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Original Article

Public Awareness of Early and Late Complications of Type 2 Diabetes - Application of Latent Profile Analysis in Determining Questionnaire Cut-Off Points

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ABSTRACT

Objectives: A questionnaire was designed to determine public understanding of early and late complications of Type 2 diabetes mellitus (T2DM) .

Methods: A cross-sectional study was performed in participants who were selected using a multi-stage sampling method and a standard questionnaire of 67 questions was proposed. An expert panel selected 53 closed-ended questions for content validity to be included in the questionnaire. The reliability of the questionnaire was tested using Cronbach's alpha coefficient giving a score of 0.84.

Results: Of the 825 participants, 443 (57.6%) were male, and 322 (41.87%) were 40 years or more. The proportion of low-, moderate- and high- awareness about T2DM and its complications was 29.26%, 62.68%, and 8.06%, respectively. Friends (56.31%) and internet and social networks (20.55%) were the 2 major sources of awareness, respectively. The medical staff (e.g., physicians) had the lowest share in the level of public awareness (3.64%) compared to other sources.

Conclusion: These results present data that shows the general population awareness of T2DM is low. Healthcare policymakers need to be effective at raising awarenes of diabetes and it should be through improved education.

Introduction

Type 2 diabetes mellitus (T2DM) is a non-communicable disease that is prevalent in all societies, with progression higher in low- or moderate-income countries [1]. In addition, according to the World Health Organization (WHO), the diabetes prevalence in the world has doubled from 1980 (4.7%) to 2014 (8.5%) [2]. In addition, in recent years the prevalence of diabetes in low- and middle-income countries has risen faster than in high-income countries [2].

Diabetes was the leading cause of 5.1 million deaths worldwide in 2012, and the deaths in low- and middle-income countries occurs predominantly before the age of 70 years [2]. In addition, diabetes creates many complications such as heart attack [3], stroke [4], vision loss [5], and renal failure [6]. A previous study has indicated that deaths from T2DM are rising [7].

It should be noted that increasing knowledge and awareness for the prevention of Type 1 diabetes has been ineffective, but it is thought that increasing awareness may lead to reductions in the prevalence of T2DM [2]. Early diagnosis of T2DM is necessary to prevent and reduce the human burden of the disease. Therefore, assessment of public awareness on T2DM and identifying people with low awareness is very important

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for effective health planning. On the other hand, raising the level of awareness of people with a low level of knowledge about diabetes can help prevent T2DM. Measuring the awareness rate of individuals is difficult without the use of a suitable tool such as a questionnaire. Despite the large number of questionnaire tools that have been developed to measure awareness on T2DM, numerous studies have used crude scores to assess awareness. In those studies, awareness scores could not be categorized into statistically distinct subgroups (e.g., low-, moderate-, or high- awareness). The first aim of the present study was to determine statistically distinct subgroups and identify a cut-off point based on awareness scores. The second aim was to investigate the relationship between public awareness of T2DM and socio-demographic factors.

Materials and Methods

1. Participants

In this cross-sectional study, 825 healthy participants were recruited from Hamadan, west of Iran in 2016. Of the 825 questionnaires, 769 (93.21%) participants returned completed questionnaires. Participants were selected by a multi-stage sampling method, and informed consent obtained. Firstly, 15 centers of the 32 health centers were randomly sampled. Secondly, 11 registered individuals were randomly sampled in each health center as the primary point of the cluster. Thirdly, in each cluster, in addition to the primary point of the cluster, 4 eligible people were selected in their neighborhood (i.e., a sample size of each cluster was 5).

The Research Council and the Ethics Committee of Hamadan University of Medical Sciences approved the study (IR.UMSHA. REC.1394.238). Informed consent was obtained from all individual participants included in the study.

2. Questionnaire

In the present study, a standard questionnaire was used to measure public awareness of T2DM and its complications, which included 53 closed-ended questions (containing 7 subscales, such as fundamentals of diabetes, common symptoms of diabetes, early complications of T2DM, late complications of diabetes, diet, methods for blood sugar control, and source of information about T2DM). The answer to each question had 3 options (i.e., yes, no and I do not know). The correct answer was given a score of 1, and the incorrect answer/ I do not know was given a score of zero. Firstly, 67 questions were designed according to an expert panel (*n* = 10), with 53 questions confirmed. The content validity of the questions was approved by the expert panel. In addition, confirmatory factor analysis was used to determine goodness

of fit of the questionnaire. To determine the content validity ratio, the expert panel should judge each item with the question: "Is diabetes awareness measured by this item?" They chose 1 of 3 answers; "essential," "useful but not essential," or "neither necessary nor useful" to the performance of the construct. Content validity ratio was considered to be more than 0.8.

Soltanian et al [8] determined internal consistency of the questionnaire and reported that Cronbach's alpha coefficient and ICC were 0.84 and 0.82, respectively.

3. Latent Profile Model

Before determining the cut-off points, it needs to be specified that the data can be divided into several categories using latent profile analysis (LPA). In other words, LPA was used to determine the number of classes or subgroups based on the participants' awareness scores. Using LPA, the probability of assigning each individual to the subgroups was determined and the results were considered as the gold standard. A latent profile analysis for the response vector of p normally distributed variables (i = 1,..., p) with K classes (j = 1,..., K) defined as a finite mixture model [9,10] (see Equation 1):

$$f(x_i) = \sum_{j=1}^{K} \eta_j \prod_{i=1}^{P} \frac{1}{\sqrt{2\pi\sigma_{ij}^2}} \exp(\frac{-(x_i - \mu_{ij})^2}{\sigma_{ij}^2}) \quad \text{(Equation 1)}$$

where η_j is the probability that any individual is a member of class j ($\sum_{j=1}^{K} \eta_j = 1$), x_i is the observed response to variable i, μ_{ij} and σ_{ij}^2 are the mean and the variance for variable i for an individual from class j, respectively.

4. The goodness of fit criteria for evaluation LPA

After dividing the knowledge scores of individuals into several subgroups (e.g., 1, 2 and 3 subgroups), the goodness of their fitness was examined and 1 of them selected. To increase the accuracy of the selection of the number of subgroups, several goodness of fit criteria were applied including Akaike's Information Criteria (AIC) [11], Bayesian Information Criteria (BIC) [12], Sample size adjusted Bayesian Information Criteria (SSABIC) [13], Lo-Mendell-Rubin Adjusted Likelihood Ratio Test (LMRT) [14] and the Entropy criterion for determining the number of latent classes and accuracy of classifying individuals [10]. The lower values of AIC, BIC, SSABIC indicate more parsimonious models [11-13]. The LMRT statistically compares a normal mixture distribution model with a lower number of classes against an alternative normal mixture distribution model with more number of classes. A significant *p* value indicates that the model with more number of classes fits better than another one [10,14]. The Entropy criterion

Table 1. Fit indices from the latent profile analysis.

No. of Latent Class	AIC	BIC	Sample-Size Adjusted BIC ($n^* = (n + 2) / 24$)	Entropy	Lo-Mendel-Rubin adjusted LRT test	p
C = 1	20788.290	20853.321	20808.865			
C = 2	18559.220	18661.412	18591.552	1.000	2203.618	< 0.001
C = 3	17416.604	17555.957	17460.693	0.919	1137.224	< 0.001

AIC = Akaike's information criteria; BIC = bayesian information criteria; LRT = likelihood ratio test.

determines the accuracy of classifying individuals into their appropriate classes where higher values indicate better fits. The Entropy values > 0.80 indicate that the latent classes are highly discriminating [9,14].

5. Determination of cut-off points

The number and measure of cut-off points were determined using Youden's index [15], and each individual was assigned to a subgroup based on the cut-off points.The surfaceunder the ROC curve was calculated using the results of the LPA (as the gold standard) and the Youden's index [16]. The cut-off points that have the highest surfaceunder the ROC curve were selected as optimal cut-off points.

The Youden's index takes an optimal value means that the correct classification is maximum overall. The Youden's index can take a value between 0 and 1 in practical applications, corresponding to an inadequate and a good pointer, respectively.

In this study, qualitative variables were described by frequency, and qualitative variables were described as mean ± SD. Statistical analyses were performed using M-plus 6.0 [17], R 3.3.0 package of DiagTest3Grp [18].

Results

In this study, the response rate to the questionnaire was 93.21%, and the proportion of male and female respondants was 57.6% (n = 443) and 42.4% (n = 326), respectively. More than half of the participants (58.13%) were 40 years or less.

1. Latent profile analysis

A latent profile analysis with 1-, 2- and 3- latent classes was performed on the 7 dimensions of the awareness questionnaire for T2DM. Five indices (Table 1) were used to decide whether awareness scores would be divided into 1, 2 or 3 subgroups. The results suggested that the knowledge scores should be divided into 3 subgroups [e.g., low-, moderate-, and high- awareness (Table 1)].
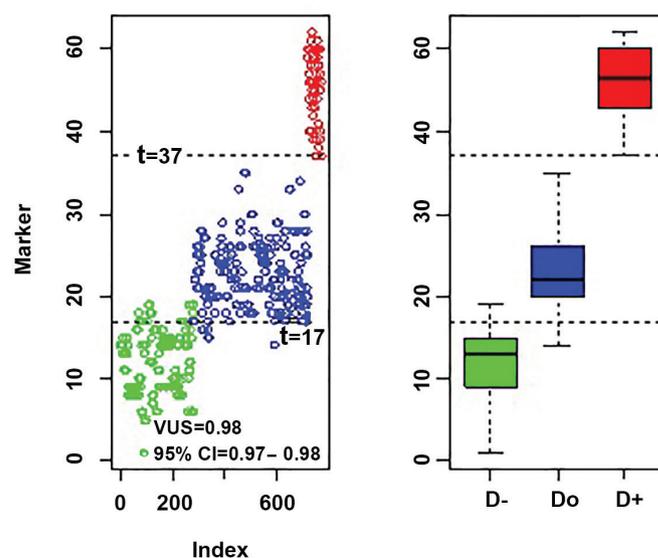

Figure 1. Result of volume under receiver operating characteristics surface.

2. The optimal cut-off points

To divide the knowledge scores into 3 subgroups, it required 2 cut-off points (thresholds). Those 2 cut-off points were determined by the extended Youden's index and volume under the receiver operating characteristic surface simultaneous. Those cut-off points were 17 and 37. The Youden's index measure based on the 2 thresholds was 0.92 (95% CI: 0.90–0.93) and correct classification proportions for low-, moderate- and high- awareness groups were 92%, 91%, and 99%, respectively (Figure 1). Therefore, based on the results score ≤ 16, 17-36 and ≥ 37 indicating low-, moderate-, and high- awareness, respectively.

3. Association between awareness scores and demographic characteristics

Characteristics of participants are shown in Table 1. Mean (SD) age of the participant was 24.92 (2.89) years. The people

Table 2. Demographic characteristics and their association with T2DM awareness level using multiple ordinal logistic regression and multiple logistic regression.

Variables	n (%)	Awareness scores *			OR§	p§	OR¶	p¶
		Low (n = 225)	Moderate (n = 482)	High (n = 62)				
Gender								
Male	443 (57.6)	93 (41.3)	318 (65.9)	32 (51.6)	0.33	< 0.001	0.381	< 0.001
Female	326 (42.4)	132 (58.7)	164 (34.1)	30 (48.4)	1		1	
Age (y)								
≤ 25	121 (15.7)	15 (6.7)	68 (14.1)	38 (61.3)	0.36	< 0.001	0.91	0.012
26-40	326 (42.39)	79 (35.1)	227 (47.1)	20 (32.2)	0.51	< 0.001	0.82	< 0.001
41-54	257 (33.42)	96 (42.7)	157 (32.57)	4 (6.5)	0.34	< 0.001	0.85	< 0.001
≥55	65 (8.45)	35 (15.6)	30 (6.2)	0 (0.0)	1		1	
Marriage status								
Single	267 (34.7)	48 (21.3)	176 (36.5)	43 (69.4)	2.16	< 0.001	1.18	0.60
Married	502 (65.3)	177 (78.7)	306 (63.5)	19 (30.6)	1		1	
Education								
Illiterate	110 (14.3)	41 (18.2)	69 (14.3)	0 (0.0)	1		1	
Primary	114 (14.8)	83 (36.9)	31 (6.4)	0 (0.0)	1.24	< 0.001	1.31	0.017
Secondary	101 (13.1)	40 (17.8)	61 (12.7)	0 (0.0)	1.21	< 0.001	1.28	0.081
High school	88 (11.4)	17 (7.6)	65 (13.5)	6 (9.7)	2.69	< 0.001	2.07	0.030
Bachelor	180 (23.4)	29 (12.9)	143 (29.7)	8 (12.9)	2.29	< 0.001	1.88	0.023
≥ M.Sc.	176 (16.4)	15 (6.7)	113 (23.4)	48 (77.4)	2.16	< 0.001	2.12	0.042
Family history of diabetes								
First degree †	58 (7.5)	18 (8.0)	55 (11.4)	19 (30.6)	3.13	< 0.001	2.14	< 0.001
Second degree ‡	44 (5.7)	7 (3.1)	52 (10.8)	7 (11.3)	1.97	< 0.001	2.01	< 0.001
No	667 (50.0)	200 (88.9)	375 (77.8)	36 (58.1)	1		1	

T2DM = type 2 diabetes mellitus.
* Awareness scores were divided into 3 categories based on latent profile analysis and Youden's index.
† First degree denotes father/mother/sister/brother; ‡ Second degree denotes aunt/uncle/cousin.
§ OR and P denotes Odds ratio and statistical significance, respectively, and were estimated by multiple ordinal logistic regression.
¶ OR and P were estimated by multiple logistic regression (low v.s. moderate + high).
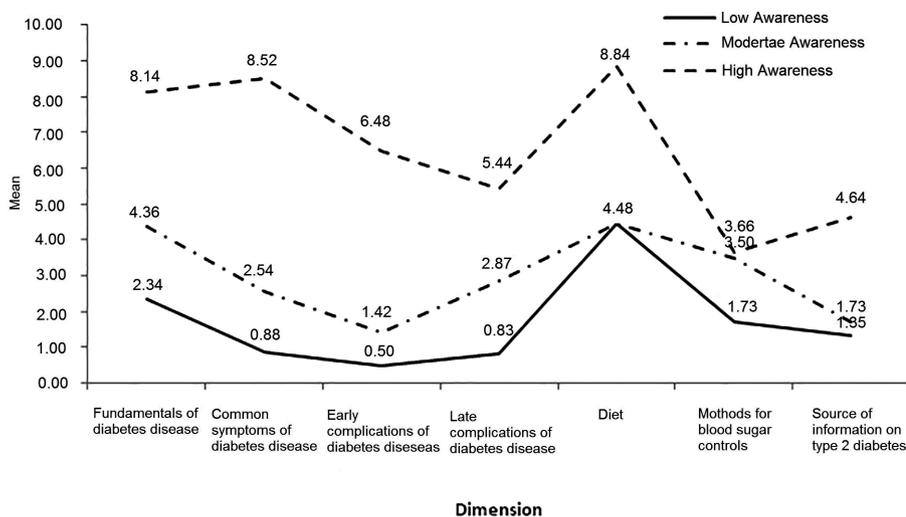

Figure 2. The mean scores of people's awareness in 3 subgroups (i.e., low-, moderate- and high level). The range of fundamentals of diabetes disease (0-8), common symptoms of diabetes disease (0-10), early complications (0-7), late complications (0-6), diet (0-12), methods for blood sugar control (0-5), the source of information (0-5).

Table 3. The correct response to interview questions about T2DM disease amongst 769 participants.

Statements	n	%
1- Fundamentals:		
Do you know the normal level of blood sugar in humans?	209	27.18
Is the rise in blood sugar symptomatic of diabetes disease?	620	80.62
Is diabetes a hereditary disease?	309	40.18
Is diabetes preventable?	429	55.79
Is diabetes disease curable?	389	50.58
Did you know about Type I diabetes and its properties?	187	24.32
Did you know about Type II diabetes and its properties?	227	29.52
Did you know about gestational diabetes and its properties?	54	7.02
2-Which of the following disorders is a symptom of diabetes?		
Polydipsia	81	10.53
Urinating more often than normal, particularly needing to do so during the night	302	39.27
Enuresis	113	14.69
Feeling tired during the day, particularly after meals	84	10.92
Sudden loss of weight	94	12.22
Birth weight more than 4 kg	125	16.25
Feeling abnormally thirsty	102	13.26
Often feeling hungry, particularly if you feel hungry shortly after eating	264	34.33
Itching of the skin, particularly itchiness around the genitals	192	24.97
Slow Healing	170	22.11
3-Which of the following is an early complication of diabetes?		
Coma	125	16.25
Failing blood pressure	373	48.50
Breathe deep and hard (Kussmaul breathing)	198	25.75
Recurrent infections	145	18.86
Dizziness	97	12.61
Wannes	144	18.73
Blurring vision	306	39.79
4-Which of the following is an late complication of diabetes?		
Ocular disorders	182	23.67
Kidney disease and kidney disorders	255	33.16
Ulcers in the legs	316	41.09
Heart failure	400	52.02
Stroke	340	44.21
Impotence	247	32.12
5-Which of the following foods increases blood sugar when consumed excessively?		
Rice and Grains	235	30.56
Bea	126	16.38
Green Vegetables	423	55.01
Sweet Fruits (such as: apple, orange, banana, Grapes)	522	67.88
Fruit Tart (such as: Lemon, Sour)	317	41.22
Meat	268	34.85
Poultry	155	20.16
Milk, yogurt, buttermilk	566	73.60
Butter, cream, curd	451	58.65
Honey and Ice-Cream	253	32.89
Mayonnaise	498	64.78
Sausage	209	27.18
6-What are the following ways to control blood sugar and diabetes?		
Low-calorie diet	161	20.94
A periodic visit to a physician	480	62.42
Regular sport and physical activity	452	58.78
Eat more fiber	98	12.74
Weight loss	140	18.21

T2DM = type 2 diabetes mellitus.

that belonged to the higher awareness category were more likely to be (a) female, (b) single, (c) have a family history of diabetes, (d) have higher education, and (e) lower age (Table 2). Of all participants (n = 769), 225 (29.26%), 482 (62.68%) and 62 (8.06%) had low- , moderate- and high- awareness level of T2DM and its early and late complications, respectively.

In this study, approximately a quarter of the participants (24.32%) knew about Type 1 diabetes, whilst less than one-third (29.52%) knew about T2DM (Table 3). The results show that approximately half of the participants (55.79%) knew that T2DM was preventable (Table 3) and the rest believed that T2DM was not preventable. The participants knew about failure
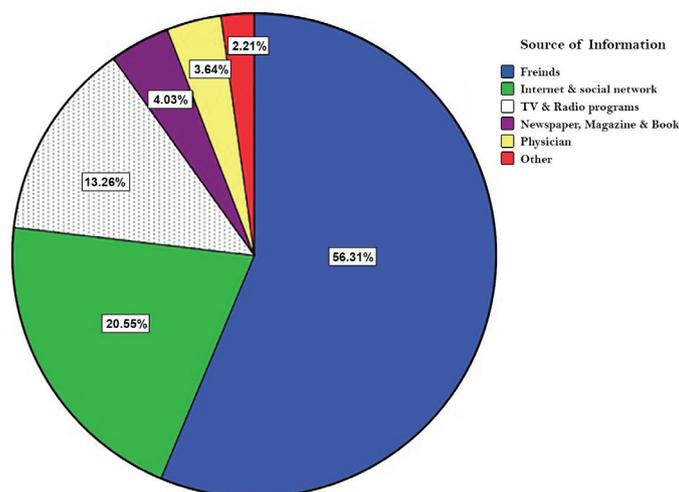
Figure 3. Source of information of participants concerning T2DM. T2DM = type 2 diabetes mellitus.

of blood pressure (48.5%) and blurred vision (39.79%), more than other early complications of T2DM (Table 3). In addition, the participants were more aware of heart failure (52.02%) and stroke (44.21%), among the late complications of T2DM (Table 3).

Awareness score of blood sugar control methods was low, even amongst the people who were in the third group (i.e., individuals with a high awareness level), whilst nutrition knowledge was more than the other dimensions (Figure 2). Knowledge of people in the low- and moderate- groups, on early or late complications of T2DM, was less than the other dimensions (Figure 2).

Figure 3 showed that friends (56.31%), and the internet and social networks (20.55%), were the most important source of information about T2DM amongst the public, whilst medical staff (e.g., physician) had the lowest frequency (3.64%).

Discussion

Early diagnosis of diabetes symptoms can prevent T2DM and reduce the risk of developing complications of the disease (e.g., vascular problems, kidney, etc.). In addition, lifestyle changes, through increased physical activity and weight loss, will play a more effective role in reducing the risk of developing T2DM. In most cases, early diagnosis of diabetes can restore normality to high blood sugar levels in the body. A prerequisite for preventing diabetes in any society is knowing the level of awareness and sources of information about diabetes.

In this study, a questionnaire was used that did not have a cut-off point. For this reason, 3 basic tasks were identified. Firstly, the number of awareness classes was set based on

data by a quantitative method (i.e., latent profile analysis) to classify participants from a heterogeneous population into homogeneous subgroups based on an individual's measures on continuous variables. Secondly, the cut-off point using Yoden's index was obtained; and thirdly, the individuals were categorized based on the cut-off points.

Three different classes were found to be more suitable than 1- or 2- classes to classify individuals into homogeneous subgroups. To adjust for gender, age, married status, and family history of diabetes effect, LPA was used. Youden's index classified individuals into 3 classes based on awareness scores (i.e., low, medium, and high awareness). Previous studies did not determine the cut-off points for their questionnaires [8,19-22].

In accordance with 3 cut-offs (i.e., ≤ 16, 17-36 and ≥ 37), only 8.06% of participants had high awareness, while the rest had low (i.e., 62.68%) or moderate (i.e., 29.26%) awareness. Therefore, awareness regarding T2DM among the general population is inadequate in the west of Iran. Such results were shown in East Asia [20,23], Africa [24,25], and some Middle East regions [19]. Overall, the results of this study and studies conducted in China [23], Tanzania, India and Bushehr [19] show that people's level of diabetic awareness and its complications is low, therefore, ongoing education programs should be implemented to raise people's awareness about diabetes. In addition, diabetes screening should be performed routinely.

This study showed that the average score of awareness of diet related to T2DM is higher than other dimensions. Despite the awareness of people about healthy diets, the prevalence of T2DM in Iran is increasing. Perhaps such a paradox is the lack of awareness of people's attitude to diabetes or low perceived sensitivity of people. It is recommended that perceived sensitivity and barriers be taken into consideration in educational programs.

The results from this study were similar to Xu's study [23] which showed that females have more diabetic awareness than males, but in the southern region of Iran [19] and India [26], it was reported that men's awareness was higher than women. Therefore, because of the contradiction between the results of the studies, it is not possible to be certain that which gender has more diabetic awareness. It seems the relationship between gender and awareness depends on the climate and the research community.

In the present study, the level of diabetes awareness among older people was lower than that of younger people. The relationship between age and knowledge of people has already been reported [27]. Therefore, it is recommended that the level of public awareness must be increased, especially in the elderly. For this reason, policymakers should implement training courses for middle-aged people.

The results showed that having a diabetic person in a

family could increase awareness, while people who do not have diabetes in their family have a low level of knowledge of diabetes. Therefore, it is important to educate families that have not had first hand experience of diabetes.

We showed that more than half of the participants (56.31%) received information about T2DM disease from friends. This may be considered a high proportion. Friends may not be a reliable scientific source of information on diabetes, thus it is advisable to inform the public through official sources (e.g., television programs, newspapers and medical staff). The important sources of information on diabetes was different in the present study, i.e., mainly friends, compared with Xu's study, i.e., books and newspaper [23]. In this study, 4.03% and 3.68% participants received information about T2DM from books and magazines, and medical staff (e.g., physicians), respectively, which is a small amount. Of course, this difference is due to the age structure in the 2 studies. In other words, the participants in Xu's study were young (i.e., students), while in our study there was a wider range of age groups.

The results of this study were similar to previous studies [23,25], demonstrating that people have little knowledge about diabetes and its complications. Therefore, in order to reduce the incidence of T2DM, young people who have an incentive to change their lifestyle have to be considered.

Our study showed that the general population had a low awareness of the early and late complications of T2DM as well as its early symptoms. Perhaps this has led to less self-awareness and knowledge to live a healthy lifestyle. Therefore, it is suggested that future training programs focus more on complications of T2DM disease and its early symptoms.

In this study, although 62.62% and 58.78% of participants explained that periodic visit to a physician and regular sport and physical activity can control T2DM disease, respectively, these proportions are still low, with an increase in T2DM prevalence. Therefore, the benefits of exercise needs to be provided in education programs for these communities.

The results in this study showed that people's knowledge of the symptoms of T2DM is very low and this may lead to the latent development of diabetes within the community if there is a lack of general awareness of the disease.

Conclusion

The results of this study showed that people's understanding about T2DM disease is low, so health policymakers should raise diabetic awareness in the public using training programs. There should be a focus on education using accurate scientific and medical information via medical staff, books and newspapers, and TV and radio programs. Older people are more at risk for diabetes and because their level of awareness is low, the health policymakers must increase understanding, particularly in young people.

Acknowledgments

Conflicts of Interest

The authors have declared that they have no competing interests.

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