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Analytical hierarchy process model for severity of risk factors associated with type 2 diabetes

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Type 2 diabetes has been an increasing public health problem with an estimated forecast of 300 million around the world by the year 2025. It places a serious constraint on individual's activities caused by hyperglycemia resulting from defects in insulin secretion, insulin action or both. Although extensive epidemiological researches have shown an association between various risk factors and the development of type 2 diabetes, there has been no research on the measurement or determination of the relative severity of these risk factors regarding their contributions to the incidence and prevalence of type 2 diabetes. In this research, 13 risk factors associated with type 2 diabetes were identified from epidemiological studies. The degree of severity of these risk factors was ascertained by professionals using structured Liket format with 6 choices. The data obtained were used in ranking the risk factors, which assisted in selecting the most contributing risk factors to the development of type 2 diabetes. The result revealed that heredity contributes as high as 0.5388; obesity contributes 0.1038; physical inactivity contributes 0.0230; dietary contributes 0.0230; age contributes 0.1038; IGT contributes 0.1038; and gestational diabetes is 0.1038. This result could serve as input to neural network model.

Key words: Type 2 diabetes, severity, risk factors, analytical hierarchy process, artificial neural network.

INTRODUCTION

Information technology has made appreciable impact in the development of healthcare. Several studies (Palaniappan and Huey, 2006; Isa et al., 2005; Siral and Raof, 2004) have shown significant impact of information and communication technology on healthcare and type 2 diabetes is not left out. In recent times, the number of people suffering from diabetes mellitus is increasing day by day. It constitutes 85 to 90% of all cases of diabetes and it usually occurs in adults over 40 years of age (Boutayeb et al., 2004). Excess global mortality attributable to type 2 diabetes in the year 2000 was estimated at 1 million deaths in developing nations and 1.9 million deaths in developed nations, or 2.8% of all deaths globally (Franks et al., 2007). By the year 2025, the expected number of subjects with type 2 diabetes around the world is 300 million (Lyssenko et al., 2005). In a simple laymen term, diabetes is a chronic lifelong disease characterized by too much sugar in blood resulting from defects in insulin secretion, insulin action, or both, which increase the risks of long-term damage, dysfunction and failure of various organs especially the eyes, kidneys, nerves, heart, gallbladder or blood vessels (Kumari et al., 2010; Patil et al., 2010; Osadolor et al., 2008). Several epidemiological studies (Omolase et al., 2010; Omorogiuwa et al., 2010; Ugoya et al., 2008; Omoregie and Osagie, 2008) have associated various risk factors to the development of type 2 diabetes. Some of the risk factors identified include physical inactivity,

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obesity, heredity, age, ethnicity, dietary, gestational diabetes, alcohol consumption, sleep duration, smoking cigarette, sex, presence of impaired glucose tolerance (IGT), and close marital alliances restricted within a clan.

Although extensive epidemiological researches have shown an association between various risk factors and the development of type 2 diabetes, few researches have investigated which factors is important than other. Current and future forecast for the prevalence of type 2 diabetes, and the increasing need in deciding whether to consider all features or only the most important contributing features suggest the need for research to determine the strength of risk factors associated with development of type 2 diabetes. Another motivation for this research is the increasing importance to identify individuals at high risk of developing type 2 diabetes. Thus, this paper adapts various risk factors identified by epidemiologists and proffer relative strength of association to the development of type 2 diabetes using analytical hierarchy process. One of the most prominent methods in determining relative importance of alternatives in decision-making is Analytical Hierarchy Process (AHP). It uses fundamental scale of absolute numbers, proved in practice and validated by decision problem experiments (Abdullahi and Azman, 2011).

AHP has been used successfully in many fields including health sciences. For instance, Abdullahi and Azman (2011) used AHP framework in identifying sedentary lifestyle contributing approximately 60% to the development of obesity followed by genetics having about 26% and then medical and psychiatric illness having about 14%. Mukherjee and Das (2010) applied AHP in comparing a new blood pump with two competitors based on technical, medical and social requirements. Their research changed the evaluators' perspectives, reduced disagreements, and ended in a reliable evaluation of the pump's performance. Kumar et al. (2009) applied AHP for vendor selection problem of small, medium and large scale. After analysis of the results, they found that for large scale industries, vendor reliability, product quality and vendor experience are the top three vendor selection problems that needs to be taken up on priority for effective vendor selection. In production planning and control related research, Kodali and Chandra (2001) applied AHP to justify total productive maintenance and confer the adequacy of total productive maintenance implementation. According to them, the research could be useful for strategic and operational decisions in reallocating resources and it aid managers in assessing the total productive status quo. AHP has also been used in environmental impact assessment research. Ramanathan (2001) applied AHP for capturing the perceptions of stakeholders on the relative severity of different socio-economic impacts, which could help the authorities in prioritizing their environmental management plan, and help in allocating the budget available for mitigating adverse socio-economic impacts. Similarly, Benjamin (2002) presented findings of a survey of the housing location selection preferences among the staff of Universiti Utara Malaysian. The findings revealed that the most important criteria considered by Universiti Utara Malaysian staff were road facilities, followed by religious centers and cost of living. Thus, this paper focused on determining the strength of risk factors associated with development of type 2 diabetes using AHP. Application of AHP in selecting and ranking risk factors from literatures and experts respectively is first presented. This is followed by computational steps of AHP and the results. Thereafter, summary and conclusion are drawn.

APPLICATION OF AHP IN SELECTING AND RANKING RISK FACTORS

At first instance, eleven risk factors were adopted from epidemiological studies, which were used for pilot study. During the pilot study, two risk factors were additionally identified by the respondents. This brought the number of risk factors to thirteen. They are heredity, obesity, physical inactivity, dietary, age, ethnicity, sleep duration, smoking cigarette, sex, presence of impaired glucose tolerance, close marital alliances restricted within a clan, alcohol consumption and gestational diabetes. These risk factors are decomposed as represented in Figure 1.

In order to ascertain the degree of severity of these risk factors, views of professionals were collected using structured Likert format with six choices as shown in Table 1. To achieve pertinent information, certain inclusion criteria were imposed on the selection of 408 respondents. All the participants were qualified medical doctors with some consultants in diabetes and endocrinology. This criterion ensured that participants have adequate knowledge on diabetes. Data gathered from research instrument within North East of Nigeria are as summarized for easy understanding and interpretation as shown in Table 2.

Table 2 revealed that 192 of the respondents ranked heredity as absolute (highest) while none of the respondent ranked it as equally neutral. Similarly, 336 of the respondents ranked obesity as very strong (highest) risk factor while none of the respondents ranked it as moderate or equally neutral, and so forth. Table 3 presents the summary of Table 2 by selecting the highest value as a yardstick to adjudicate the rating of each risk factor.

Further analysis revealed that only one risk factor was ranked absolute, four ranked very strong, two strong, three moderate and three equally neural. Table 4 presents these figures. Risk factors ranked absolute, very strong, and strong were compared pair-wise to form a judgmental matrix.

RESULTS

A pair-wise comparism matrix, denoted by 'A', was formed as follows

$$A = \begin{pmatrix} 1 & 9 & 9 & 9 & 9 & 9 & 9 \\ \frac{1}{9} & 1 & 7 & 7 & 1 & 1 & 1 \\ \frac{1}{9} & \frac{1}{7} & 1 & 1 & \frac{1}{7} & \frac{1}{7} & \frac{1}{7} \\ \frac{1}{9} & \frac{1}{7} & 1 & 1 & \frac{1}{7} & \frac{1}{7} & \frac{1}{7} \\ \frac{1}{9} & 1 & 7 & 7 & 1 & 1 & 1 \\ \frac{1}{9} & 1 & 7 & 7 & 1 & 1 & 1 \\ \frac{1}{9} & 1 & 7 & 7 & 1 & 1 & 1 \end{pmatrix}$$

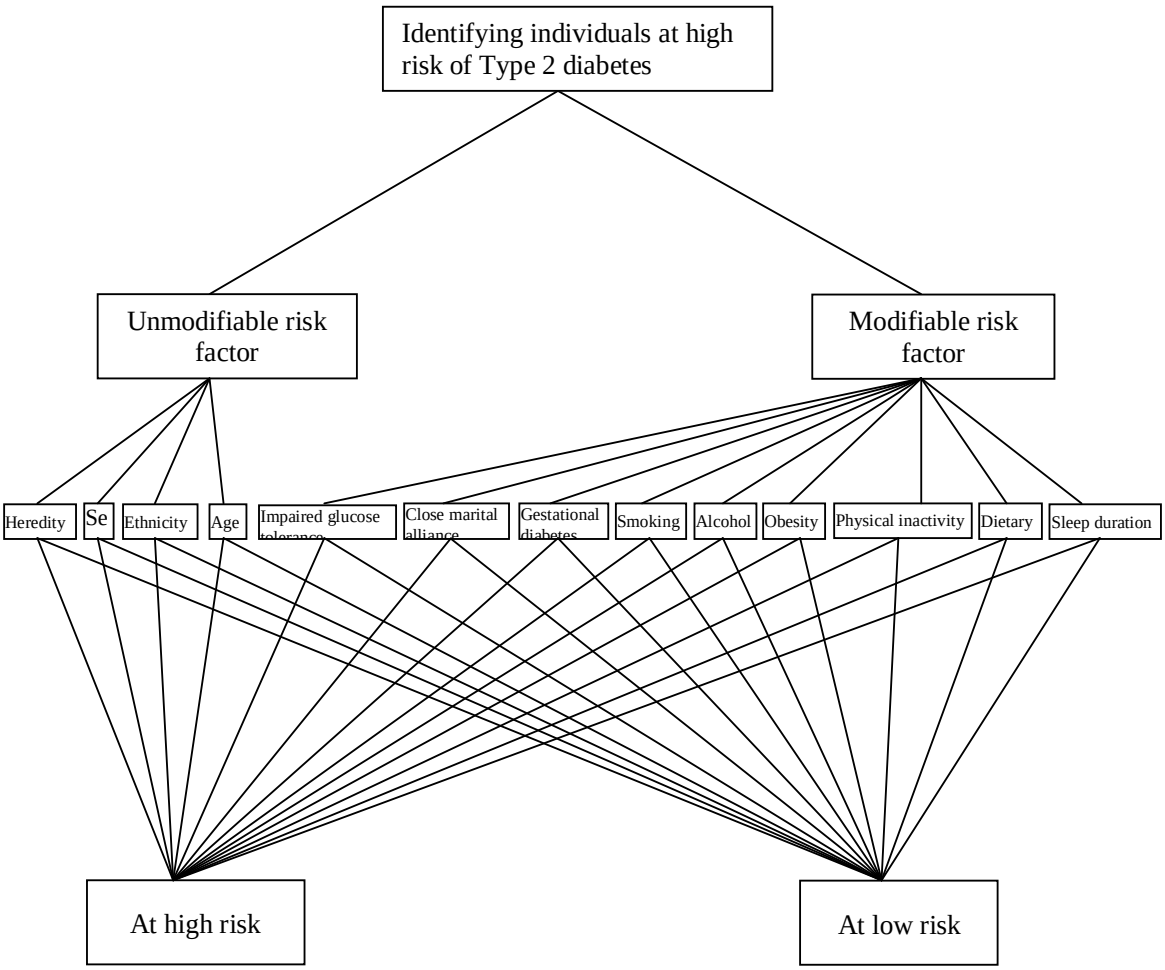

Figure 1. Schematic presentation of the AHP model.

Table 1. Saaty's relative rating scale.

S. No	Rating	Relative
1	Absolute	09
2	Very strong	07
3	Strong	05
4	Moderate	03
5	Neutral	01

Adopted from Saaty (1980).

The relative weight matrix was determined from 'A' by normalizing into a new matrix 'N'. The process requires dividing the elements of each column by the sum of the elements of the same column.

$$N = \begin{pmatrix} 0.60 & 0.68 & 0.23 & 0.23 & 0.68 & 0.68 & 0.68 \\ 0.07 & 0.08 & 0.18 & 0.18 & 0.08 & 0.08 & 0.08 \\ 0.07 & 0.01 & 0.03 & 0.03 & 0.01 & 0.01 & 0.01 \\ 0.07 & 0.01 & 0.03 & 0.03 & 0.01 & 0.01 & 0.01 \\ 0.07 & 0.08 & 0.18 & 0.18 & 0.08 & 0.08 & 0.08 \\ 0.07 & 0.08 & 0.18 & 0.18 & 0.08 & 0.08 & 0.08 \\ 0.07 & 0.08 & 0.18 & 0.18 & 0.08 & 0.08 & 0.08 \end{pmatrix}$$

The relative contributions of the risk factors to the development of type 2 diabetes were determined by computing average of each row of matrix N to form matrix O.

$$O = \begin{pmatrix} 0.5388 \\ 0.1038 \\ 0.0230 \\ 0.0230 \\ 0.1038 \\ 0.1038 \\ 0.1038 \end{pmatrix}$$

The level of inconsistency is acceptable since consistency ratio is 0, which is less than 0.1. Matrix O is represented in Table 5. This result revealed that relative contribution of heredity to the development of type 2 diabetes is 53.88%, which is within the same range as stated by Kaprio et al. (1992) that heritable factor contribute as high as 40%.

SUMMARY AND CONCLUSION

In this paper, AHP was used to determine the relative

Table 2. Data obtained from respondents.

Risk factor	Risk rating				
	Absolute	Very strong	Strong	Moderate	Neutral
Heredity	192	168	36	12	-
Obesity	48	336	24	-	-
Physical inactivity	86	74	146	74	28
Dietary	24	116	216	28	24
Age	24	180	60	96	48
Ethnicity	-	72	48	120	168
Sleep duration	-	48	76	104	180
Sex	-	24	84	156	144
Impaired glucose tolerance	96	252	24	24	12
Close marital alliance	-	48	72	60	228
Smoking	12	120	108	156	12
Alcohol consumption	12	132	84	180	-
Gestational diabetes	48	216	108	24	12

Table 3. Summary of data from professionals.

Risk factor	Rating	Relative
Heredity	Absolute	09
Obesity	Very strong risk	07
Physical inactivity	Strong	05
Dietary	Strong	05
Age	Very strong risk	07
Ethnicity	Neutral risk	01
Sleep duration	Neutral risk	01
Sex	Moderate	03
Impaired glucose tolerance	Very strong risk	07
Close marital alliance	Neutral risk	01
Smoking	Moderate risk	03
Alcohol consumption	Moderate risk	03
Gestational diabetes	Very strong risk	07

Table 4. Summary of the ranked risk factors with their frequency.

Rating	Risk factors	Frequency	Relative
Absolute	Heredity	1	09
Very strong	Obesity, age, impaired glucose tolerance, gestational diabetes	4	07
Strong	Physical inactivity, dietary	2	05
Moderate	Sex, alcohol, smoking	3	03
Neutral	Ethnicity, sleep duration, close marital	3	01

severity of risk factors to the development of Type 2 diabetes. In order to ascertain the degree of severity of the risk factors, views of professionals were collected using structured Likert format. The data obtained were used to rank the risk factors as follows: Heredity as absolute; Obesity, Age, IGT gestational diabetes as very strong; Physical inactivity and dietary as strong; Sex, Alcohol consumption and Smoking as moderate; while

Table 5. Relative contributions of risk factors to the development of type 2 diabetes.

S/No	Risk factor	Relative contribution	Ranking
1	Heredity	0.5388	I
2	Obesity	0.1038	II
3	Age	0.1038	II
4	Impaired glucose tolerance	0.1038	II
5	Gestational diabetes	0.1038	II
6	Physical inactivity	0.0230	III
7	Dietary	0.0230	III

Ethnicity, Sleep duration and Close marital as equally neutral. Based on the ranking, pair-wise comparison matrix was formed using risk factors that were ranked as absolute, very strong and strong and their strength of association was determined using computational steps of AHP. The result revealed that Heredity contributes as high as 0.5388, Obesity contributes 0.1038, Physical inactivity contributes 0.0230, Dietary contributes 0.0230, Age contributes 0.1038, IGT contributes 0.1038 and Gestational diabetes is 0.1038. These relative contributions to the development of Type 2 diabetes could be part of input features in addition to the rated evaluation of an individual that would predict individuals at high risk of developing Type 2 diabetes. The results of this research will serve as input to neural network model.

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