Socio-Demographic Factors and Evaluation of the Degree of Public Risk of Developing Diabetes Type 2 in Relation to Takaful Policy

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Abstract. The alarming increase in type 2 diabetes have not only impacted the public with mental and physical distress but have also increased anxiety and burden on financial aspects in relation to preventing and treating the disease. This has mostly been a result of increasing health care costs and unhealthy diet and lack of physical activity on a consistent basis; therefore, causing people to be unaware of their health status which may have already developed into the early onset of such disease. This study aims to evaluate the degree of the Malaysian public's risk in developing diabetes type 2; and further investigate the relationship of socio-demographic factors in explaining the variation in risk categories. The study employs both descriptive as well as inferential statistics such as the multinomial logistic regression in achieving the objectives. Findings from the sample of 860 Malaysians in the study reveal that almost half of the respondents are in the intermediate risk category of developing diabetes type 2; while results from the regression portray that, factors such as marital status, household income, and education levels play significant roles in the willingness to pay for takaful policy related to diabetes. Finally, the study also provides an evaluation of the degree of risk among three scenarios to show their degree of risk in terms of probabilities.

Keywords: diabetes type 2 · risk factors · socio-demographics · takaful

1 Introduction

Non-communicable diseases (NCDs) are considered one of the world's biggest causes of death. Specifically, diabetes, which is known as a chronic disease has turned into a

significant public health and global concern. This debilitating condition has now reached more than 180 million diagnosed with diabetes which is further forecasted to increase by the next ten years. Malaysia is certainly not excluded from this phenomenon where the rate is also increasing over the years. This is supported by data provided by the 2006 National Health and Morbidity Survey (NHMS) where those above 18 years had higher prevalence of diabetes about 11.6% and based on the NHMS (2019), increased to 13.4% in 2015, which further increased to about 17.3% in 2019. According to a study by [1], even though there were many health awareness campaigns, it is estimated that one in every five Malaysians above the age of 30 have diabetes. From the report, the highest risk of diabetes mellitus (DM) are females, those residing in urban areas and those in the older age group. Additionally, according to [2], among the major races in Malaysia, Indians are considered more prevalent to have diabetes, where Malays and Chinese fall second and third respectively. The rise in number of diagnosed diabetes patients has been also linked with the prevalence of becoming overweight or obese. In 2015 this has increased to 47.7% for adults as they did not follow the requirements suggested for food intakes according to the local food pyramid, which is especially crucial among the fruits and vegetables category. This has been worsened by the low levels of physical activity. A study conducted by [3] stated that there are studies that looked at figures on prevalence rates which ranged from 27 to 31% for cases of obesity and overweight children in school. In this case, it was more prevalent among boys who are in primary school, while the Indian ethnicity and rural location was still part of the risk factors. This may be because school children did not practice exercises in their daily routine.

Furthermore, starting from 1980 to 2014, the World Health Organization (WHO) statistics in [4] show that diabetes prevalence rate among 18-year-old adults have substantially increased from 4.7% to 8.5%. This condition is certainly worrying as the rate has also increased among the middle- and low-income countries including Malaysia. The NHMS in 2011 and 2015 have reported that these rates were lowest for the 18–19 age group with 2.1% and 5.5% respectively: while this peaked for the 65–69 age group in 2011 while 60–64 age group in 2015 at 36.6% and 38.3% respectively. Moreover, the overall DM prevalence experiences the highest increase among the younger age groups which are at 5.9% for the 20–24 age group and 8.9% for the 25–29 age group [5].

Overall, it can be deduced that the associated risk factors of DM include being overweight or obese and the lack of physical activity and bad eating habits among the general population. According to [3], the main causes of obesity and being overweight include unhealthy dietary practices and sedentary lifestyle. Similarly, according to [2], poor adherence to diet, combined with sedentary lifestyle and high carbohydrate intake are major factors of the type 2 diabetes (T2D) in patients. More specifically, [6] mentioned other significant factors of T2D which is not only limited to abdominal obesity but also added hypertension and information on family history as fundamentals that contribute to diabetes; while factors such as age, waist size and poor habits in their diet are those considered as factors linked to pre-diabetes. In addition, two factors indicated by [6] and [7[also included stress and smoking status as traditional contributors towards T2D, similar to previous research by [8, 9] and [10]. It has also been found that genetic and lifestyle are also factors of T2D, however based on [11], genetic variants contribute only

a small amount to the spike in prevalence compared to the dietary patterns and physical activity.

Socio-demographic factors such as incomes, ethnic groups and residential area are among important roles that increase the type 2 diabetes mellitus as reported by NHMS 2015. This has been mentioned earlier, where abdominal obesity is found to be more prevalent in the urban population, who are females and Indian. In contrast, [11] suggests that people who come from the rural area are more prevalent in increasing the number of diagnosed patients with diabetes; other than factors such as older age, family history and obesity.

In essence, the objectives of the paper include to categorize those at risk of having diabetes according to risk score levels using the AUDRISK Model (Low, Intermediate and High); to explore the relationship between socio-demographic factors and the risk categories, and finally to identify the probabilities of risks in relation to underwriting insurance or takaful policies.

2   Methodology

A cross sectional survey was implemented in this study where 860 respondents from the public are involved. They are considered from the public who may be at risk to develop diabetes over the long term; however not yet diagnosed with diabetes. A convenience sampling approach was used as the survey was conducted online using Google form, due to the COVID-19 restrictions. The information gathered through the questionnaire includes a section on socio-demographic factors [age, number of children, income, location, and educational level]. The other sections include questions related to risk factors of diabetes, including respondents' own perception of risk and health status; and captured respondents' willingness to pay for takaful related to diabetes. Other than that, information on components closely linked to diabetes were also collected, such as weight, body mass index (BMI), lifestyle and eating behaviors and blood pressure medication. Based on this information, the risk score is calculated using a modified version of the AUDRISK risk assessment tool and risk components are categorized into three clusters which are low, intermediate, and high risk. Figure 1 shows the AUDRISK risk assessment tool which has been used in several studies in the past.

The study applied both descriptive and inferential analysis to achieve its objectives. Descriptive statistics was basically to identify the respondents' characteristics and socio-demographic patterns based on the variables mentioned above. Additionally, to understand the relationship between the socio-demographic variables and risk clusters, a multinomial logistic regression is used.

2.1   Multinomial Logistic Regression

Since the dependent variable in this study consists of three categories of risk, and the independent variables contain a mixture of discrete and continuous types, the most suitable analysis is the multinomial logistic regression. To calculate the probability of responses, the following equations were used, based on [12].

$$\widehat{P}(Y = 0|X) = \frac{e^{h_0(x)}}{[1 + e^{h_0(x)} + e^{h_1(x)} + e^{h_2(x)}]} \tag{1}$$

The Australian Type 2 Diabetes Risk Assessment Tool (AUSDRISK)

1. Your age group

Under 35 years	☐	0 points
35 – 44 years	☐	2 points
45 – 54 years	☐	4 points
55 – 64 years	☐	6 points
65 years or over	☐	8 points

2. Your gender

Female	☐	0 points
Male	☐	3 points

3. Your ethnicity/country of birth:

3a. Are you of Aboriginal, Torres Strait Islander, **Pacific Islander or Maori descent?**

No	☐	0 points
Yes	☐	2 points

3b. Where were you born?

Australia	☐	0 points
Asia (including the Indian sub-continent), Middle East, North Africa, Southern Europe	☐	2 points
Other	☐	0 points

4. Have either of your parents, or any of your brothers or sisters been diagnosed with diabetes (type 1 or type 2)?

No	☐	0 points
Yes	☐	3 points

5. Have you ever been found to have high blood glucose (sugar) (for example, in a health examination, during an illness, during pregnancy)?

No	☐	0 points
Yes	☐	6 points

6. Are you currently taking medication for high blood pressure?

No	☐	0 points
Yes	☐	2 points

7. Do you currently smoke cigarettes or any other tobacco products on a daily basis?

No	☐	0 points
Yes	☐	2 points

8. How often do you eat vegetables or fruit?

Every day	☐	0 points
Not every day	☐	1 point

9. On average, would you say you do at least 2.5 hours of physical activity per week (for example, 30 minutes a day on 5 or more days a week)?

Yes	☐	0 points
No	☐	2 points

10. Your waist measurement taken below the ribs (usually at the level of the navel, and while standing)

Waist measurement (cm) [   ]

For those of Asian or Aboriginal or Torres Strait Islander descent:

Men	Women		
Less than 90 cm	Less than 80 cm	☐	0 points
90 – 100 cm	80 – 90 cm	☐	4 points
More than 100 cm	More than 90 cm	☐	7 points

For all others:

Men	Women		
Less than 102 cm	Less than 88 cm	☐	0 points
102 – 110 cm	88 – 100 cm	☐	4 points
More than 110 cm	More than 100 cm	☐	7 points

Add up your points [   ]

Your risk of developing type 2 diabetes within 5 years*:

☐ *5 or less: Low risk*
Approximately one person in every 100 will develop diabetes.

☐ *6-11: Intermediate risk*
For scores of 6-8, approximately one person in every 50 will develop diabetes. For scores of 9-11, approximately one person in every 30 will develop diabetes.

☐ *12 or more: High risk*
For scores of 12-15, approximately one person in every 14 will develop diabetes. For scores of 16-19, approximately one person in every 7 will develop diabetes. For scores of 20 and above, approximately one person in every 3 will develop diabetes.

*The overall score may overestimate the risk of diabetes in those aged less than 25 years.

If you scored 6-11 points in the AUSDRISK you may be at increased risk of type 2 diabetes. Discuss your score and your individual risk with your doctor. Improving your lifestyle may help reduce your risk of developing type 2 diabetes.

If you scored 12 points or more in the AUSDRISK you may have undiagnosed type 2 diabetes or be at high risk of developing the disease. See your doctor about having a fasting blood glucose test. Act now to prevent type 2 diabetes.

Fig. 1. Audrisk Risk Assessment Tool

$$\widehat{P}(Y = 1|X) = \frac{e^{h_1(x)}}{[1 + e^{h_0(x)} + e^{h_1(x)} + e^{h_2(x)}]} \tag{2}$$

$$\widehat{P}(Y = 2|X) = \frac{e^{h_2(x)}}{[1 + e^{h_0(x)} + e^{h_1(x)} + e^{h_2(x)}]} \tag{3}$$

where Eqs. (1) to (3) are the logistic regression equations to represent the three risk clusters (low, intermediate, and high) and

$$h_0(x) = \hat{a}_0 + \sum_{i=1}^{n} \widehat{\beta}_{0i}X_i$$

$$h_1(x) = \hat{a}_1 + \sum_{i=1}^{n} \widehat{\beta}_{1i}X_i$$

where $h_0(x)$ and $h_1(x)$ are two equations derived from the multinomial logistic regression parameter estimates with 'high' as the reference category.

2.2 Variables Description

Data used in the multinomial logistic regression are described in Table 1, while details of other variables are provided in the Appendix.

3 Results and Discussion

3.1 Descriptive Analysis

The respondents are all Malaysians, consisting of 860 people where majority are Malay and Muslims. The descriptive analysis of the respondents can be referred to in T In terms of age group, those in the 21–25-year-old category form the largest group which is about 40.9%, while more than half of the respondents were single (56.4%). Other than that, in terms of occupation, 36% of the respondents are from the private sector, while around 83.4% are categorized in Class 1, which is the lowest risk occupational group. It is also found that most of the respondents fall under the B40 income group (RM0-RM4,849) which is around 68.3% based on the household income information requested in the survey. Additionally, only 10% had ever received any types of financial aid, including assistance for health and education. Table 1 in the Appendix shows the detailed descriptive analysis for the respondents of this study.

Based on the information as in the AUDRISK risk assessment tool, respondents of the survey are categorized into the three risk clusters: low, intermediate, and high. The categories' frequencies and percentages are summarized in Table 2.

Table 1. Data and Variables Description

Type of Variable	Symbol	Variable Name	Description
Dependent	Y	Risk Clusters	Low Intermediate High
Independent	X_1	Marital Status	Single Married Others
	X_2	Residential Area	Urban Sub-urban Rural
	X_3	Occupation	Private Sector Government Servant Housewife Entrepreneur/Self-employed Pensioner/Retired Student Not Employed Others
Independent	X_4	Age	<20
			21–25
			26–30
			36–40
			41–45
			46–50
			51–55
			56–60
			61–65
			66–70
			71–75
			>75
	X_5	Gender	Male Female
	X_6	Family History	Yes No
	X_7	Ethnicity	Malay Chinese Indian Others

Table 2. Risk Categories

Risk Level (Category)	Frequency (n)	Percentage (%)
Low	226	26.3
Intermediate	396	46.0
High	238	27.7
Total	860	100.0

Table 3. Multinomial Logistic Regression Results

Variables	Chi-Square	Sig.
Intercept	5.092	0.078
Ethnic	2.986	0.225
Religion	1.525	0.467
Marital Status	13.172	0.001*
No. of Children	19.389	0.000*
Other dependents	1.193	0.551
Residential Area	0.776	0.678
Education	21.423	0.000*
Occupation Category	1.262	0.532
Occupational Risk	1.833	0.400
Occupational Status	1.267	0.531
Household Income	17.274	0.000*
Financial Aid	0.571	0.752

3.2 Risk of Diabetes

The multinomial logistic regression is used to obtain the second and third objectives. The objectives include to analyze the socio-demographic factors that have significant relationship on risk categories and to calculate the probabilities for different categories of risk, which is to determine the most likely value. From the parameter estimates of the regression, the following equations are derived. Table 3 shows the results for objective 2.

From the results in Table 3, only four variables out of twelve are considered significant towards the risk factors, which include marital status, number of children, education, and household income. This shows that these variables can play significant roles in determining the health of an individual in relation to diabetes. For the third objective, the same regression method was used; however, to be consistent with [12], some variables

Table 4. Model of Good Fit

Model	Model Fitting Criteria	Likelihood Ratio Tests		
	−2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	1445.193			
Final	926.674	518.519	14	0.000

Table 5. Pseudo R-Square

Model of Fit	R-Square
Cox and Snell	0.453
Nagelkerke	0.514
McFadden	0.283

were omitted where only seven variables are included, as described in Table 1. From the parameter estimates of the second regression, the following equations are derived.

$$h_0(x) = -1.808 - 0.549X_1 - 0.027X_2 + 0.035X_3 - 0.892X_4 + 0.695X_5 + 3.535X_6 - 0.03X_7 \tag{4}$$

$$h_1(x) = 0.064 - 0.327X_1 - 0.027X_2 + 0.059X_3 - 0.574X_4 + 0.58X_5 + 2.017X_6 - 0.028X_7 \tag{5}$$

For identifying the goodness of fit of how well the independent variables explain the dependent variable, we look at the likelihood ratio in Table 4 which shows a value of 1,445.193 while the full model is 926.674; where the difference is the Chi-Square value of 518.519. The p-value corresponding to the chi-square test with 14 degrees of freedom is 0.000 in which we can conclude that independent variables chosen in the model are statistically significant at the 1% level. Regression results in Table 5 also show the Nagelkerke measurement of pseudo-R-squared. The value of 0.514 means that 51.4% of the variation in the respondents' socio-demographic factors explains the variations in the degree of risks.

This study also investigates how the different socio-demographic factors affect the different degrees of risk (risk clusters). Three cases are considered, where these are depicted in Table 6, Table 7, and Table 8.

For example, from Table 6, a Malay, married, government-employed, 35-year-old female who lives in an Urban residential area and has a family history of diabetes would be categorized as high according to the regression results whereas from Table 7, only a change in the marital status puts the individual into an intermediate risk, while other variables are kept constant. In Table 6, to get the values of $h_0(x)$ and $h_1(x)$ which are −2.428 and −0.22 respectively, the coding of variables on each socio-demographic factor is inputted in Eq. (4) and Eq. (5).

From Table 7 to Table 8, a change in the individual's age and family history status changes the degree of risk from intermediate to low. The degrees of risk identified based

Table 6. Degree of Risk of Takaful Policyholder: Case 1

Risk Factors		Marital Status	Residence	Occupation	Age	Gender	Family History	Ethnicity
		Married	**Urban**	**Government**	**36–40**	**Female**	**Yes**	**Malay**
$h_0(x)$	−2.428							
$h_1(x)$	−0.22							
Probabilities Degree of Risks	Low	0.04666					() **Low**	
	Intermediate	0.42449					() **Intermediate**	
	High	**0.52889**					(/) **High**	

Table 7. Degree of Risk of Takaful Policyholder: Case 2

Risk Factors		Marital Status	Residence	Occupation	Age	Gender	Family History	Ethnicity
		Single	**Urban**	**Government**	**36–40**	**Female**	**Yes**	**Malay**
$h_0(x)$	−1.879							
$h_1(x)$	0.107							
Probabilities Degree of Risks	Low	0.06742					() **Low**	
	Intermediate	**0.49122**					(/) **Intermediate**	
	High	0.44137					() **High**	

Table 8. Degree of Risk of Takaful Policyholder: Case 3

Risk Factors		Marital Status	Residence	Occupation	Age	Gender	Family History	Ethnicity
		Single	**Urban**	**Government**	**21–25**	**Female**	**No**	**Malay**
$h_0(x)$	3.637							
$h_1(x)$	3.266							
Probabilities Degree of Risks	Low	**0.58262**					(/) **Low**	
	Intermediate	0.40204					() **Intermediate**	
	High	0.01534					() **High**	

on the socio-demographic profiles of individuals would be able to assist in underwriting decisions by a takaful or insurance provider in handling those who are at risk or may already been diagnosed with diabetes. In other words, by looking at certain socio-demographic factors and the probabilities of risks would put the potential insurance or takaful policy at either low, intermediate, and higher risks. Therefore, insurance and takaful companies may decide to accept those in the low-risk category with a lesser premium while may accept or reject those in the intermediate risk depending on the companies' decision-making strategies in underwriting.

4   Conclusion

In this study, it has been shown that various socio-demographic factors do influence the degree of risk for diabetes. Data was collected from 860 respondents who are considered at risk of having diabetes on information that are related to diabetes risk factors. The study will help insurers and takaful operators to understand probabilities in relation to their risk groups, if a product related to diabetes is to be considered. It would also assist in understanding underwriting decisions to help decide which risk should be accepted and rejected.

Appendix

Table 1.

Item	Category	Frequency (n)	Percentage (%)
State	Selangor	246	28.6
	W. P. Kuala Lumpur	34	4.0
	W. P. Putrajaya	4	0.5
	Negeri Sembilan	51	5.9
	Melaka	25	2.9
	Johor	122	14.2
	Perak	41	4.8
	Kedah	18	2.1
	Pulau Pinang	9	1.0
	Perlis	22	2.6
	Pahang	28	3.3
	Terengganu	53	6.2
	Kelantan	65	7.6
	Sabah	122	14.2
	Sarawak	20	2.3
Age	Below 20–year-old	17	2.0
	21–25-year-old	352	40.9
	26–30-year-old	156	18.1
	31–35-year-old	57	6.6
	36–40-year-old	61	7.1
	41–45-year-old	37	4.3

(*continued*)

Item	Category	Frequency (n)	Percentage (%)
	46–50-year-old	73	8.5
	51–55-year-old	50	5.8
	56–60-year-old	36	4.2
	61–65-year-old	9	1.0
	66–70-year-old	4	0.5
	71–75-year-old	4	0.5
	75 and above	4	0.5
Gender	Male	316	36.7
	Female	544	63.3
Ethnic	Malay	724	84.2
	Chinese	8	0.9
	India	4	0.5
	Sabah Native	84	9.8
	Sarawak Native	10	1.2
	Others	30	3.5
Religion	Muslim	844	98.1
	Buddhist	4	0.5
	Christian	10	1.2
	Others	2	0.2
Marital Status	Single	485	56.4
	Married	356	41.4
	Divorce	12	1.4
	Widow/Widower	7	0.8
Number of Children	No children	515	59.9
	1–5 persons	297	34.5
	6–10 persons	46	5.3
	11–15 persons	2	0.2
Other Dependants (e.g. parent, grandparent)	No	506	58.8
	1–5 persons	346	40.2
	6–10 persons	8	0.9
	Urban	439	51.0
	Sub-Urban	229	26.6
	Rural	192	22.3

(*continued*)

Item	Category	Frequency (n)	Percentage (%)
Highest Academic Qualification	No formal education	5	0.6
	Primary school	12	1.4
	Secondary school	111	12.9
	Diploma/Certificate	159	18.5
	Degree & above	573	66.6
Occupation	Private sector employee	312	36.3
	Government servant	199	23.1
	Housewife	46	5.3
	Entrepreneur/Self-employed	100	11.6
	Pensioner/Retired	10	1.2
	Student	156	18.1
	Not working	31	3.6
	Others (Athlete; farmer; shop assistant)	6	0.7
Risk Classification	Class 1: You are involved with indoor work that is less risky	717	83.4
	Class 2: You are involved with outdoor work or are riskier than Class 1	57	6.6
	Class 3: You are involved with risky sub-machine	66	7.7
	Class 4: You are involved with dangerous work and heavy machinery	20	2.3
Occupational Status	Permanent	531	61.7
	Part-Time	129	15.0
	Contract	200	23.3
Monthly Household Income	RM0.00 – RM4,849	587	68.3
	RM4,850 – RM10,959	184	21.4
	RM10,960 and above	89	10.3
Receive Welfare, Healthcare or Education Assistance	Yes (Source: family; Baitulmal; JPA; PTPTN; Jabatan Agama; SOCSO; PERKESO; BSH & etc.) (Amount: RM50 – RM150,000)	86	10.0
	No	774	90.0

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