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Causative Factors of Gestational Diabetics in Women – An Analysis on the Consequential Impacts using LASFCM

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Abstract

Pregnancy is the typical stage in every life cycle of woman where many biochemical and physiological changes take place in all the systems. The adaptation of these changes by the human body differs from one individual to another and it may result in many threats. Gestational Diabetics (GD) is one of the serious threats faced by women during pregnancy. The outbreak of GD is the resultant of several factors which are categorized as genetic, environmental, social and behavioural. The mitigation of this diabetic condition is very essential as it affects the foetus and the mother. The consequential impacts of the factors of GD have to be determined to initiate the preventive measures and to devise the curative medications in accordance to it. This paper introduces the concept of linguistic average super fuzzy cognitive map (LASFCM) which makes use of experts' opinion in terms of linguistic variables to find the substantial outbreak of GD.

Keywords: Gestational Diabetics, LASFCM, Linguistic variable, fuzzy cognitive map

Mathematics Subject Classification (2010): 90C70

1. Introduction

Mathematical Modelling of Medical problems is gaining greater significance for past decades and the use of different mathematical tools

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and concepts play an imperative role in drawing inferences of the diseases and its impacts. One such extensive mathematical instrument is Cognitive maps introduced by Robert Axelrod in 1976.[1] A cognitive map is a simple oriented pictorial representation with vertices (nodes) and arcs (edges). The vertices symbolize the factors considered for study and analysis; connected by directed edges if there exists a relation. The weights of the edges are quantified by the values -1,0,1 if the relation between nodes have negative impact, no impact and positive impact respectively.

Later in 1986 Kosko [6] extended Cognitive Maps to Fuzzy Cognitive Maps (FCM) in which the weights of the edges are quantified by the values [-1,1]. In FCM, the oriented pictorial representation and the association matrix is formulated with the help of experts, but in recent times Super fuzzy cognitive maps (SFCM) are used for decision making, in which n experts work on a problem to form an integrated dynamical system. The same procedure of finding the hidden pattern in FCM is also used in SFCM.[6] The method of SFCM is then extended to Average SFCM (ASFCM). On profound analysis the experts give their feedback in terms of numeric values which is not much realistic. But in this research work ASFCM[8] is modified into linguistic ASFCM (LASFCM) in which the experts give their feedback in the form of linguistic variable, which is then quantified in terms of hexagonal fuzzy numbers. This type of linguistic representation is more pragmatic and rational which has made it practically feasible in making sensible decisions.

In this research work of determining the prime causative factor of GD, the method of LASFCM is used. The article is structured as follows: section 2 briefs the different factors of GD; section 3 comprises of preliminary definitions; section 4 presents the proposed methodology; section 5 adapts the methodology to the problem considered; section 6 discusses the results.

2. Causative Factors of Gestational Diabetics

Gestational Diabetics is not caused by just one factor rather the cause of it differs from one victim to another. The consequential impacts of several factors on ones functioning system of insulin secretion result in GD. The researchers out of their profound analysis have stated the following causative factors and the sub factors.[2, 3, 4, 5]

3. Preliminaries

This section contains the basic definitions pertaining to this research work.

Table 1: Causative Factors of GD

Factor	Sub-facor
Genetic Factors:	Member of Ethnic group Prediabetic history Genotypic analyses
Environmental Factors:	Increased bodyweight Age > 25 Hormonal changes
Behavioural Factors:	Lack of exercise Imbalanced Diet Unhealthy life style

Definition 3.1. *A fuzzy set A is a subset of the universal set X is the set of all ordered pair* $(x, \mu_A(x))$ *where x is an element and* $\mu_A(x)$ *is the membership value of x,the membership function is defined as* $\mu_A : X \rightarrow [0, 1]$.

Definition 3.2. [7] *Fuzzy Cognitive Map (FCM) is an oriented pictorial representation of the association that exists between vertices in terms of arcs.*

Definition 3.3. *The stability state attained by a vector say* C_i*, i = 1, 2, ... n at time t in a dynamical system is called as hidden pattern. The distinctive state vector is the fixed point.*

Definition 3.4. *The FCM settles down with a state vector repeating of the form* $A_1 \rightarrow A_2 \rightarrow A_3 \rightarrow \ldots A_i$*. A sequence of FCM states keeps repeating indefinitely. This sequence is known as a limit cycle.*

Definition 3.5. *Linguistic Variable is a variable which takes linguistic values rather numeric.*

Definition 3.6. *A hexagonal fuzzy number is specified by 6 – tuples,* $H = (a1, a2, a3, a4, a5, a6)$ *such that all* $ai's$ *are real numbers and* $a1 \leq a2 \leq a3 \leq a4 \leq a5 \leq a6$ *where the membership function is*

$$\mu_{\tilde{A}}(x) = \begin{cases} \frac{1}{2}\frac{x-a1}{a2-a1} & a1 \leq x \leq a \\ \frac{1}{2} + \frac{1}{2}\frac{x}{a3-a2} & a2 \leq x \leq a3 \\ 1 & a3 \leq x \leq a4 \\ 1 - \frac{1}{2}\frac{x-a4}{a5-a4} & a4 \leq x \leq a5 \\ \frac{1}{2}\frac{a5-x}{a6-a5} & a5 \leq x \leq a6 \\ 0 & otherwise \end{cases}$$

Definition 3.7. *Hexagonal quantification of linguistic terminologies:*

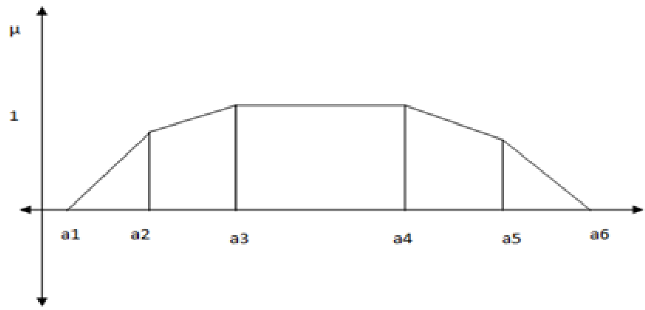

Figure 1: Membership Function of Hexagonal Fuzzy Number

Linguistic Variable	*Hexagonal Weight*
Very Low	*(0.05, 0.05, 0.1, 0.15, 0.2, 0.25)*
Low	*(0.15, 0.2, 0.25, 0.3, 0.35, 0.4)*
Medium	*(0.3, 0.35, 0.4, 0.45, 0.5, 0.55)*
High	*(0.45, 0.5, 0.55, 0.6, 0.65, 0.7)*
Very High	*(0.65, 0.7 ,0.75, 0.8, 0.9, 1)*
Equal Impact	*(1,1,1,1,1,1)*

4. Methodology

The algorithm of the proposed methodology is as follows:

1. The Linguistic Super fuzzy cognitive matrix (Lij) is determined from the group of n experts.

2. The Linguistic Average Super fuzzy cognitive matrix ($Aij = Lij/n$) is determined.

3. The initial vector is passed onto Aij and the resultant vector is thresholded and updated at each level.

4. The hidden pattern is attained until the vectors obtained at repeated iterations are same.

5. Adaptation of the Proposed Methodology to the Problem

The various factors and the association between the factors are acquired from four experts which are represented as linguistic super fuzzy cognitive maps. The LASFCM is obtained from the linguistic super fuzzy cognitive maps.

Table 2: Linguistic Super Fuzzy Cognitive matrix L1

	A_1^1	A_2^1	A_3^1	A_1^2	A_2^2	A_3^2	A_1^3	A_2^3	A_3^3	A_1^4	A_2^4	A_3^4
A_1^1	0	M	H		(0)			(0)			(0)	
A_2^1	VL	0	VH									
A_3^1	VL	H	0									
A_1^2		(0)		0	VL	H		(0)			(0)	
A_2^2				M	0	M						
A_3^2				H	VL	0						
A_1^3		(0)			(0)		0	M	VL		(0)	
A_2^3							M	0	VL			
A_3^3							L	L	0			
A_1^4		(0)			(0)			(0)		0	L	H
A_2^4										L	0	VH
A_3^4										L	L	0

Table 3: Linguistic Super Fuzzy Cognitive matrix L2

	A_1^1	A_2^1	A_3^1	A_1^2	A_2^2	A_3^2	A_1^3	A_2^3	A_3^3	A_1^4	A_2^4	A_3^4
A_1^1	0	M	H		(0)			(0)			(0)	
A_2^1	L	0	VH									
A_3^1	VL	VH	0									
A_1^2		(0)		0	VL	H		(0)			(0)	
A_2^2				H	0	M						
A_3^2				H	L	0						
A_1^3		(0)			(0)		0	H	L		(0)	
A_2^3							M	0	VL			
A_3^3							VL	VL	0			
A_1^4		(0)			(0)			(0)		0	VL	H
A_2^4										L	0	VH
A_3^4										L	VL	0

Table 6: The Linguistic Average Super Fuzzy Cognitive Matrix

	A_1^1	A_2^1	A_3^1	A_1^2	A_2^2	A_3^2	A_1^3	A_2^3	A_3^3	A_1^4	A_2^4	A_3^4
A_1^1	0	.5	.5375		(0)			(0)			(0)	
A_2^1	.1625	0	.744									
A_3^1	.1625	.688	0									
A_1^2		(0)		0	.125	.594		(0)			(0)	
A_2^2				.5	0	.425						
A_3^2				.5375	.1625	0						
A_1^3		(0)			(0)		0	.5	.2		(0)	
A_2^3							.463	0	.125			
A_3^3							.238	.238	0			
A_1^4		(0)			(0)			(0)		0	.2	.5375
A_2^4										.2	0	.8
A_3^4										.275	.2	0

Table 4: Linguistic Super Fuzzy Cognitive matrix L3

	A_1^1	A_2^1	A_3^1	A_1^2	A_2^2	A_3^2	A_1^3	A_2^3	A_3^3	A_1^4	A_2^4	A_3^4
A_1^1	0	H	H		(0)			(0)			(0)	
A_2^1	VL	0	VH									
A_3^1	VL	VH	0									
A_1^2		(0)		0	VL	VM		(0)			(0)	
A_2^2				H	0	M						
A_3^2				M	VL	0						
A_1^3		(0)			(0)		0	H	L		(0)	
A_2^3							M	0	VL			
A_3^3							L	VL	0			
A_1^4		(0)			(0)			(0)		0	L	M
A_2^4										VL	0	VH
A_3^4										L	L	0

Table 5: Linguistic Super Fuzzy Cognitive matrix L4

	A_1^1	A_2^1	A_3^1	A_1^2	A_2^2	A_3^2	A_1^3	A_2^3	A_3^3	A_1^4	A_2^4	A_3^4
A_1^1	0	H	M		(0)			(0)			(0)	
A_2^1	VL	0	VH									
A_3^1	L	H	0									
A_1^2		(0)		0	VL	H		(0)			(0)	
A_2^2				M	0	M						
A_3^2				H	VL	0						
A_1^3		(0)			(0)		0	M	VL		(0)	
A_2^3							H	0	VL			
A_3^3							L	M	0			
A_1^4		(0)			(0)			(0)		0	VL	H
A_2^4										VL	0	VH
A_3^4										L	VL	0

Let M = [(1 0 0) (1 0 0) (1 0 0) (1 0 0)]

$$\rightarrow ML = [(111)(101)(110)(101)] = M1$$

$$\rightarrow M1L = [(111)(101)(110)(101)] = M2$$

$$\therefore M1 = M2 \quad (1)$$

Let N = [(0 1 0) (0 1 0) (0 1 0) (0 1 0)]

$$\rightarrow NL = [(011)(110)(010)(011)] = N1$$

$$\rightarrow N1L = [(011)(111)(010)(011)] = N2$$

$$\rightarrow N2L = [(011)(111)(010)(011)] = N3$$

$$\therefore N2 = N3 \quad (2)$$

Let O = [(0 0 1) (0 0 1) (0 0 1) (0 0 1)]

$$\rightarrow OL = [(011)(101)(001)(001)] = O1$$

$$\rightarrow O1L = [(011)(101)(001)(001)] = O2$$

$$\therefore O1 = O2 \quad (3)$$

6. Results and Discussion

The equations (1), (2) and (3) state the follow-on of the initial vectors. If the first sub factor of each prime factor is kept in ON position then the resultant vector M2 represents the consequential impacts and the position of other factors. By repeating in the same fashion the vectors N2 and O2 also represent the ON and OFF positions of the other factors. The same procedure can be repeated by keeping certain combination of factors in ON position and the effects can be analyzed by applying the same methodology.

7. Conclusion

This paper introduces the new method of LASFCM to determine the consequential impacts of the causative factors of GD. This method is highly advantageous than ASFCM as it considers the linguistic input of the experts into consideration rather than just numerical values. The proposed method can be extended with different types of fuzzy numbers and a comparative analysis can also be made for further broadening.

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