The living experience of a diabetic adult in India using Fuzzy Relational Maps (FRM)

A.Victor Devadoss[1], **V.Susanna Mystica**[2]
1 Department of Mathematics, Loyola College, Chennai - 600 034, India, hanivictor@ymail.com
2 Department Of Bio-Technology, St.Joseph's College Of Engineering , Chennai-119 , India, susivictor@ymail.com

Abstract - In *this paper we find the relation between the risk factors and the symptoms of diabetes among adults using Fuzzy Relational Maps. Diabetes is a problem with the body's fuel system. It is caused by lack of insulin, a hormone made in the pancreas that is essential for getting energy from food. There are two kinds of diabetes: type 1 and type 2. Type 2 diabetes accounts for 90% of all diabetes cases. In this research paper we examine the adults experiencing diabetes using fuzzy relational maps. We have arrived at interesting conclusions. This paper has four sections. In section one we recall the definition of fuzzy relational maps. Section two is devoted to the description of the problem. Section three is devoted to the adaptation of the fuzzy relation maps to the Diabetic problem. In section four we give the conclusions based on our study.*

Keywords: Fuzzy Relational Maps (FRM), Risk factors, Symptoms , Type2 Diabetic, Adult, Urban, rural.

1. Introduction:

The new notion called Fuzzy Relational Maps (FRMs) was introduced by Dr. W.B.Vasantha and Yasmin Sultana in the year 2000. In FRMs we divide the very casual associations into two disjoint units, like for example the relation between a teacher and a student or relation; between an employee and an employer or a relation; between the parent and the child in the case of school dropouts and so on. In these situations we see that we can bring out the casual relations existing between an employee and employer or parent and child and so on. Thus for us to define a FRM we need a domain space and a range space which are disjoint in the sense of concepts. We further assume no intermediate relations exist within the domain and the range space. The number of elements in the range space need not in general be equal to the number of elements in the domain space.

1.1. Fuzzy Relational Maps (FRMs)

In our discussion the elements of the domain space are taken from the real vector space of dimension n and that of the range space are real vectors from the vector space of dimension m (m in general need not be equal to n). We denote by R the set of nodes $R_1, \ldots, R_m$ of the range space, where $R_i = \{(x_1, x_2, \ldots, x_m) / x_j = 0 \text{ or } 1\}$ for i = 1, … ,m. If $x_i = 1$ it means that the node R_i is in the ON state and if $x_i = 0$ it means that the node R_i is in the OFF state. Similarly D denotes the nodes $D_1,\ldots,D_n$ of the domain space where $D_i = \{(x_1,\ldots, x_n) / x_j = 0 \text{ or } 1\}$ for i = 1, …, n. If $x_i = 1$, it means that the node D_i is in the on state and if $x_i = 0$ it means that the node D_i is in the off state. A FRM is a directed graph or a map from D to R with concepts like policies or events etc. as nodes and causalities as edges. It represents casual relations between spaces D and R. Let D_i and R_j denote the two nodes of an FRM. The directed edge from D to R denotes the casuality of D on R , called relations. Every edge in the FRM is weighted with a number in the set {0, 1}.

Let $e_{i\,j}$ be the weight of the edge $D_i R_j$, $e_{i\,j} \in \{0.1\}$. The weight of the edge D_iR_j is positive if increase in D_i implies increase in R_j or decrease in D_i implies decrease in R_j. i.e. casuality of D_i on R_j is 1. If $e_{i\,j} = 0$ then D_i does not have any effect on R_j. We do not discuss the cases when increase in D_i implies decrease in R_j or decrease in D_i implies increase in R_j. When the nodes of the FRM are fuzzy sets, then they are called fuzzy nodes, FRMs with edge weights {0, 1) are called simple FRMs. Let $D_1, \ldots, D_n$ be the nodes of the domain space D of an FRM and $R_1, \ldots, R_m$ be the nodes of the range space R of an FRM.

Let the matrix E be defined as $E = (e_{i\,j})$ where $e_{i\,j} \in \{0, 1\}$; is the weight of the directed edge D_iR_j (or R_jD_i), E is called the relational matrix of the FRM. It is pertinent to mention here that unlike the FCMs, the FRMs can be a rectangular matrix; with rows corresponding to the domain space and columns corresponding to the range space. This is one of the marked difference between FRMs and FCMs.

Let $D_1, \ldots, D_n$ and $R_1,\ldots,R_m$ be the nodes of an FRM. Let D_iR_j (or $R_j D_i$) be the edges of an FRM, j = 1, …, m, i = 1, …, n. The edges form a directed cycle if it possesses a directed cycle. An FRM is said to be acycle if it does not posses any directed cycle.

An FRM with cycles is said to have a feed back when there is a feed back in the FRM, i.e. when the casual relations flow through a cycle in a revolutionary manner the FRM is called a dynamical system.

Let D_iR_j (or R_jD_i), $1 \le j \le m$, $1 \le i \le n$. When R_j (or D_i) is switched on and if casuality flows through edges of the cycle and if it again causes $R_i(D_j)$, we say that the dynamical system goes round and round. This is true for any node R_i (or D_j) for $1 \le i \le m$, (or $1 \le j \le n$). The equilibrium state of this dynamical system is called the hidden pattern. If the equilibrium state of the dynamical system is a unique state vector, then it is called a fixed point. Consider an FRM with R_1, …, R_m and D_1, …, D_n as nodes. For example let us start the dynamical system by switching on R_1 or D_1. Let us assume that the FRM settles down with R_1 and R_m (or D_1 and D_n) on i.e. the state vector remains as (10…01) in R [or (10…01) in D], this state vector is called the fixed point. If the FRM settles down with a state vector repeating in the form $A_1 \rightarrow A_2 \rightarrow \ldots \rightarrow A_i \rightarrow A_1$ or ($B_1 \rightarrow B_2 \rightarrow \ldots \rightarrow B_i \rightarrow B_1$) then this equilibrium is called a limit cycle.

Methods of determination of hidden pattern.

Let R_1, …, R_m and D_1, …, D_n be the nodes of a FRM with feed back. Let E be the $n \times m$ relational matrix. Let us find a hidden pattern when D_1 is switched on i.e. when an input is given as vector A_1= (1000...0) in D the data should pass through the relational matrix E. This is done by multiplying A_1 with the relational matrix E. Let $A_1E = (r_1, \ldots, r_m)$ after thresholding and updating the resultant vector (say B) belongs to R. Now we pass on B into E^T and obtain BE^T. After thresholding and updating BE^T we see the resultant vector say A_2 belongs to D. This procedure is repeated till we get a limit cycle or a fixed point.

2. Description of the problem

2.1. Intoduction

Diabetes is a problem with the body's fuel system. It is caused by lack of insulin, a hormone made in the pancreas (an organ that secretes enzymes needed for digestion) that is essential for getting energy from food. There are two kinds of diabetes:

In type 1 diabetes, which usually starts in children, the body stops making insulin completely.

In type 2 diabetes, also called adult-onset diabetes, the body still making insulin, but cannot use it properly.

Most adults with diabetes have type 2; in fact, type 2 diabetes accounts for 90% of all diabetes cases.

2.2. Facts about Diabetes in Adults

- Diabetes is not contagious disease.
- Diabetes has a genetic component and is greatly influenced by environmental factors related to Lifestyle
- Diabetes contributes to the deaths
- Diabetes often leads to blindness, heart and blood vessel disease, strokes, kidney failure, amputations, and nerve damage.
- Uncontrolled diabetes can complicate pregnancy and put a mother at risk for having a baby with birth defects.
- India has the largest number of people with diabetes, roughly around 35 million. of this approximately13 million still remain undetected.
- Indians develop diabetes almost one decade earlier than whites. This could be due to the fact that Indians have a low-risk threshold for many of the acquired diabetic factors, like obesity.
- In India, diabetes is more prevalent among males than females(ratio being 1:0.6)
- Amongst diabetics, 4.6% urban and 1.9% of rural population had a direct relation with diabetes.
- Diabetes was twice as frequent amongst vegetarians as non-vegetarians. A higher prevalence of diabetes in urban India
- Expatriate Indians tend to be more overweight, have stronger generic factor, being emigrants, live and marry amongst close relatives and thus have a much higher prevalence of diabetes.
- In India, the average male weight is 55kg and the female, 48.5 kg. Among those detected to be diabetic, 31.5% were overweight. It would seem that leanness does not have negative correlation with diabetes in a country like India.
- The recent World Health Organization report suggests that over 19% of the world's diabetic population currently resides in India. This translates to over 35 million diabetic subjects, and these numbers are projected to increase to nearly 80 million by 2030.
- Obesity raises the risk for diabetes by as much as 93%, and an inactive lifestyle can raise it by as much as 25%.

2.3. Diabetes shifts base in India

Midway through their journey into urbanization, suburbs and small towns are finding themselves in precarious health. Results of a cohort study presented at an international conference recently shows that a higher number of people living in semi-urban areas have diabetes and hypertension when compared to those in cities. Health care experts are concerned that a greater number of people in these areas now run the risk of cardiac arrests, renal failures and strokes. Says Dr. S. Thanikachalam lead investigator of the study and cardiology head at Sri Ramachandra university, who presented the results at an international conference in the city recently: " We found that nearly 22.2% of people in semi-urban areas have diabetes compared to 17.5% in urban and 14.5% in rural areas. Similarly, the number of people with hypertension was 26.4% in suburban areas compared to 17.3% in urban and 17.9% in the rural population." The number of people with prediabetic and pre-hypertensive conditions was also found to be higher in semi-urban areas. Here is the logic: Suburbs and small towns have moved away from the routine physical exertions of villagers and neither do they have the awareness and wherewithal for an organized exercise regime like gymnasia.

The study, funded by the department of Science and Technology screened 6,000 people in Chennai, Tiruvallur and Kancheepuram. "We found 43.3% of people with abnormal glucose metabolism, 75.3% with abnormal lipid profiles and 52% with high blood pressure. Though only a person with blood pressure higher than 140/90 is considered hypertensive, people with 135/85 also require intervention. So, at least 50% of our population would require intervention in one form or another," says Dr. Thanikachalam. State health secretary VK Subburaj says the government is seized of the matter. "We have programmes like door-to-door screening of people. We have been working out new awareness and prevention strategies", he said.

Another disturbing trend the study revealed was that nearly 80% of the people had shown signs of physiological distress, including anxiety, stress or depression. "It was due to various factors including loss of a family member, financial problems or even other emotional issues. We have adequate studies that prove How lack of good mental health can trigger a series of non-communicable diseases. We think it is necessary to have a series of problems including counseling for such people," he said. Now 'rich man's diseases' come calling on city slums

Despite the health department's ambitious project to provide health for all, a study by a city based hospital and research centre shows how poverty has pushed Chennai's slum dwellers into a series of health problems and chronic disorders. The study has generated interest among healthcare experts particularly because many feel the city's epidemic pattern of diabetes is beginning to see a change. A study by MV Hospital for diabetes led by Dr. Vijay Vishwanathan, which screened over 900 people, showed that at least 17.2% of them had respiratory illness and 13.5% had other infections. Anemia was high among women of all age groups and many children were found to be underweight. "In Chennai, more than 25% of the total population are slum dwellers. About 40% of this slum population lives along the rivers and canals and the rest are on the pavements. We saw how slums are largely neglected in terms of provision of healthcare facilities," Says Dr. Vijay Vishwanathan. His team carried out the study to explore the living conditions and determining the health related problems that affect the underprivileged section of the urban population from all parts of Chennai. The study published in the Indian Journal of Community Medicine got 326 men and 574 women to answer an questionnaire covering socio-demographic details, housing and environmental details, health problems, and behavior, They were then taken to a hospital for clinical examination.

"At least 48% had no access to safe drinking water and 66% had no toilets. About 53% lived in temporary shelter." Said Shabana Tharkar, Who did the study along with Dr. Vijay. But what makes their condition worse is that in addition to malnutrition and communicable diseases, their modified diet has led to increase in blood sugar. A parallel study by the Madras Diabetes Research Foundation has shown that the incidence of diabetes in Chennai slums has gone up by 134% in the last ten years. The Dr. V. Mohan of Madras Diabetes Research Foundation says the epidemic pattern of lifestyle disorders is beginning to see a change within cities. "I term the causes as influenza or sedentary, "he said. "Diabetes was once called the rich man's disease. In 10 years, it is likely to become the disease of the poor. And we are seeing differences even within the city. Our study has shown a slowdown in the incidence of diabetes in the middle and upper middle class because they are aware and they can afford exercises. Those in slum dwellers have two-wheelers instead of bicycles. The lack of physical activity and consumption of packaged foods and aerated drinks are showing on their health. "says Dr. Mohan.

2.4. The high risk factors for developing Diabetes

Type 2 diabetes affects all types of people. However, there are factors that can put anyone at higher risk for developing the diabetic are

- Being overweight (body-mass index of 25+)
- Carrying fat around the waist and stomach
- Being sedentary

- Being more than 45 years old (being over 65 increases risk even further)
- Having a family history of type 2 diabetes
- Having gestational diabetes or having a baby that weighed 9 lbs or more
- Being of Indian, or Native Indian descent
- Having a low high-density lipoprotein (HDL) cholesterol level (less than 35)
- Having a high triglyceride level (250 or above)
- Having high blood pressure (140/90 mm/Hg or higher)

Type 2 diabetes used to be quite rare before middle age and people living in the rural areas in India but now affects more and more young people who are overweight. Being overweight, even as a child or teenager is a significant risk factor for developing diabetes as an adult.

2.5. The Symptoms of Diabetes

Diabetes in adults may start slowly. In fact, millions of people don't even know they have it.

They may just feel very tired at first, then later may have these symptoms:

Urinating more than usual, as the body tries to get rid of the extra sugar in the blood, Feeling unusually thirsty, because the body needs to replace the lost fluid, Nausea, Blurred vision, Feeling hungry while losing weight, Frequent infections, Skin sores that won't heal. It's important to remember that diabetes symptoms may not be the same for everyone. The symptoms of type 2 diabetes may come on gradually. Some people may have no symptoms at all. Many people have type 2 diabetes and don't know it. Untreated diabetes can cause serious health problems, such as blindness, heart and blood vessel damage, and permanent nerve damage. In this paper, we give an algebraic approach to the Diabetic problem faced by an adult. This study is significant because most of the adults in India can adopt the same procedure. All South Asians in general and Indians in particular are prone to diabetes. Thus all Indians above the age 25 years ought to be tested for diabetes. By knowing this age group an adult least can take steps to treat himself. This linguistic questionnaire was used to obtain the attributes and using these attributes and the opinion of the experts we have used FRM to analyze the problem.

3. Adoption of FRM model to study about Type2 Diabetic Problem

We have made a sample survey of around 120 people living in Chennai(Patients of M.V. Hospital for Diabetes, Royapettah). They were interviewed using a linguistic questionnaire. The Fuzzy concepts, i.e. attributes are first given in the form of matrix relational equations and then solved. In this paper we use this method to find who the victims of Diabetes are. The following risk factors are the developing condition for diabetes and taken as the attributes of our study

3.1. Attributes Related to the risk factors

The domain space G connected with the risk factors are given by $G = \{G_1, \ldots, G_{10}\}$

G_1 : Carrying fat around the waist and stomach

G_2 : Being sedentary

G_3 : Being more than 45 years old

G_4 : Having a family history of type 2 diabetes

G_5: Having gestational diabetes or having a baby that weighed 9 lbs or more

G_6 : Being of Indian, or Native Indian descent

G_7 : Having a low high-density lipoprotein (HDL) cholesterol level less than 35)

G_8 : Having a high triglyceride level (250 or above)

G_9 : Having high blood pressure (140/90 mm/Hg or higher)

G_{10}: Being overweight (body-mass index of 25+)

3.2. Attributes Related to the Symptoms

The Range space S connected with the symptoms are given by $S=\{S_1,\ldots S_7\}$

S_1: Frequent urination

S_2: Excessive thirst

S_3: Nausea

S_4: Blurring vision

S_5: Extreme hunger and losing weight

S_6: Frequent infections

S_7: Skin sores that won't heal

Now using the expert's opinion. We have the following relation matrix by taking Risk factors $G_1 \ldots G_{10}$ as the rows and Symptoms $S_1, \ldots\ldots, S_7$ as the columns.

3.3. First Experts Opinion

The opinion of the first expert is a Diabetic patient from urban and is given vital importance. His opinion is transformed into the Fuzzy Relational matrix P_1 given by

$$P_1 = \begin{array}{c} \\ G_1 \\ G_2 \\ G_3 \\ G_4 \\ G_5 \\ G_6 \\ G_7 \\ G_8 \\ G_9 \\ G_{10} \end{array} \begin{array}{c} \begin{array}{ccccccc} S_1 & S_2 & S_3 & S_4 & S_5 & S_6 & S_7 \end{array} \\ \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 1 & 1 \\ 1 & 0 & 1 & 0 & 1 & 0 & 0 \\ 1 & 1 & 1 & 0 & 1 & 1 & 0 \\ 1 & 0 & 0 & 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 & 1 & 1 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 1 \\ 1 & 1 & 0 & 0 & 0 & 1 & 0 \\ 1 & 0 & 1 & 0 & 0 & 0 & 0 \end{bmatrix} \end{array}$$

The hidden pattern of the state vector X = (0 0 01 0 0 0 0 0 0) is obtained by the following method:

$XP_1 \hookrightarrow (1\ 1\ 1\ 0\ 1\ 1\ 0) = Y$

$YP_1^T \hookrightarrow (1\ 1\ 1\ \ 1\ 1\ 1\ 1\ 1\ 1\ 1) = X_1$

$X_1P_1 \hookrightarrow (\ 1\ 1\ \ 1\ 1\ 1\ 1\ 1\ ) = Y_1$

(Where $\hookrightarrow$ denotes the resultant vector after thresholding and updating)

When we take G_4 in the ON state (i.e. Having a family history of type 2 diabetes) and all other attributes to be in the off state. We see the effect of X on the dynamical system P_1 is a fixed point given by the binary pair

{(1 1 1 1 1 1 1 1 1 1), (1 1 1 1 1 1)}.

When we are having a family history of type 2 diabetes node alone in the on state we get say X = (1 1 1 1 1 1)

The resultant to be the fixed point given by the binary pair {(1 1 1 1 1 1 1 1 1 1), (1 1 1 1 1 1)}.

When the on state is taken as node G_4 we see the hidden pattern is the fixed point which is the same binary pair, which makes all the nodes to be in the on state in the domain space and also makes all the nodes in the range space to be in the on state.

3.4. Second Experts Opinion

The opinion of the second expert who happens to be a Diabetic patient from rural area and his opinion is transformed into the Fuzzy Relational matrix P_2 is given by:

$$P_2 = \begin{array}{c} \\ G_1 \\ G_2 \\ G_3 \\ G_4 \\ G_5 \\ G_6 \\ G_7 \\ G_8 \\ G_9 \\ G_{10} \end{array} \begin{array}{c} \begin{array}{ccccccc} S_1 & S_2 & S_3 & S_4 & S_5 & S_6 & S_7 \end{array} \\ \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 \end{bmatrix} \end{array}$$

The hidden pattern of the state vector X = (0 0 01 0 0 0 0 0 0) is obtained by the following method:

$XP_2 \hookrightarrow (0\ 0\ 1\ 0\ 0\ 0\ 0) = Y$

$YP_2^T \hookrightarrow (0\ 0\ 0\ \ 1\ 0\ 0\ 0\ 0\ 0\ 1) = X_1$

$X_1P_2 \hookrightarrow (0\ 0\ 1\ 0\ 0\ 0\ 0) = Y_1$

$Y_1P_2^T \hookrightarrow (0\ 0\ 0\ \ 1\ 0\ 0\ 0\ 0\ 0\ 1) = X_1$

When we take G_4 in the ON state (i.e. Having a family history of type 2 diabetes) and all other attributes to be in the off state. We see the effect of X on the dynamical system P_1 is a fixed point given by the binary pair {(0 0 0 1 0 0 0 0 0 1), (0 0 1 0 0 0 0)}. Since the working is time consuming, a C program is formulated for finding the hidden pattern.

4. Conclusions and Suggestions

The cause of diabetes continues to be a mystery, although both genetics and environmental factors such as obesity and lack of exercise appear to play roles. The principal reason for

escalating diabetes and regional disparities appears to be rapidly occurring socioeconomic changes and affluence associated with dietary excess and reduced physical activity. Chennai showed a steady increase in the prevalence of diabetes in the urban population. The major observation of the study had been the low amount of physical activity in the urban population in India is the main cause. Increasing urbanisation tends to lead to lower physical activity worldwide. The impact of urbanisation and its influence on life style has been the cause of diabetes.

Early identification of the high risk individuals would help in taking appropriate intervention in the form of dietary changes and increasing physical activity, thus helping to prevent, or at least delay, the onset of diabetes. This means that identification of at risk individuals is extremely important to prevent diabetes in India. The following steps are suggested to prevent diabetes.

- Watch for and treat symptoms of low blood sugar, which may be a medication side effect
- Watch out for early signs of complications such as problems with eyes, feet, skin and kidneys
- It's important to remember that diabetes symptoms may not be the same for everyone
- The symptoms of type 2 diabetes may come on gradually. Some people may have no symptoms at all. Many people have type 2 diabetes and don't know it.
- Untreated diabetes can cause serious health problems, such as blindness, heart and blood vessel damage, and permanent nerve damage.
- Seeing doctor regularly for checkups and a discussion of risk for diabetes is key to staying healthy.
- Eat in a way that keeps blood sugar as steady as possible
- Lose weight if necessary
- Test blood sugar correctly
- Learn to take insulin shots

Start a fitness program

5. References

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