easily followed by both the general population and T2DM patients [7, 26, 27]. Furthermore, previous reviews have stated that the effectiveness of the existing guidelines, which set goals based on macronutrient quantity, was still equivocal in efforts to reduce the risk of T2DM [26, 27]. Thus, the Malaysian Ministry of Health (MOH) has been implementing MNT to provide individualised nutritional recommendations based on personal preferences to manage the dietary intake of T2DM patients [24]. However, this approach only showed a 16.4% rate of compliance among Malaysian T2DM patients despite its effectiveness in glycaemic control [24]. Despite the efforts of the MOH to manage T2DM, lack of patient compliance with dietary counselling remains a huge challenge for both health practitioners and T2DM patients themselves.

The main limitation of this study was the cross-sectional study design that only included baseline data. The causal and temporal effects of macronutrient intake on T2DM patients were not considered. Future research should include controlled trials or prospective data analyses so that the causal effects of specific components of carbohydrate, protein and fat can be studied.

# Conclusion

The T2DM patients in this study mainly consumed moderate amounts of carbohydrate and protein but had a high fat intake. Compliance with RNI recommendations for macronutrient proportions was satisfactory for carbohydrate and protein but not for fat. This trend shows that T2DM patients preferred fat over protein to replace lower proportions of carbohydrate. Further research regarding specific components of carbohydrate, protein and fat is necessary to understand the effects of macronutrients on T2DM in Malaysia. This study has also revealed a high proportion of newly diagnosed T2DM patients (20.1%), indicating a lack of awareness among the general population regarding this disease.

# Abbreviations

T2DM: Type-2 Diabetes Mellitus; TEI: total energy intake; NHMS: National Health and Morbidity Survey; PURE: Prospective Urban and Rural Epidemiological Study; RESTU: Risk Epidemiological Study; FFQs: food frequency questionnaires; TMC: The Malaysian Cohort; MOH: Malaysian Ministry of Health; MNT: medical nutrition therapy.

# Declarations

### Ethics approval and consent to participate

Ethical approval was obtained from Hamilton Health Sciences Research Ethics Board (PHRI), Hamilton Health Sciences and McMaster University, Hamilton, Ontario, Canada; Research and Ethics Committee

(UKM Medical Centre); and Research and Ethics Committee (UiTM). The research is under the project code PHUM-2012-01. A written consent was obtained from each participant before conducting the survey. All methods were carried out in accordance to relevant guideline.

## Consent for publication

Not applicable

## Availability of data and materials

The data that support the findings of this study are available from PHRI but restrictions apply to the availability of the data, which were used under license for the current study, and are not publicly available. Data are however available from the authors upon reasonable request and with permission from PHRI.

## Conflict of interest

The authors declare that there is no conflict of interest.


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## Authors' contributions

Conceptualization, Z.M.I, N.H.I, R.I, A.M.T and M.H.J ; data collection, K.H.Y ; data analysis, N.H.A.R, N.Z.A and K.H.Y; funding acquisition, N.H..I, R.I, and M.H.J; methodology, Z.M.I, N.H..I, R.I, A.M.T, M.H.J and K.H.Y; writing—original draft preparation, N.H.A.R and Z.M.I; writing—review and editing; N.H.A.R, Z.M.I, N.H.I, R.I, A.M.T, M.H.J, N-A.M.N.K, N.M-N.; supervision, N.H.I. All authors have read and agreed to the published version of the manuscript.


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