Identification of Risk Factors for Type II Diabetes in Almadinah Almunawara, The Kingdom of Saudi Arabia

Abstract

The goal of this study is to identify the risk factors of type II diabetes (T2D) in Al Madinah in the Kingdom of Saudi Arabia (KSA). Data were collected from the Primary Health Care Center (PHCC) of Al Madinah, KSA, from 2009 to 2014. The data are grouped or summarized, where the patients have different types of diabetes. The dependent variable is the type of T2D, and the independent variables (risk factors) are age (1- 45+ years), gender (male and female), and nationality (Saudis and non-Saudis). A multinomial logit model is used since the response, a nominal categorical variable, has four levels measured on nominal scale: 'diabetes during pregnancy & delivery', 'diabetes with other complications', 'diabetes without complications', and 'acetone diabetes'. The results from the fit of multinomial logit model show that all predictors are statistically significant (p> 0.05).

Keywords: Type II Diabetes; Types of T2D; Al Madinah Al Munawara; Multinomial logit model

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Introduction

Diabetes mellitus or diabetes is defined as a chronic disorder in which a person has high blood sugar, either because the body does not produce enough insulin, or cells do not respond adequately to the insulin that is produced [1]. There are two main types of diabetes: type-I diabetes (T1D), which is characterized by the autoimmune destruction of the insulin-producing cells in the pancreas, and type II diabetes (T2D), which is the most common form and is characterized by a reduced production of insulin and an inability of the body tissues to respond fully to insulin [2].

Diabetes represents one of the most challenging public health problems of the 21st century and is reaching to an epidemic level globally [3]. The total number of people with T2D is expected to increase from 171 million in 2000 to 366 million in 2030 [3]. Unfortunately, the prevalence of T2D has already reached to 366 million worldwide by 2011 according to the international Diabetes Federation (IDF), and the projection is that prevalence of T2D on a global scale could well reach to 530 million people in 2030.[3] T2D related mortalities accounted for 4.6 million deaths in 2011 for people aged 20–79 years, accounting for 8.2% of global all-cause mortality for people in this age group with an estimated rate of one death every seven seconds [4].

Following the global trend there has been a rising tide of T2D and its associated complications in the Arabic speaking countries (East Mediterranean, Arabic peninsula, and Northern Africa) as these regions have some of the highest rates of diabetes in the world [5]. Diabetes prevalence is projected to double over the next two decades in the middle eastern countries [6]. In December 2011, another alarm awakened Arab governments when International Diabetes Federation announced the latest diabetes estimates at the fifth conference held in Dubai [1]. Six of the top 10 countries with the highest prevalence of diabetes (in adults aged 20 to 79 years) are in the Middle East: Kuwait (21.1%), Lebanon (20.2%), Qatar (20.2%), Saudi Arabia (20.0), Bahrain (19.9%) and UAE (19.2%) [1]. In the Arab region, the number of deaths attributed to diabetes is about 170,000 adult people, representing more than 10% of all deaths in the region [1].

In this paper we focus on T2D cases in one of the major cities in the KSA, Al Madinah Al Munawara. The KSA experienced a rapid economic growth over the past 4 decades, which led to a remarkable increase in living standards and adoption of a 'Westernized' lifestyle, characterized by unhealthy dietary patterns, and decreased physical activity [7]. A national survey in 2004 estimated that 23.7% of Saudi adults (age 30-70 years) suffered from T2D, and another 14.1% had impaired fasting glucose [7]. Prevalence of diabetes was significantly higher in urban areas (25.5% versus 19.5% in the rural areas) [8]. The burden of diabetes in KSA is likely to increase and reach disastrous levels, unless a comprehensive epidemic control program is implemented rigorously promoting healthy eating, exercise and active lifestyles, and curbing obesity [9,10]. Family history has a major role in the cause of diabetes. Recent studies in genetic research have also identified the genetic variants linked with T2D [11,12]. Family history of diabetes is also used as a predictor of T2D in population-based screening programs [13]. However, roughly half of the risk of T2D can be attributed to lifestyle.

In a 12-year prospective study in the USA, the risk of diabetes significantly increased among men with a dietary pattern characterized by higher consumption of refined sugar, carbohydrate, red/processed meat, French fries, high-fat dairy products, refined grains, sweets, and desserts, compared to those having a dietary pattern comprising of fresh vegetables and fruits, fish, poultry, and whole grains [14]. Poor dietary habits and obesity are closely linked with T2D and its complications in the USA [15]. While the Arab populations are known to have a genetic predisposition to diabetes, dietary patterns and physical activity play an equally important role in its cause.

A regional study in Qatar found that obesity, family history, and smoking habits were equally associated with diabetes [16]. In the KSA, diabetes, along with hypertension and coronary artery disease has emerged as a major challenge to the health system. The World Health Organization estimates that non-communicable diseases will soon become the principal global cause of morbidity and mortality in KSA [17].

While the risk factors for T2D are well established, there is very little information on the relationships between different types of T2D and potential risk factors. In Saudi Arabia, no population-based study has been attempted to investigate the association between diabetes types independently of the effects of gender, age, citizenship status for grouped data. This study attempts to investigate the association between different types of diabetes and demographic risk factors such as, gender, age and citizenship status among patients who live in Saudi Arabia.

Data Exploration

Data were collected from the primary health care centers (PHCC) of Al Madinah, KSA, from 2009 to 2014. The patients have different types of diabetes: "diabetes during pregnancy & delivery", "diabetes with other complications", "diabetes without complications", or "acetone diabetes." Only a number of demographic factors are available as potential risk factors. These are age groups in 1-4, 5-14, 15-44, and 45+ years, nationality, classified as Saudi and non-Saudi, and gender. Another limitation of the data is that age information is not available for each gender and nationality level. Total number of patients with different types of diabetes is reported for four age groups. Thus we conducted two separate analyses: 1) type of diabetes versus sex and nationality and 2) type of diabetes versus age. Type of diabetes, the response variable is measured on a nominal scale, since there is no natural ordering for the type of diabetes. In our first analysis, gender and nationality are considered as predictors variables and in our second analysis only age is considered as a predictor variable. Data exploration and the analysis have been performed using the R statistical package.

Figure 1 shows the number of patients according to the type of diabetes. It shows that the majority of the patients have diabetes without complications. The next largest category is the patients who have diabetes with other complications. Figure 2 shows that women are more likely to have diabetes than men. Most of the records of diabetes were found in Saudi population as Figure 3 shows. Figure 4 shows that most of the patients who have acetone diabetes or sugar coma are men. Both men and women have diabetes with other complications with approximately 45% and 56% respectively. This result suggests that both men and women are more likely to have diabetes with other complications.

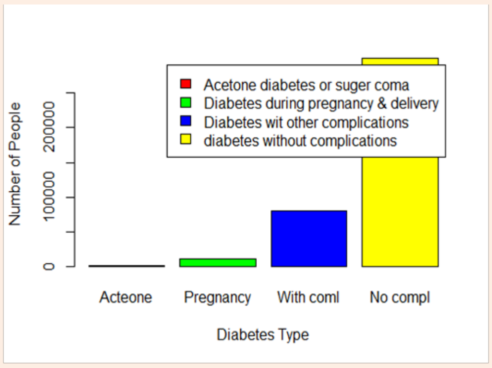

Figure 1: Number of Cases According to Diabetes Type.

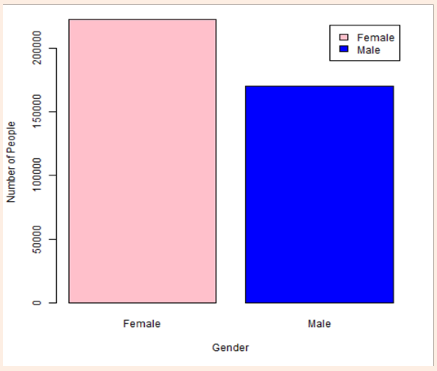

Figure 2: Number of Cases According to Sex.

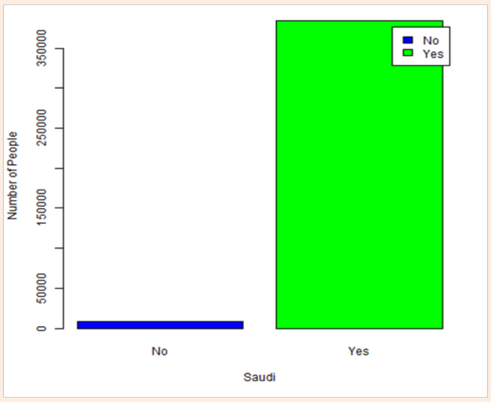

Figure 3: Characteristic of Patients by Citizenship.

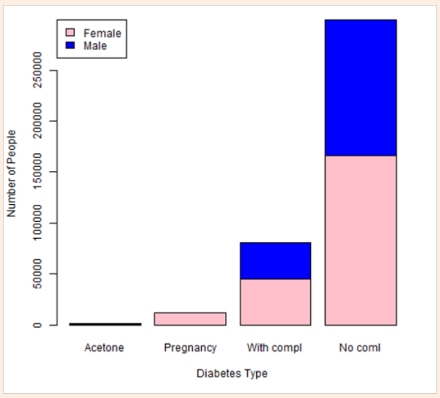

Figure 4: Number of Cases According to Diabetes Type and Gender.

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Models for Multinomial Responses

When response categories fall under more than two categories, it can be modeled using a multinomial distribution. The response, which is the type of diabetes, has four categories: 'diabetes during pregnancy & delivery', 'diabetes with other complications', 'diabetes without complications' and 'acetone diabetes or sugar coma'. Let Y_{ij} represent one of the possible outcomes, which occurs with probability π_{ij}, representing the count in $(i,j)^{th}$ cell.

The multinomial logit model is an extension to the binary logistic regression model for the response with more than two levels measure on nominal scale. The form of the multinomial logit model is similar to the form of the binary logits, but it has two or more logits. The number of logits is one less than the levels of the categorical response. For example, if there are *k* response categories, and the k^{th} categorical response is considered as the reference level, then the multinomial logit model uses *k-1* logits which can be written as:

$$\text{Log} \quad (P(Y=(j \mid x)/(P(Y)=k \mid x)) = X^T\beta_j,\ j=1,2,...,k-1$$

and the probability of being in the j the category can be written as,

$$P(Y=j \mid x) = \frac{exp(X^T\beta_j)}{1+\sum_{j=1}^{k-1}\exp\left(X^T\beta_j\right)}.$$

The response in our data is the type of diabetes, which falls into four nominal categories. A multinomial logit model is the best-suited regression model for the nominal response variable types of diabetes. Dummy coding is considered for all categorical covariates. Thus three multinomial logit modes for the odds of 'diabetes during pregnancy and delivery' (π_1/π_4), 'diabetes with other complications' (π_2/π_4) and 'diabetes without complications' (π_3/π_4) with respect to 'acetone diabetes or sugar coma' respectively can be written as follows:

$$Log\ (\pi_1/\pi_4) = \beta_{01} + \beta_{11}Sex + \beta_{21}nationality \qquad (1)$$

$$Log\ (\pi_2/\pi_4) = \beta_{02} + \beta_{12}Sex + \beta_{22}nationality \qquad (2)$$

$$Log\ (\pi_3/\pi_4) = \beta_{03} + \beta_{13}Sex + \beta_{23}nationality \qquad (3)$$

Here π_i is the probability that the response falls under i^{th} category, *i=1,2,3* representing the first three types of diabetes and π_4 is the probability that the response is the 'acetone diabetes or sugar coma' considered as the reference category.

Diabetes Type versus Gender and Nationality

The effect of gender and nationality on the odds of three diabetes types: 'diabetes during pregnancy and delivery', 'diabetes with other complications', and 'diabetes without complications' with respect to the fourth category 'acetone diabetes or sugar coma' is of interest. Table 1 presents parameter estimates, their standard errors, corresponding z-and p-values of the Wald tests from the multinomial logit model fit to types of diabetes on gender and nationality. These results can be interpreted in terms of odds ratios given in Table 1. For example, the odds of having 'diabetes during pregnancy and delivery' compared to 'acetone diabetes' is 1.59 times higher for Saudi nationals than that of non-Saudi nationals. Further, the findings suggest that the covariates gender and nationality are statistically significant predictors for the odds of the three types of diabetes with respect to the 'acetone diabetes'.

Diabetes Type versus Age

Since age specific information in not available for gender, nationality, and types of diabetes, but only available for types of diabetes, we perform a separate analysis for diabetes type and age. Table 2 presents parameter estimates, their standard errors, corresponding z- and p-values of the Wald tests from the multinomial logit model fit to types of diabetes on age. The odds ratios calculated in Table 2 show that the odds of having any of the three types of diabetes compared to 'acetone diabetes' is higher for the older age groups: 5-14, 15-44, and 45+ while compared to the age group 1-4 years. The results indicate that the odds of having these three types of diabetes compared to 'acetone diabetes' at later stage of the Saudi population is quite high. The findings of this study warrant raising awareness on this major public health issue and educating people in the KSA about active and healthier life style that may help reduce the incidence of T2D in this population.

Table 1: Diabetes Type vs. Gender and Saudi Status.

	Predictors	Coefficients	Standard Error	Z-Value	P-Value	Odds Ratio
Diabetes During Pregnancy & Delivery	Intercept	2.78	0.104	26.64	0	16.18
	Saudi Yes	0.462	0.099	4.63	0	1.59
	Gender Male	-13.01	4.69	-2.78	0.01	0
Diabetes with other Complications	Intercept	3.47	0.096	36.18	0	32.15
	Saudi Yes	1.15	0.09	12.76	0	3.16
	Gender Male	-0.77	0.058	-13.08	0	0.46
Diabetes without Complications	Intercept	4.07	0.095	42.86	0	58.54
	Saudi Yes	1.87	0.089	20.92	0	6.46
	Gender Male	-0.73	0.058	-12.55	0	0.48

Table 2: Diabetes Type vs Age.

	Predictors	Coefficients	Standard Error	Z-Value	P-Value	Odds Ratio
Diabetes During Pregnancy & Delivery	Intercept	-17.12	0.045	-375.49	0	3.60E-08
	Age 5-14	17.54	0.13	134.96	0	4.20E+07
	Age 15-44	19.73	0.055	358.55	0	3.70E+08
	Age 45+	18.91	0.054	347.53	0	1.60E-01
Diabetes with other Complications	Intercept	4.64	0.046	14.622	0	1.00E+02
	Age 5-14	0.42	0.345	1.184	0.24	1.5
	Age 15-44	-0.87	0.321	-2.72	6.50E-03	4.20E-01
	Age 45+	-0.41	0.32	-1.27	2.10E-01	6.70E-01
Diabetes without Complications	Intercept	3.19	0.322	9.901	0	24
	Age 5-14	3.17	0.349	9.089	0	24
	Age 15-44	2.02	0.325	6.214	5.20E-10	7.6
	Age 45+	2.3	0.325	7.088	1.30E-12	10

Conclusion

From the public health point of view, identification of the risk factors for different types of diabetes and implementation of necessary intervention policies are very important. Since the type of diabetes is measured on a nominal scale with four levels, we considered a multinomial logit model to estimate the odds of being in different types of diabetes categories for gender, nationality, and age groups. The multinomial logit model allows a nominal categorical response variable to have more than two levels. We used this model to predict the probabilities of the different possible outcomes of a categorically distributed dependent variable, given a set of independent variables. In addition, the model can give us a clear picture about the effect of the independent variables.

The results from the analysis of the type of diabetes versus gender and nationality show that the odds of having different types of diabetes differ across gender and nationality. Also the results from the analysis of the type of diabetes versus age show that the odds of having different types of diabetes differ across age groups.

One limitation of our study is that the data does not include age specific information for gender and nationality. This led us to conduct a separate analysis to determine the association between the type of diabetes and age group.

This study can be extended by considering more covariate or risk factors, if available. A trend component to the model may also improve the predictability of the model. Due to limitations of the data, these features were not explored in the current research.

Acknowledgement

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Conflict of Interest

None.

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