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POLYCYSTIC OVARIAN SYNDROME A THREAT TO INFERTILITY IN WOMEN - DIAGNOSIS BY NEUTROSOPHIC LINGUISTIC FUZZY MATRICES

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ABSTRACT. In recent times, the problem of infertility in women is climbing the altitude. Extensive research on this issue has labelled Polycystic Ovarian Syndrome (PCOS) is one of the prime causes of infertility. PCOS are of various kinds and the symptoms are quite similar. The process of diagnosis is filled with uncertainty as the symptom of different types of PCOS and other hormonal imbalances are like. To handle such instances of impreciseness and ambiguity, the notion of fuzzy matrices can be used to represent the symptoms and the types of PCOS. This article presents various kinds of PCOS and its symptoms. The association between symptoms and PCOS and the affected are represented as neutrosophic fuzzy matrices. The proposed method of diagnosis differs from the earlier models by the representation and computational procedure. The diagnosis by neutrosophic linguistic fuzzy matrices is an innovative initiative and it can be extended to other kinds of fuzzy representations.

1. INTRODUCTION

The concept of fuzzy has intense applications in the field of medicine; especially the notion of Fuzzy matrices is extensively used by the medical experts in diagnosing the diseases of the patients. Fuzzy representations of data are the channel to handle the impreciseness and vagueness in decision making. The

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fuzzy sets are extended to intuitionistic fuzzy sets with membership and non-membership functions. The concept of indeterminacy is introduced by Florentine and it is represented together with truth and false membership functions. The representation of fuzzy matrices with interval valued representations and soft sets are also used to make the decision making feasible. Based on these earlier works, a decision making model using fuzzy matrix with neutrosophic linguistic representations is proposed to make optimal diagnosis of polycystic ovarian syndrome (PCOS).

The occurrence of disorders related to PCOS is the resultant of the malfunctioning of the internal system of human and it is predominantly found in women, [1]. The fertility of women is greatly affected by the imbalance of hormones caused by external and internal factors. The problem of fertility is gaining more concern amidst the medical researchers, as many women subject themselves to treatment for child bearing. There are many causes of infertility in women but one of the prime causes in PCOS and the record of infertility cases due to PCOS is climbing high. The contributing factors of PCOS and its symptoms have categorized PCOS to many kinds. Initially in the process of diagnosis, it is quite difficult to identify the victim with the common symptoms, thus the prevalence of uncertainty drags the diagnosis to next stage as proper treatment can be administered only after identifying the kind of PCO the person is affected by. Also in this scenario the symptoms of the various kinds of PCOS are quite similar. This makes the decision making more complicated. To resolve such crisis the fuzzy matrix with neutrosophic linguistic representation can be used to model this decision making circumstance. In this proposed decision making model, four kinds of PCOS such as Insulin Resistant, Pill induced, Lean type and Hidden PCOS and the symptoms like Anovulation, obesity, Androgenic Alopecia, Hirsutism and Acne are considered for the study. Also the elements of the relation matrix are represented by linguistic neutrosophic sets. These representations are given by the medical experts in the field of gynecology. The relation matrices between the symptoms cum kinds of PCOS and patients cum symptoms are formulated respectively with neutrosophic linguistic representations. The truth, indeterminacy and false membership values are represented by linguistic variables rather than numerical values [2–4]. The degree of indeterminacy is essential as, it reflects the difficulty of the medical experts in drawing

conclusions from the available data. The proposed model is validated with the primary data of the patients suffering from infertility problems.

The paper is structured as follows: section 2 comprises of the methodology; section 3 presents the validation of the proposed model; section 4 discusses the results and the last section concludes the research work with the scope of model extension.

2. METHODOLOGY

Fuzzy matrix in medical diagnosis has various illustrations, for instance Sophia Porchelvi in [5] has used triangular representations of fuzzy matrix in which the victims of the diseases are determined. By adopting the same procedure in the construction of relation matrix, the following steps of the proposed methodology are listed as follows.

Step 1: Construct the symptom - disease neutrosophic linguistic matrix $\mathfrak{Zd}$.
Step 2: Formulate the patient - symptom neutrosophic linguistic matrix $\mathfrak{Zp}$.
Step 3: Convert the linguistic fuzzy representations to triangular fuzzy numbers.
Step 4: Compute $\mathfrak{R}_1$, where $\mathfrak{R}_1 = \mathfrak{Zp}$ and

$$\mathfrak{Zd}[operator - max(min), min(max), min(max)]\,.$$

Step 5: Calculate $\mathfrak{R}_2$, where $\mathfrak{R}_2 = \mathfrak{Zp}.\ H - \mathfrak{Zd}(H =\sim \mathfrak{Zd})$.
Step 6: Determine $\mathfrak{R}_3$, where $\mathfrak{R}_3 = W - \mathfrak{Zp}.\ \mathfrak{Zd}(W =\sim \mathfrak{Zp})$.
Step 7: Find $\mathfrak{R}_4 = Max\{\mathfrak{R}_2, \mathfrak{R}_3\}[(Max, min, min)]$.
Step 8: Obtain $\mathfrak{R}_5 = \mathfrak{R}_1 - \mathfrak{R}_4$.
Step 9: The decision maker firmly confirms the kind of disease or disorder the person is suffering from.

3. VALIDATION OF THE PROPOSED MODEL

The proposed decision making model is validated with the primary data of the people suffering PCOS problem. The relation matrix $\mathfrak{Zp}$ is presented below.

The above matrices represent the optimal diagnosis of the kinds of PCOS to the patients.

	Anovulation	**Obesity**	**Androgenic Alopecia**	**Hirsutism**	**Acne**
Patient 1	(0.9,0.3,0.1)	(0.5,0.3,0.7)	(0.5,0.3.0.5)	(0.9,0.3,0.1)	(0.7,0.1,0.3)
Patient 2	(0.7,0.1,0.3)	(0.7,0.1,0.3)	(0.9,0.3,0.1)	(0.9,0.3,0.1)	(0.3,0.5,0.9)
Patient 3	(0.9,0.3,0.1)	(0.5,0.3,0.7)	(0.7,0.1,0.3	(0.5,0.3,0.7)	(0.9,0.3,0.1)
Patient 4	(0.9,0.3,0.1)	(0.9,0.3,0.1)	(0.5,0.3,0.7)	(0.5,0.3,0.7)	(0.3,0.5,0.9)
Patient 5	(0.5,0.3,0.7)	(0.7,0.1,0.3)	(0.1,0.1,0.9)	(0.9,0.3,0.1)	(0.7,0.1,0.3)
Patient 6	(0.7,0.1,0.3)	(0.5,0.3,0.7)	(0.9,0.3,0.1)	(0.7,0.1,0.3)	(0.3,0.5,0.9)
Patient 7	(0.5,0.3,0.7)	(0.5,0.3,0.7)	(0.7,0.1,0.3)	(0.3,0.5,0.9)	(0.9,0.3,0.1)

FIGURE 1. The relation matrix $\mathfrak{Z}\mathfrak{d}$

	Insulin Resistant PCOS	Pill Induced PCOS	Lean type PCOS	Hidden PCOS
Anovulation	(0.9,0.3,0.1)	(0.9,0.3,0.1)	(0.7,0.1,0.3)	(0.7,0.1,0.3)
Obesity	(0.5,0.3,0.7)	(0.5,0.1,0.7)	(0.1,0.3,0.7)	(0.9,0.3,0.1)
Androgenic Alopecia	(0.9,0.3,0.1)	(0.5,0.3,0.7)	(0.9,0.3,0.1)	(0.9,0.3,0.1)
Hirsutism	(0.7,0.1,0.3)	(0.9,0.3,0.1)	(0.7,0.1,0.3)	(0.5,0.3,0.7)
Acne	(0.9,0.3,0.1)	(0.9,0.3,0.1)	(0.9,0.3,0.1)	(0.5,0.3,0.9)

FIGURE 2. The relation matrix $\mathfrak{R}_1$

	Insulin Resistant PCOS	Pill Induced PCOS	Lean type PCOS	Hidden PCOS
Patient 1	(0.9,0.3,0.1)	(0.9,0.3,0.1)	(0.7,0.3,0.3)	(0.7,0.3,0.3)
Patient 2	(0.9,0.3,0.1)	(0.9,0.1,0.1)	(0.9,0.1,0.1)	(0.9,0.1,0.1)
Patient 3	(0.9,0.3,0.1)	(0.9,0.3,0.1)	(0.9,0.3,0.1)	(0.7,0.3,0.3)
Patient 4	(0.9,0.3,0.1)	(0.9,0.3,0.1)	(0.7,0.3,0.3)	(0.9,0.3,0.1)
Patient 5	(0.7,0.3,0.3)	(0.9,0.1,0.1)	(0.7,0.3,0.3)	(0.7,0.3,0.3)
Patient 6	(0.9,0.1,0.1)	(0.7,0.3,0.3)	(0.9,0.1,0.1)	(0.9,0.1,0.1)
Patient 7	(0.9,0.3,0.1)	(0.9,0.3,0.1)	(0.9,0.3,0.1)	(0.7,0.3,0.3)

FIGURE 3. The relation matrix $\mathfrak{R}_2$

	Insulin Resistant PCOS	Pill Induced PCOS	Lean type PCOS	Hidden PCOS
Patient 1	(0.5,0.7,0.7)	(0.5,0.7,0.5)	(0.5,0.7,0.7)	(0.7,0.7,0.5)
Patient 2	(0.7,0.7,0.5)	(0.7,0.7,0.5)	(0.7,0.7,0.5)	(0.7,0.7,0.5)
Patient 3	(0.5,0.7,0.7)	(0.7,0.7,0.5)	(0.5,0.7,0.7)	(0.9,0.7,0.5)
Patient 4	(0.7,0.7,0.5)	(0.7,0.7,0.5)	(0.7,0.7,0.5)	(0.7,0.7,0.5)
Patient 5	(0.7,0.7,0.5)	(0.7,0.7,0.5)	(0.7,0.7,0.5)	(0.7,0.7,0.5)
Patient 6	(0.7,0.7,0.5)	(0.7,0.7,0.5)	(0.7,0.7,0.5)	(0.7,0.7,0.5)
Patient 7	(0.5,0.7,0.7)	(0.7,0.7,0.5)	(0.5,0.7,0.7)	(0.9,0.7,0.5)

FIGURE 4. The relation matrix $\mathfrak{R}_3$

	Insulin Resistant PCOS	Pill Induced PCOS	Lean type PCOS	Hidden PCOS
Patient 1	(0.5,0.7,0.5)	(0.5,0.7,0.7)	(0.5,0.7,0.5)	(0.7,0.7,0.5)
Patient 2	(0.9,0.5,0.3)	(0.9,0.5,0.3)	(0.9,0.5,0.3)	(0.5,0.5,0.7)
Patient 3	(0.7,0.7,0.5)	(0.7,0.7,0.3)	(0.7,0.7,0.5)	(0.7,0.7,0.5)
Patient 4	(0.9,0.5,0.3)	(0.9,0.5,0.3)	(0.9,0.5,0.3)	(0.7,0.5,0.5)
Patient 5	(0.7,0.3,0.1)	(0.7,0.3,0.1)	(0.7,0.3,0.1)	(0.7,0.3,0.1)
Patient 6	(0.9,0.5,0.1)	(0.9,0.5,0.1)	(0.7,0.3,0.1)	(0.9,0.1,0.3)
Patient 7	(0.7,0.5,0.3)	(0.9,0.5,0.1)	(0.7,0.5,0.3)	(0.7,0.5,0.5)

FIGURE 5. The relation matrix $\mathfrak{R}_4$

	Insulin Resistant PCOS	Pill Induced PCOS	Lean type PCOS	Hidden PCOS
Patient 1	(0.5,0.7,0.5)	(0.5,0.7,0.5)	(0.5,0.7,0.5)	(0.7,0.7,0.5)
Patient 2	(0.9,0.5,0.3)	(0.9,0.5,0.3)	(0.9,0.5,0.3)	(0.7,0.5,0.5)
Patient 3	(0.7,0.7,0.5)	(0.7,0.7,0.3)	(0.7,0.7,0.5)	(0.7,0.7,0.5)
Patient 4	(0.9,0.5,0.3)	(0.9,0.5,0.1)	(0.9,0.5,0.1)	(0.7,0.5,0.5)
Patient 5	(0.7,0.3,0.1)	(0.7,0.3,0.1)	(0.7,0.3,0.1)	(0.7,0.3,0.1)
Patient 6	(0.9,0.5,0.1)	(0.9,0.5,0.1)	(0.9,0.5,0.1)	(0.9,0.5,0.1)
Patient 7	(0.7,0.5,0.3)	(0.9,0.5,0.1)	(0.7,0.5,0.3)	(0.9,0.5,0.3)

FIGURE 6

4. Results and Discussion

Figure 3 clearly presents the patients and the kind of PCOS they are suffering from. The proposed decision making model plays a vital role in diagnosing the diseases or the disorders which are closely related and do not differ much. The representation of the data in the form of linguistic neutrosophic sets is the significant aspect of the model. The kinds of PCOS are characterized by similar symptoms but still the treatment differs, to handle these crisis these decision making models can be applied for medical diagnosis.

5. Conclusion

The proposed model is highly compatible and feasible, as it reflects the expert's opinion in a more pragmatic manner. The real existing scenario is projected in the form of neutrosophic linguistic representations and the application of fuzzy matrix in determining the optimal diagnosis makes the decision making process easier. The formulated model can be extended with other fuzzy sets representation.

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