Factors Associated with the Risk of Type 2 Diabetes in Women of Childbearing Age in A Selected Community in Malaysia

Farah Yasmin Hasbullah, Barakatun Nisak Mohd Yusof & Siti Nursyuhada Badrudin

To Link this Article: http://dx.doi.org/10.6007/IJARBSS/v11-i19/11728 DOI:10.6007/IJARBSS/v11-i19/11728

Received: 09 October 2021, Revised: 12 November 2021, Accepted: 28 November 2021

Published Online: 20 December 2021

In-Text Citation: (Hasbullah et al., 2021)
To Cite this Article: Hasbullah, F. Y., Yusof, B. N. M., & Badrudin, S. N. (2021). Factors Associated with the Risk of Type 2 Diabetes in Women of Childbearing Age in A Selected Community in Malaysia. International Journal of Academic Research in Business and Social Sciences, 11(19), 205–220.

Copyright: © 2021 The Author(s)
Published by Human Resource Management Academic Research Society (www.hrmars.com)
This article is published under the Creative Commons Attribution (CC BY 4.0) license. Anyone may reproduce, distribute, translate and create derivative works of this article (for both commercial and non-commercial purposes), subject to full attribution to the original publication and authors. The full terms of this license may be seen at: http://creativecommons.org/licenses/by/4.0/legalcode

Full Terms & Conditions of access and use can be found at http://hrmars.com/index.php/pages/detail/publication-ethics

Special Issue Title: Youth and Community Wellness, 2021, Pg. 205 - 220

http://hrmars.com/index.php/pages/detail/IJARBSS JOURNAL HOMEPAGE
Factors Associated with the Risk of Type 2 Diabetes in Women of Childbearing Age in A Selected Community in Malaysia

Farah Yasmin Hasbullah², Barakatun Nisak Mohd Yusof¹,²,³ & Siti Nursyuhada Badrudin²

¹Institute for Social Science Studies, Putra Infoport, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia, ²Department of Dietetics, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia, ³Research Centre of Excellence for Nutrition and Non-Communicable Diseases, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia

Email: bnisak@upm.edu.my

Abstract
Women of childbearing age are at increased risk of type 2 diabetes (T2D), possibly due to metabolic alterations during pregnancy that contributes towards insulin resistance. However, limited studies assessed T2D risk specifically in Malaysian women of childbearing age. Hence, this study was conducted to determine factors associated with T2D risk in women of childbearing age at a selected public university in Malaysia. This cross-sectional study involved 83 childbearing-age women in Universiti Putra Malaysia (mean age: 37.7 ± 5.7 years; BMI: 26.6 ± 6.0 kg/m²). Weight, height and waist circumference were measured, and body mass index was calculated. Dietary intake and diabetes knowledge were assessed using a food frequency questionnaire and Diabetes Knowledge Questionnaire (DKQ-24), respectively. The Finnish Diabetes Risk Score (FINDRISC) tool predicted T2D risk within 10 years. A total of 66.3% (n = 55) respondents were at risk of T2D. The majority of the subjects (74%) had poor diabetes knowledge scores. Fibre intake was inadequate compared to the recommended range. Waist circumference, first- and second-degree family history of diabetes was significantly associated with increased T2D risk (p = 0.016, 0.001 and 0.009, respectively), whereas a daily consumption of fruits and vegetables was associated with reduced T2D risk (p = 0.024). The findings highlight the importance of public health action, including nutrition education, after delivery to prevent or delay their progression towards T2D.

Keywords: Childbearing-age Women, Type 2 Diabetes, Dietary Intake

Introduction
Type 2 diabetes (T2D) is a global public health issue that has reached epidemic proportions in several populations. International Diabetes Federation (IDF) estimated that about 463 million adults aged 20 – 79 were living with T2D in 2019, and this number was projected to increase to 700 million by 2045 (IDF, 2019). In Malaysia, the prevalence of T2D increased from 11.2% to 18.3% in less than 10 years (Institute for Public Health [IPH], 2019). Women were reported
to have a slightly higher prevalence of T2D compared to men (18.4% vs 18.2%) (IPH, 2019). Globally, women also had a higher diabetes-related mortality incidence than men (IDF, 2019). The economic burden of T2D includes direct costs (health expenditures related to diabetes, including medical costs for diagnosis and treatment and transportation costs) and indirect costs (productivity loss, labour drop out and mortality) (IDF, 2019; Oh et al., 2021). Thus, early identification of high-risk individuals and prevention of T2D will help in reducing the financial burden of T2D in the community.

The average age for childbearing mothers in developing countries is between 15 to 49 years old (World Health Organization [WHO], 2020). The prevalence of T2D in women of childbearing age ranged from 1.4% to 67.5%, depending on country and age (Scavini et al., 2017; Gunderson et al., 2018; Vézina-Im et al., 2018; Chivese et al., 2019; Al-Rifai et al., 2019). Multiparity may attribute to increased T2D risk in women of childbearing age (Iversen et al., 2016). Metabolic alterations during a normal pregnancy may induce a prediabetic state and could contribute towards T2D if perturbations in glucose homeostasis are not corrected after delivery. Thus, multiple pregnancies may lead to persistent insulin resistance and eventual β-cell exhaustion (Iversen et al., 2016). However, associations between parity and T2D risk in Asian women have only been investigated in few studies (Mueller et al., 2013; Tian et al., 2014). Both studies focused on women of older age (≥45 years) instead of the broader age spectrum of childbearing-age women.

Besides multiparity, predictors of T2D in women of childbearing age included ethnicity; higher body mass index (BMI), waist circumference, fasting glucose, triglycerides, degree of insulin resistance, blood pressure; and lower high-density lipoprotein cholesterol (HDL-cholesterol), diet quality scores and physical activity (Gunderson et al., 2018). A previous history of gestational diabetes mellitus (GDM) is also an independent risk factor of T2D, increasing its risk by almost ten-fold (Vounzoulaki et al., 2020).

Predictors of T2D, which have been extensively studied in several adult populations, include adiposity, unhealthy dietary patterns characterized by high consumption of processed meat and sugar-sweetened beverages and lower intakes of whole grains; sedentary behaviour or low physical activity; and smoking (Bellou et al., 2018). The risk of T2D appeared to be highest in women presented with three risk factors, including obesity, previous history of GDM, and insulin resistance or B-cell dysfunction (Fan et al., 2020). Nevertheless, studies on predictors of T2D risk, specifically in women of childbearing age, particularly in the Asian context, have been limited, which warrants the current investigation.

Diabetes risk score tools have been developed to improve risk stratification, enhance early detection of T2D, identify individuals with undiagnosed diabetes, and raise awareness in the population to modify risk factors and practice a healthier lifestyle (Saleem et al., 2017; Dugee et al., 2015). Some of the diabetes risk score tools that have been used in the Malaysian population include the Australian T2D risk assessment tool (AUSDRISK) (Hasbullah et al., 2021), Finnish Diabetes Risk Score (FINDRISC) (Lim et al., 2020; Oo et al., 2020) and Indian Diabetes Risk Score (Abdullah et al., 2018). Nonetheless, none of these studies assessed T2D risk specifically in Malaysian women of childbearing age. Hence, this study was conducted to evaluate the risk of T2D in women of childbearing age in Malaysia using a diabetes risk score tool and determine factors associated with the development of T2D.

Materials and Methods

Study Design and Population
This cross-sectional study was conducted among women of childbearing age in Universiti Putra Malaysia (UPM) Serdang, Malaysia. Respondents were Malaysians aged between 18 – 49 years old and had previously given birth. The study excluded pregnant women and those who had a prior diagnosis of type 1 or type 2 diabetes. The Ethics Committee for Research Involving Human Subjects of Universiti Putra Malaysia (JKEUPM) approved the study (JKEUPM-2019-404). Data collection was conducted from January until February 2020. Out of 16 faculties and two research centres in UPM, the study used simple random sampling to select half of the faculties (n = 8) and research centre (n = 1). Using a computerized randomizer software, the following faculties were selected: Faculties of Human Ecology; Economics and Management; Engineering; Food Science and Technology; Educational Studies; Sciences; Modern Languages and Communication; Environmental Studies. Meanwhile, the research centre randomly selected was the Family, Adolescent and Child Research Centre of Excellence. Name lists of staff of the chosen faculties and institute were obtained. Potential respondents were screened based on inclusion and exclusion criteria. Those who were eligible were invited to participate in this study.

**Sample Size Calculation**

The sample size was calculated using the formula for multiple regression (Milton, 1986). Based on the factors associated with T2D risk scores in a previous local study (Abdullah et al., 2018), a total of 70 respondents were required for the study. An additional 10% was required to account for missing data, non-response or refusal to participate, yielding a minimum of 78 respondents for the study.

**Data Collection**

Socio-demographic characteristics of respondents were obtained using questionnaires, including age, ethnicity, household income, education level, smoking habit, family history of diabetes and history of gestational diabetes mellitus (GDM). We measured respondents' height using a stadiometer (SECA model 206, Vogel & Halke GmbH & Co., Germany) and weight using a digital weighing scale (Tanita Health Equipment Ltd., Tokyo, Japan). BMI was calculated using the formula: Weight (kg) / height (m²); and classified according to the WHO cut-off values for adults (WHO, 2021). Waist circumference was measured according to the WHO protocol (WHO, 2008). The cut-off point of waist circumference to indicate abdominal obesity are ≥80 cm for women (WHO/IASO/IOTF, 2000).

The study used the FINDRISC tool to predict the risk of developing T2D within 10 years (Lindström & Tuomilehto, 2003). The risk score tool comprised of eight questions with a total score of 26: age, BMI, waist circumference, physical activity, fruit and vegetable intake, use of anti-hypertensive medication, history of hyperglycemia and family history of diabetes. T2D risk was classified into five categories based on the FINDRISC score: low risk (<7 points), slightly elevated risk (7-11 points), moderate risk (12-14 points), high risk (15-20 points) and very high risk (>20 points). Respondents were considered as having an increased risk of T2D if they scored ≥7 points. The FINDRISC tool was found to be reliable in the Malaysian population (Lim et al., 2020).

Dietary intake was assessed using a 165-item semi-quantitative food frequency questionnaire (FFQ) adapted from the Malaysian Adult Nutrition Survey (Institute for Public Health, 2014). The FFQ consisted of 14 food groups: cereal and cereal products; fast food; meat and meat products; fish and seafood; eggs; legumes and legume products; milk and dairy products; vegetables; fruits; beverages; alcoholic drinks; confectionaries; bread spreads; condiments. Respondents were asked about their frequency of food intake in the past one month (daily, weekly, monthly or not consumed) and the serving size of food. Food frequency
was then converted to daily food intake using the formula: Amount of food (g/day) = Frequency of intake (the conversion factor) x serving size of food x total number of servings x weight of food per serving (Norimah et al., 2008). Adequacy of energy and macronutrient intakes were according to the Malaysian Recommended Nutrient Intakes (RNI) (National Coordinating Committee on Food and Nutrition [NCCFN], 2017).

Knowledge about diabetes was evaluated using the 24-item diabetes knowledge questionnaire (DKQ-24) (Garcia et al., 2001). The four domains in the DKQ-24 were causes of diabetes, complications of diabetes, treatment of diabetes and hyperglycemia/hypoglycemia. Each correct answer was given "1" mark, while "0" mark was given for incorrect or unsure answers. Diabetes knowledge level was categorized as poor (<60%), acceptable (60-80%) or good (>80%). The DKQ-24 was a reliable tool to assess diabetes knowledge, as indicated by Cronbach's alpha value of 0.78 (Garcia et al., 2001). Content and construct validity of the items had also been established (Garcia et al., 2001). The Malay version of the DKQ-24 was used in a previous local study in Shah Alam, Selangor (Qamar et al., 2017).

**Statistical Analysis**
Statistical analysis was performed using IBM SPSS version 25.0 (SPSS Inc., Chicago, IL, USA). Descriptive data were presented as the mean and standard deviation for continuous variables and frequencies and percentages for categorical variables. Normality of the data was confirmed using the histogram, Kolmogorov-Smirnov test, skewness and kurtosis. Binary logistic regression was performed to determine the factors contributing to increased T2D risk. The variables with a significant association with T2D risk in bivariate analysis (p<0.05) were entered in a forward selection regression model. An odds ratio (OR) <1 indicated lower odds of T2D risk, whereas OR >1 indicated higher odds of T2D risk (Szumilas, 2010). A statistically significant level was set at p<0.05 for all tests.

**Results**
A total of 100 staff from the selected faculties and research centre were screened for eligibility. About 95 staffs were eligible based on inclusion and exclusion criteria and were invited to participate in the study. Only 83 of them completed the questionnaires and thus were included in the final analysis. The response rate was 87.4% (Figure 1).

![Figure 1. Screening and recruitment of respondents.](image-url)

Respondents were generally in their late 30s (mean age 37.7 ± 5.7 years), were overweight (mean BMI 26.6 ± 6.0 kg/m2) and had abdominal obesity (mean waist...
circumference 82.5 ± 12.2 cm). The majority of the respondents were Malays (98.8%) (Table 1). More than half (54.2%) were in the M40 income category, and most of the respondents were college or university graduates (92.8%). More than half the respondents (60.2%) had a family history of diabetes, and 51.8% were overweight or obese (Figure 2).

Table 1: Socio-demographic characteristics and anthropometry measurements of respondents (n = 83)

| Variable                                | N (%)  | Mean ± SD |
|-----------------------------------------|--------|-----------|
| Age (years)                             | 37.7 ± 5.7 |
| Ethnicity                               |        |           |
| Malay                                   | 82 (98.8%) |
| Chinese                                 | 1 (1.2%)  |
| Monthly household income a               |        | 6515 ± 4145 |
| RM <4850 / USD <1167 (B40)              | 28 (33.7) |
| RM 4850 – 10,959 / USD 1167 - 2636 (M40)| 45 (54.2) |
| RM ≥10,960 / USD 2637 (T20)             | 10 (12.0) |
| Highest education level                 |        |           |
| Secondary education                     | 6 (7.2) |
| Tertiary education (college/university) | 77 (92.8) |
| Currently smoking                       | 3 (3.6) |
| Family history of diabetes b            | 50 (60.2) |
| History of gestational diabetes mellitus| 4 (4.8) |
| Height (m)                              | 1.57 ± 0.05 |
| Weight (kg)                             | 65.4 ± 15.4 |
| Body mass index (kg/m²)                 |        | 26.6 ± 6.0 |
| Underweight (<18.5 kg/m²)               | 1 (1.2) |
| Normal range (18.5 – 24.9 kg/m²)       | 39 (47.0) |
| Overweight (25.0 – 29.9 kg/m²)          | 29 (34.9) |
| Obese (≥30.0 kg/m²)                     | 14 (16.9) |
| Waist circumference (cm)                | 82.5 ± 12.2 |
| Within recommendation (<80 cm)          | 40 (48.2) |
| Exceeded recommendation (≥80 cm)        | 43 (51.8) |

aReference: Department of Statistics Malaysia (2020)
bFamily history of diabetes includes both first-degree family (parents, siblings, own children) and second-degree family (grandparents, aunts, uncles, first cousins, nieces, nephews)
Respondents in the study had energy, carbohydrate, protein, fat, and sugar intake within the recommended range. However, total fiber intake was inadequate (Table 2).

**Table 2: Dietary intake of respondents (n = 83)**

| Variable                     | Mean ± SD   | Recommended intake<sup>a</sup> |
|------------------------------|-------------|-------------------------------|
| **Total energy intake (kcal/day)** | 2138 ± 510  | 1610 – 2370                   |
| **Carbohydrate intake**      |             |                               |
| Total amount (g/day)         | 308.2 ± 94.9| -                             |
| As part of total energy (%TEI)| 57 ± 10     | 50 – 65                       |
| **Protein intake**           |             |                               |
| Total amount (g/day)         | 93.7 ± 30.4 | 52 – 53                       |
| As part of total energy (%TEI)| 18 ± 4      | 10 – 20                       |
| **Fat intake**               |             |                               |
| Total amount (g/day)         | 58.3 ± 22.1 | -                             |
| As part of total energy (%TEI)| 24 ± 6      | 25 – 30                       |
| **Total fiber intake (g/day)** | 11.2 ± 9.5  | 20 – 30                       |
| **Sugar intake**             |             |                               |
| Total amount (g/day)         | 47.0 ± 28.2 | -                             |
| As part of total energy (%TEI)| 9 ± 5       | <10                           |

<sup>a</sup>Reference: Malaysian RNI (NCCFN, 2017)

Most of the respondents (74.7%) had poor knowledge levels regarding causes, complications and treatment of diabetes. None of the subjects was reported to have a good level of diabetes knowledge. None of the respondents answered correctly whether overeating sugar and other sweet foods is a cause of diabetes (question 1). Other questions with the least number of correct responses were regarding wound dressing (question 17; 7.2% correct response) and symptoms of hyperglycemia (question 21; 13.3% correct response) (Table 3).
More than half the subjects (66.3%) had an increased risk of developing T2D in the next 10 years (Figure 3). A portion of the respondents did not perform physical activity and did not consume fruits and vegetables daily (43.4% and 41.0%, respectively) (Table 4).

### Table 3: Knowledge level of respondents and responses for the diabetes knowledge questionnaire (DKQ-24) (n = 83)

| Variable                                                                 | N (%) | Mean ± SD |
|--------------------------------------------------------------------------|-------|-----------|
| **Knowledge score**                                                      |       | 47 ± 15   |
| Poor (<60%)                                                              | 62 (74.7) |
| Acceptable (60-80%)                                                      | 21 (25.3) |
| Good (>80%)                                                              | 0 (0)  |
| **Correct responses**                                                    |       |           |
| Q1 About sugar as a cause of diabetes                                    | 0 (0)  |
| Q2 About ineffective insulin as a cause of diabetes                      | 71 (85.5) |
| Q3 About the failure of kidney function as a cause of diabetes           | 15 (18.1) |
| Q4 About kidney producing insulin                                        | 21 (25.3) |
| Q5 About hyperglycemia if diabetes is untreated                          | 75 (90.4) |
| Q6 About the future risk of diabetes in offspring                        | 69 (83.1) |
| Q7 About diabetes being curable                                          | 20 (24.1) |
| Q8 About high fasting plasma glucose level                               | 28 (33.7) |
| Q9 About diagnosing diabetes through a urine test                        | 33 (39.8) |
| Q10 About regular exercise increases the need for diabetes medication    | 19 (22.9) |
| Q11 About types of diabetes                                              | 39 (47.0) |
| Q12 About too much food causing an insulin response                      | 17 (20.5) |
| Q13 About medication being more important than diet/exercise             | 69 (83.1) |
| Q14 About diabetes causing poor circulation                              | 46 (55.4) |
| Q15 About slow wound healing in diabetes                                 | 80 (96.4) |
| Q16 About diabetic foot care                                             | 63 (75.9) |
| Q17 About wound dressing in diabetes                                     | 6 (7.2)  |
| Q18 About food preparation                                               | 75 (90.4) |
| Q19 About diabetic nephropathy                                           | 62 (74.7) |
| Q20 About diabetic neuropathy                                            | 65 (78.3) |
| Q21 About symptoms of hyperglycemia                                      | 11 (13.3) |
| Q22 About symptoms of hypoglycemia                                       | 21 (25.3) |
| Q23 About wearing tight hose or socks                                    | 21 (25.3) |
| Q24 About diabetic diet                                                  | 18 (21.7) |
Figure 3: Risk of type 2 diabetes among respondents (n = 83)
Table 4: The diabetes risk score of respondents using the FINDRISC tool (n = 83)

| Variable                                      | N (%) | Mean ± SD |
|-----------------------------------------------|-------|-----------|
| Type 2 diabetes risk score                    |       | 9 ± 5     |
| Low risk (<7 points)                          | 28 (33.7) |           |
| Slightly elevated risk (7 – 11 points)        | 34 (41.0) |           |
| Moderate risk (12 – 14 points)                | 10 (12.0) |           |
| High risk (15 – 20 points)                    | 9 (10.8) |           |
| Very high risk (>20 points)                   | 2 (2.4) |           |

Components of FINDRISC

| Age group       | N (%)   |
|-----------------|---------|
| <35 years old   | 45 – 54 years old | 68 (81.9) |

| Body mass index | N (%)   |
|-----------------|---------|
| <25 kg/m²       | 36 (43.4) |
| 25 – 30 kg/m²   | 30 (36.1) |
| >30 kg/m²       | 17 (20.5) |

| Waist circumference | N (%)   |
|---------------------|---------|
| <80 cm              | 38 (45.8) |
| 80 – 88 cm          | 24 (28.9) |
| >88 cm              | 21 (25.3) |

| At least 30 minutes of daily physical activity | N (%)   |
|-----------------------------------------------|---------|
| Yes                                           | 47 (56.6) |
| No                                            | 36 (43.4) |

| Fruit and vegetable intake | N (%)   |
|---------------------------|---------|
| Everyday                  | 49 (59.0) |
| Not everyday               | 34 (41.0) |

| Previous regular use of anti-hypertensive medication | N (%)   |
|------------------------------------------------------|---------|
| Yes                                                  | 75 (90.4) |
| No                                                   | 8 (9.6) |

| History of hyperglycemia    | N (%)   |
|-----------------------------|---------|
| Yes                         | 18 (21.7) |
| No                          | 65 (78.3) |

| Family history of diabetes  | N (%)   |
|-----------------------------|---------|
| No family history of diabetes | 33 (39.8) |
| First-degree family (parents, siblings, own children) | 35 (42.2) |
| Second-degree family (grandparents, aunts, uncles, first cousins, nieces, nephews) | 15 (18.1) |

Logistic regression showed that waist circumference, first- and second-degree family history of diabetes were significantly associated with increased T2D risk (OR 1.809, p = 0.016; OR 1601.961, p = 0.001; and OR 218.621, p = 0.009, respectively). On the other hand, daily consumption of fruits and vegetables was significantly associated with decreased T2D risk (OR 0.019, p = 0.024). The model contributed towards an 82.6% variance in T2D risk (Table 5).
Table 5: Factors contributed towards increased risk of type 2 diabetes among respondents (n = 83)

| Variable                             | Adjusted OR | 95% CI          | P-value |
|--------------------------------------|-------------|-----------------|---------|
| First-degree family history of diabetes | 1601.961    | 17.069, 150343.883 | 0.001* |
| Second-degree family history of diabetes | 218.621     | 3.803, 12567.532   | 0.009* |
| Body mass index (kg/m^2)             | 0.576       | 0.301, 1.102      | 0.095   |
| Waist circumference (cm)             | 1.809       | 1.116, 2.934      | 0.016   |
| Total energy intake (kcal/day)       | 0.999       | 0.992, 1.005      | 0.712   |
| Carbohydrate intake (g/day)          | 1.006       | 0.980, 1.033      | 0.640   |
| Protein intake (g/day)               | 1.023       | 0.950, 1.102      | 0.541   |
| Daily intake of fruits and vegetables | 0.019       | 0.001, 0.594      | 0.024* |

OR: Odds ratio. Model R2 = 0.826. *p<0.05

Discussion

The present study investigated factors associated with T2D risk in women of childbearing age in a selected community in Malaysia. More than half (66.3%) of the respondents had an elevated risk of T2D with a risk score of ≥7 points. Factors significantly associated with increased T2D risk were family history of diabetes (both first- and second-degree) and waist circumference, whereas daily consumption of fruits and vegetables was significantly associated with decreased T2D risk.

An underlying genetic susceptibility towards diabetes is an established risk factor of T2D (Harrison et al., 2003). Family history reflects both genetic and environmental factors and thus serves as an independent predictor of T2D risk (Harrison et al., 2003). A previous study in Malaysia suggested using a family history of diabetes as a simple and quick screening tool to identify individuals at high risk of T2D (Hasbullah et al., 2021). A study involving Japanese women with a family history of diabetes in their early 20s found a correlation between family history of diabetes and postprandial hyperinsulinemia (Takeuchi et al., 2020). Their study findings suggested that reduced insulin sensitivity may lead to glucose and lipid dysmetabolism in women with a family history of diabetes although they were younger and had a normal BMI (Takeuchi et al., 2020).

On average, women in this study exceeded the waist circumference recommendation of ≥80 cm, which was comparable with a previous local study, in which the women had a mean waist circumference of 88.6 cm (Ambak et al., 2021). An increased waist circumference (>80 cm for women) could indicate abdominal obesity or visceral adiposity (Després, 2012). Visceral adiposity was associated with a multitude of metabolic abnormalities, including insulin resistance, metabolic syndrome and type 2 diabetes (Despré, 2012). Abdominal adipocytes contain more glucocorticoid receptors than subcutaneous adipocytes, which promote fat deposition in the visceral adipose and induce insulin resistance in the skeletal muscle and liver (Despré, 2012).

Daily consumption of fruits and vegetables was significantly associated with a reduced risk of T2D. Findings from several prospective studies (n = 48) found that a "mainly healthy" dietary pattern characterized by high intakes of fruits, vegetables, fish, poultry and legumes were protective against T2D (relative risk, RR 0.84) (Jannasch et al., 2017). Several plausible mechanisms may explain the protective effects of fruits and vegetables against the risk of
T2D. Fruits and vegetables are high in phytochemicals, including antioxidants, which helps in reducing systemic oxidative stress (Carter et al., 2010). They are also high in fibre, which helps reduce postprandial glucose rise and improve insulin sensitivity by slowing the rate of glucose absorption (McRae et al., 2017). Subjects in this study may have inadequate consumption of fruits and vegetables, indicated by the inadequate fibre intake overall. Thus, nutritional education should emphasize a high-fibre diet, including a high intake of fruits and vegetables, in women of childbearing age to reduce their risk of T2D.

Findings from this study can contribute to the growing body of knowledge on the common risk factors associated with the risk of T2D in women of childbearing age. Nevertheless, the study had a few limitations. Firstly, the cross-sectional design of the study did not allow causal inferences to be made. Besides, the study was only limited to one university. Due to the study location, there was an unequal ethnicity distribution, with the respondents predominantly of Malay ethnicity. Thirdly, no biochemical assessments were performed in this study. Biochemical assessments such as glucose and HbA1c levels can provide a better indicator of T2D risk than diabetes risk score tools.

Another limitation of the study is the use of a subjective method of dietary assessment, i.e. FFQ. Although FFQs have been traditionally used in epidemiologic studies to assess long-term dietary intake, this self-reported method is subject to recall errors, health consciousness bias and errors in estimating nutrients from food composition databases (Guasch-Ferré et al., 2008). Guasch-Ferré et al. (2018) has recommended the use of biomarkers, such as those identified from the metabolomics approach, to complement the use of validated FFQs and increase the accuracy of overall diet assessment.

Economic Impact of COVID-19 Pandemic on the Community

The economic impacts of the COVID-19 pandemic and the subsequent nationwide-imposed lockdown have been massive. Malaysia had recorded an accumulated loss of RM63 billion up to a month after the Movement Control Order (MCO) began on March 18, 2020 (Hashim et al., 2021). Approximately 81% of COVID-19 patients had comorbidities, including diabetes and cardiovascular diseases (Hashim et al., 2021). This has put a tremendous strain on the healthcare system in Malaysia, including daily demand for testing, increased hospitalization, and increased need for health care infrastructures such as ICU beds, ventilators and personal protective equipment (PPE) (Hashim et al., 2021).

During MCO, several economic activities either had to be closed down, or conducted under strict standard operating procedures (SOPs), causing widespread unemployment (Hashim et al., 2021). In an extensive online survey involving several countries, including Thailand, Italy, the United Kingdom, Slovenia and Malaysia (n = 5058), fewer individuals with a flexible income (such as contract or freelance workers) and other/no income were working during COVID-19 compared to those with a fixed income (Osterrieder et al., 2021). The majority of the women in this study were from the low- and average-income category (87.9%), which might mean that they were more financially affected by the COVID-19 pandemic. A previous online survey reported that 41.4% of respondents from low-income families in the USA had a decrease in fruits and vegetables due to COVID, and the majority of the respondents reported being food insecure (93.5%) (Sharma et al., 2020). The combination of stress (such as employment or financial hardship) and poor dietary habits can hinder efforts in disease prevention (Seligman & Schillinger, 2010). Thus, future studies should look into community health strategies such as food security and developing a rapid screening tool that include dietary patterns to prevent T2D among women of childbearing age.
Conclusions
Women of childbearing age with a family history of diabetes, increased waist circumference and low intake of fruits and vegetables increased T2D risk. Public health action, including nutrition education, after delivery, is highly needed to prevent or delay their progression towards T2D. Population-based studies with a larger sample size are recommended, focusing on developing a rapid screening tool to predict T2D risk.

Funding
The research was funded by the Fundamental Research Grant Scheme (FRGS) by the Ministry of Higher Education Malaysia (04-01-12-1132FR).

Acknowledgement
The authors would like to extend gratitude towards the study participants.

Conflict of Interest
The authors declare no conflict of interest.

References
Abdullah, N., Murad, N., Attia, J., Oldmeadow, C., Kamaruddin, M. A., Jalal, N. A., Ismail, N., Jamal, R., Scott, R. J., & Holliday, E. G. (2018). Differing contributions of classical risk factors to type 2 diabetes in multi-ethnic Malaysian populations. *International Journal of Environmental Research and Public Health*, 15(12), 2813. https://doi.org/10.3390/ijerph15122813

Al-Rifai, R. H., Majeed, M., Qambar, M. A., Ibrahim, A., AlYammahi, K. M., & Aziz, F. (2019). Type 2 diabetes and pre-diabetes mellitus: a systematic review and meta-analysis of prevalence studies in women of childbearing age in the Middle East and North Africa, 2000-2018. *Systematic Reviews*, 8(1), 268. https://doi.org/10.1186/s13643-019-1187-1

Ambak, R., He, F. J., Othman, F., Michael, V., Yusoff, M. F., & Aris, T. (2021). Salt intake was higher among males and those with high BMI and waist circumference: Introduction to the Malaysian Community Salt Survey (MyCoSS), a population-based salt intake survey in Malaysia. *Journal of Health, Population, and Nutrition*, 40 (Suppl 1), 23. https://doi.org/10.1186/s41043-021-00229-y

Bellou, V., Belbasis, L., Tzoulaki, I., & Evangelou, E. (2018). Risk factors for type 2 diabetes mellitus: An exposure-wide umbrella review of meta-analyses. *PloS One*, 13(3), e0194127. https://doi.org/10.1371/journal.pone.0194127

Carter, P., Gray, L. J., Troughton, J., Khunti, K., & Davies, M. J. (2010). Fruit and vegetable intake and incidence of type 2 diabetes mellitus: systematic review and meta-analysis. *BMJ*, 341, c4229. https://doi.org/10.1136/bmj.c4229

Chivese, T., Werfalli, M. M., Magodoro, I., Chinhoyi, R. L., Kengne, A. P., Norris, S. A., & Levitt, N. S. (2019). Prevalence of type 2 diabetes mellitus in women of childbearing age in Africa during 2000-2016: a systematic review and meta-analysis. *BMJ Open*, 9(5), e024345. https://doi.org/10.1136/bmjopen-2018-024345

Department of Statistics Malaysia. (2020). Household income estimates and incidence of poverty report, Malaysia, 2020.
Després J. P. (2012). Body fat distribution and risk of cardiovascular disease: an update. Circulation, 126(10), 1301–1313. https://doi.org/10.1161/CIRCULATIONAHA.111.067264

Dugee, O., Janchiv, O., Jousilahti, P., Sakihya, A., Palam, E., Nuorti, J. P., & Peltonen, M. (2015). Adapting existing diabetes risk scores for an Asian population: a risk score for detecting undiagnosed diabetes in the Mongolian population. BMC Public Health, 1–9. https://doi.org/10.1186/s12889-015-2298-9

Fan, Y., Wang, L., Liu, H., Zhang, S., Tian, H., Shen, Y., Tuomilehto, J., Yu, Z., Yang, X., Hu, G., & Liu, M. (2020). \( \beta \)-Cell function or insulin resistance was associated with the risk of type 2 diabetes among women with or without obesity and a history of gestational diabetes. BMJ Open Diabetes Research & Care, 8(1), e001060. https://doi.org/10.1136/bmjdrc-2019-001060

Garcia, A. A., Villagomez, E. T., Brown, S. A., Kouzekanani, K., & Hanis, C. L. (2001). The Starr County Diabetes Education Study: development of the Spanish-language diabetes knowledge questionnaire. Diabetes Care, 24(1), 16–21. https://doi.org/10.2337/diacare.24.1.16

Guasch-Ferré, M., Bhupathiraju, S. N., & Hu, F. B. (2018). Use of metabolomics in improving assessment of dietary intake. Clinical Chemistry, 64(1), 82–98. https://doi.org/10.1373/clinchem.2017.272344

Gunderson, E. P., Lewis, C. E., Lin, Y., Sorel, M., Gross, M., Sidney, S., Jacobs, D. R., Jr, Shikany, J. M., & Quesenberry, C. P., Jr (2018). Lactation duration and progression to diabetes in women across the childbearing years: The 30-year CARDIA study. JAMA Internal Medicine, 178(3), 328–337. https://doi.org/10.1001/jamainternmed.2017.7978

Harrison, T. A., Hindorff, L. A., Kim, H., Wines, R. C., Bowen, D. J., McGrath, B. B., & Edwards, K. L. (2003). Family history of diabetes as a potential public health tool. American Journal of Preventive Medicine, 24(2), 152–159. https://doi.org/10.1016/s0749-3797(02)00588-3

Hasbullah, F. Y., Fong, K. Y., Ismail, A., Mitri, J., & Mohd Yusof, B. N. (2021). A comparison of nutritional status, knowledge and type 2 diabetes risk among Malaysian young adults with and without family history of diabetes. Malaysian Journal of Medical Sciences, 28(1), 75–86. https://doi.org/10.21315/mjms2021.28.1.10

Hashim, J. H., Adman, M. A., Hashim, Z., Mohd Radi, M. F., & Kwan, S. C. (2021). COVID-19 epidemic in Malaysia: Epidemic progression, challenges, and response. Frontiers in Public Health, 9, 560592. https://doi.org/10.3389/fpubh.2021.560592

Institute for Public Health. (2014). National Health and Morbidity Survey 2014: Malaysian Adult Nutrition Survey (MANS). Volume I: Methodology and general findings. IPH.

International Diabetes Federation. (2019). IDF diabetes atlas (9th ed.). IDF.

Iversen, D. S., Støy, J., Kampmann, U., Voss, T. S., Madsen, L. R., Møller, N., & Ovesen, P. G. (2016). Parity and type 2 diabetes mellitus: a study of insulin resistance and \( \beta \)-cell function in women with multiple pregnancies. BMJ Open Diabetes Research & Care, 4(1), e000237. https://doi.org/10.1136/bmjdrc-2016-000237

Jannasch, F., Kröger, J., & Schulze, M. B. (2017). Dietary patterns and type 2 diabetes: A systematic literature review and meta-analysis of prospective studies. The Journal of Nutrition, 147(6), 1174–1182. https://doi.org/10.3945/jn.116.242552
Lim, H. M., Chia, Y. C., & Koay, Z. L. (2020). Performance of the Finnish Diabetes Risk Score (FINDRISC) and Modified Asian FINDRISC (ModAsian FINDRISC) for screening of undiagnosed type 2 diabetes mellitus and dysglycaemia in primary care. *Primary Care Diabetes, 14*(5), 494–500.

Lindström, J., & Tuomilehto, J. (2003). The diabetes risk score: a practical tool to predict type 2 diabetes risk. *Diabetes Care, 26*(3), 725–731. https://doi.org/10.2337/diacare.26.3.725

McRae, M. P. (2017). Dietary fiber is beneficial for the prevention of cardiovascular disease: An umbrella review of meta-analyses. *Journal of Chiropractic Medicine, 16*(4), 289–299. https://doi.org/10.1016/j.jcm.2017.05.005

Milton, S. (1986). A sample size formula for multiple regression studies. *Public Opinion Quarterly, 50*, 112-118.

Mueller, N. T., Mueller, N. J., Odegaard, A. O., Gross, M. D., Koh, W. P., Yuan, J. M., & Pereira, M. A. (2013). Higher parity is associated with an increased risk of type-II diabetes in Chinese women: the Singapore Chinese Health Study. *BJOG: An International Journal of Obstetrics and Gynaecology, 120*(12), 1483–1489. https://doi.org/10.1111/1471-0528.12364

National Coordinating Committee on Food and Nutrition. (2017). Recommended nutrient intakes for Malaysia: A report of the technical working group on nutritional guidelines. NCCFN.

Norimah, A. K., Jr, Safiah, M., Jamal, K., Haslinda, S., Zuhaida, H., Rohida, S., Fatimah, S., Norazlin, S., Poh, B. K., Kandiah, M., Zalilah, M. S., Wan Manan, W. M., Fatimah, S., & Azmi, M. Y. (2008). Food consumption patterns: Findings from the Malaysian Adult Nutrition Survey (MANS). *Malaysian Journal of Nutrition, 14*(1), 25–39.

Oh, S.H., Ku, H., & Park, K.S. (2021). Prevalence and socioeconomic burden of diabetes mellitus in South Korean adults: a population-based study using administrative data. *BMC Public Health, 21*(1), 548.

Oo, A., Al-abed, Lwin, O., Sham, S., Sim, T., Mukti, N., Zahariuluddin, A., & Jaffar, Faizul. (2020). Type 2 diabetes mellitus prediction in Malaysia using modified diabetes risk assessment tool. *Malaysian Journal of Public Health Medicine, 20*(1), 15-21. https://doi.org/10.37268/mjphm/vol. 20/no.1/art.442

Osterrieder, A., Cuman, G., Pan-Ngum, W., Cheah, P. K., Cheah, P. K., Peerawaranun, P., Silan, M., Orazem, M., Perkovic, K., Groselj, U., Schneider, M. L., Poomchaichote, T., Waithira, N., Asarath, S. A., Naemiratch, B., Ruangkajorn, S., Skof, L., Kulpijit, N., Mackworth-Young, C., Ongkili, D., & Cheah, P. Y. (2021). Economic and social impacts of COVID-19 and public health measures: results from an anonymous online survey in Thailand, Malaysia, the UK, Italy and Slovenia. *BMJ Open, 11*(7), e046863. https://doi.org/10.1136/bmjopen-2020-046863

Qamar, M., Iqubal, R. R. M., Ahmad, S., Shaikh, F. A., & Ismail, N. E. (2017) Awareness of diabetes mellitus among general public in Shah Alam, Malaysia: A cross-sectional study. *Asian Journal of Pharmaceutical and Clinical research, 10*(9), 192–196.

Saleem, S. M., Khan, S. M. S., & Jan, S. S. (2017). Finnish Diabetic Risk Score: A Tool for Predicting Risk of Undiagnosed Type 2 Diabetes Mellitus. *Annals of Medical and Health Sciences Research, 7*, 295–298.

Scavini, M., Rossi, M. C., Scardapane, M., Nicolucci, A., Manicardi, V., Russo, G., Di Bartolo, P., Giorda, C. B., Musacchio, N., Ceriello, A., Genovese, S., Molinari, C., Dozio, N., & AMD-Annals Study Group (2018). Portrait of women with type 1 or type 2 diabetes
of childbearing age attending diabetes clinics in Italy: the AMD-Annals initiative. *Acta Diabetologica*, 55(2), 193–199. https://doi.org/10.1007/s00592-017-1076-9

Seligman, H. K., & Schillinger, D. (2010). Hunger and socioeconomic disparities in chronic disease. *The New England Journal of Medicine*, 363(1), 6–9. https://doi.org/10.1056/NEJMp1000072

Sharma, S. V., Chuang, R. J., Rushing, M., Naylor, B., Ranjit, N., Pomeroy, M., & Markham, C. (2020). Social determinants of health-related needs during COVID-19 among low income households with children. *Preventing Chronic Disease*, 17, E119. https://doi.org/10.5888/pcd17.200322

Szumilas M. (2010). Explaining odds ratios. *Journal of the Canadian Academy of Child and Adolescent Psychiatry*. 19(3), 227–229.

Takeuchi, M., Wu, B., Honda, M., Tsuboi, A., Kitaoka, K., Minato, S., Kurata, M., Kazumi, T., & Fukuo, K. (2020). Decreased arterial distensibility and postmeal hyperinsulinemia in young Japanese women with family history of diabetes. *BMJ Open Diabetes Research & Care*, 8(1), e001244. https://doi.org/10.1136/bmjdrcc-2020-001244

Tian, Y., Shen, L., Wu, J., Chen, W., Yuan, J., Yang, H., Wang, Y., Liang, Y., & Wu, T. (2014). Parity and the risk of diabetes mellitus among Chinese women: A cross-sectional evidence from the Tongji-Dongfeng cohort study. *PloS One*, 9(8), e104810. https://doi.org/10.1371/journal.pone.0104810

Vézina-Im, L. A., Nicklas, T. A., & Baranowski, T. (2018). Associations Among Sleep, Body Mass Index, Waist Circumference, and Risk of Type 2 Diabetes Among U.S. Childbearing-Age Women: National Health and Nutrition Examination Survey. *Journal of Women’s Health*, 27(11), 1400–1407. https://doi.org/10.1089/jwh.2017.6534

Vounzoulaki, E., Khunti, K., Abner, S. C., Tan, B. K., Davies, M. J., & Gillies, C. L. (2020). Progression to type 2 diabetes in women with a known history of gestational diabetes: systematic review and meta-analysis. *BMJ*, 369, m1361. https://doi.org/10.1136/bmj.m1361

World Health Organization, International Association for the Study of Obesity, International Obesity Task Force (WHO/IASO/IOTF). (2000). The Asia-Pacific perspective: redefining obesity and its treatment. Health Communications Australia.

World Health Organization. (2008). STEPwise approach to NCD risk factor surveillance (STEPS). https://www.who.int/teams/noncommunicable-diseases/surveillance/systemstools/steps

World Health Organization. (2020). Women of reproductive age (15-49 years) population. https://www.who.int/data/gho/indicator-metadata-registry/imr-details/women-of-reproductive-age-(15-49-years)-population-(thousands)

World Health Organization. (2021). Body mass index – BMI. https://www.euro.who.int/en/health-topics/disease-prevention/nutrition/a-healthy-lifestyle/body-mass-index-bmi