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Fuzzy Computerized Profile Prediction of Luteinizing Hormone

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ABSTRACT: The aim of the study is to predict the hormonal profile of Luteinizing Hormone throughout the female menstrual cycle. The present research acknowledged just for healthy, adult and non-pregnant female. The proposed new technique used fuzzy logic as tool to deal with uncertainty and estimate LH profile under various circumstances. Fuzzification appertain on conventional reference degree of LH, utilized trapezoidal membership (μ_L, μ_N and μ_H) and if-then rule to evaluate LH as low, normal and high.

Keywords: Infertility, Luteinizing Hormone (LH), μ_L, μ_N and μ_H.

NOMENCLATURE: μ_L is low fuzzy membership function, μ_N is normal fuzzy membership function, μ_H is high fuzzy membership function.

I. INTRODUCTION

Reproduction is re-produce or produce again, is a continuous process. Reproduction is essential for the survival of organism. This study is corresponding to human. Females having capability to give birth to human, because of the female menstrual cycle. Fertility defines reproduction and relationship between fertility and infertility, infertility is inversely propositional to fertility. Now a day's infertility becomes a global issue among fertile aged couples. According to bulletin of The World Health Organization (WHO) (http://www.who.int/ bulletin/volumes/88/12/10-011210/en/), infertility affects up to 15% of reproductive-aged couples worldwide. The development of reproductive technologies has enabled better reproductive efficiency and treatment for infertility. Infertility defined, as 1 year of attempted conception without success, is one of the most common health disorders relating young adults. Clinical evaluation of infertility specified that if a pregnancy has not occurred after 1 year of regular unprotected intercourse, because by that time 85% of couples attempting conception will have been successful [4]. Infertility is an issue, caused by both male and female. This study concerns with female infertility. There are many factors affects fertility like environmental, social, biological, psychological etc. Female fertility diagnosis begins with the diagnosis of female menstrual cycle. Typical female menstrual cycle is of 28 days of an adult female. During the cycle various hormones like Follicle Stimulating Hormone (FSH), Luteinizing Hormone (LH), Prolactin (PRL), Progesterone and Estrogen takes part under various circumstances.

A Fuzzy Logic System for fertility prediction corresponding to the Basal Body Temperature (BBT) technique based on FAM, help females to predict their fertility based on automatic BBT charting and online monitoring concepts, effectively [10]. In this experiment, author endeavored to counsel answer for regarding the issue with medical expert's that they don't have general electronic LH estimate through the female menstrual cycle. Mathematical conversion of a real-life problem with uncertainty is a complex issue. Fuzzy Logic establish itself as a one of the best tool to resolve uncertainty and facility with the lingual conversion of the same also. That is why, fuzzy logic used as a tool to execute the methodology. The proposed work introduces a novel fuzzy equation model to deliver final model to figure rate of fertility (female fertility) which give more appropriate infertility analysis and will help in infertility management. Better infertility management is accomplished by giving precision to the medical expert's prognosis with respect to LH status all through the female menstrual cycle. Conventional hormonal analysis approach is, if current test value between its standard reference range is ponder as normal. If current test value below its lower limit is reckon as low and if greater then upper limit is considered as high. This fuzzification methodology is applied on standard normal reference range of LH, independently for all three phases of female menstrual cycle.

Appropriate fuzzification is implemented with if-then rule and trapezoidal membership function as μ_L, μ_N and μ_H as low, normal and high, respectively. That is the reason, presented model, gives common and more exact elucidation of LH current status. Generally medical expert's prediction are individual experience-based estimations which may or may not vary.

II. LUTEINIZING HORMONE

The female menstrual cycle is a complex process. Menstrual cycle is divided into three phase follicular phase, ovulation phase and luteal phase, respectively. The pituitary gland releases two hormones, FSH (Follicle Stimulating Hormone) and LH (Luteinizing Hormone). FSH stimulates a follicle to grow. LH stimulates the follicle to manufacture and secrete estrogen. LH plays an important role to know the best possibility when to get fertile. Ovulation, Fertile Window and LH Surge are the key terms to tract best fertile day. Ovulation is the second phase of female menstrual cycle. In the typical 28 days menstrual cycle 14 day is considered as ovulation day. This is the phase where ovaries release an egg into a fallopian tube, where it waits for the company of your partner's sperm to get fertile. Basically, Fertile Window is the time period when fertility chance is maximum and unprotected intercourse may result in a pregnancy. The fertile window begins five days prior to ovulation, and ends the day after an egg is released, Days 9-14 [1]. Ovulation is the crucial event of fertile window. LH surge is the situation when LH hormone is at its peak. LH surge, triggering the release of the most developed egg. At the same time, female cervical mucus becomes more slippery to help sperm make their way to the egg.

The human ovulatory cycle is associated with a specific pattern of hormonal changes. Just before ovulation, women experience an increase in estrogen (an ovarian hormone) and luteinizing hormone (LH; a pituitary hormone). Estrogen and LH fluctuate together, peaking around the same time within each menstrual cycle. The rise of these two hormones indicates that ovulation will occur within 24-36 hours, whereby the greatest chance for conception occurs within a 48-hour period surrounding ovulation. If a woman does not become pregnant in this period, estrogen and LH levels drop significantly. Thus, the window of fertility is accompanied by a distinct hormonal marker—a spike in estrogen and LH—that is specific to the fertile phase in a woman's cycle [3]. LH surge was investigated by Women daily first morning urine collection, charted basal body temperature, cervical mucus discharge, and underwent serial ovarian ultrasound [5]. The main objective was to determine whether ovulation or failure to ovulate could be detected accurately by the use of ultrasound. The ovaries were scanned with every 1 to 3 days for morphologic changes consistent with follicle development, ovulation, and development of the corpus luteum. This technique was found to be quick, inexpensive, and efficient [2].

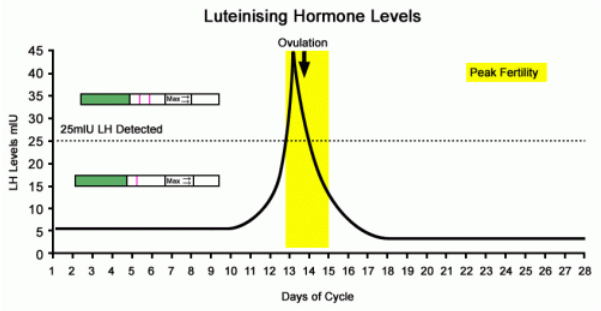

Fig. 1. Luteinizing Hormone [10].

III. FUZZY LOGIC

Fuzzy logic is introduced by L.A. Zadeh in 1965. Fuzzy Logic is multi value logic, deals with the in-between values of either [0,1], means value between yes or no, by defining fuzzy set and its degree of membership function [6]. Fuzzy Logic proposed concepts like linguistic variables and fuzzy if–then rules, FL-generalization, the concepts of precisiation and cointension, NL-Computation, computing with words (CW) and precipitated natural language (PNL), possibility theory and probability theory etc., ensures its requirement to the real world.

Fuzzification is a process that determines the degree of membership to the fuzzy set based on fuzzy membership function. The first step is to

- Create a fuzzy set of the parameters. The parameters will be described with three linguistic variables (low, normal and high).
- The degree of membership for a fuzzy system is of the range [0 1]. A range of the fuzzy value
  using the linguistic variables will be determined by the expert.
- The fuzzy rule will be developed with the assistance of the domain expert [8].

IV. METHODOLOGY

The proposed new fuzzy equation model of Luteinizing Hormone (LH) is limited for a non-pregnant, healthy, adult female means gender must be female, pregnancy status must be negative, age must be greater than or equal to 18yrs. and female don't have affliction from any kind of health disorder like cancer, tubal disorder, HIV etc.

Hormones reference ranges may or may not vary laboratory to laboratory, in light of the fact that preferably, labs should either affirm these compasses or choose their own specific reference ranges, in perspective of the peoples they serve. However, performing detailed reference range studies can be strategically mind boggling, and are beyond the capabilities of numerous clinical laboratories. This is particularly considerable for reproductive hormones, for which serum concentrations change on a very basic level all through the menstrual cycle, and also from woman to woman [7]. For this study, Luteinizing Hormone, standard reference ranges of a healthy, adult female at follicular phase is 1.90 – 12.50, mid cycle peak is 8.70 – 76.30 and luteal phase is 0.50 – 16.90, measuring unit is mIU/mL. For the melioration of fuzzy membership function, contemplate them as 1-13, 8-77 and 0-18 respectively.

The fuzzification of LH has three sections with respect to the female menstrual cycle phases (Follicular Phase, Mid Cycle Peak or Ovulation Phase and Luteal Phase). Each trapezoidal membership function has its own definition, represented through graph. Graphs are generated in MS-EXCEL 2016. Every fuzzy membership function further divided into three sub sections as μ_L, μ_N and μ_H where μ_L is a fuzzy membership function belongs to class 'Low', μ_N is a fuzzy membership function associated with class 'Normal' and μ_H is a fuzzy membership function club with class 'High'. The current input test value of LH predict itself corresponding to μ_L, μ_N and μ_H. accordingly.

A. Fuzzification of Follicular Phase

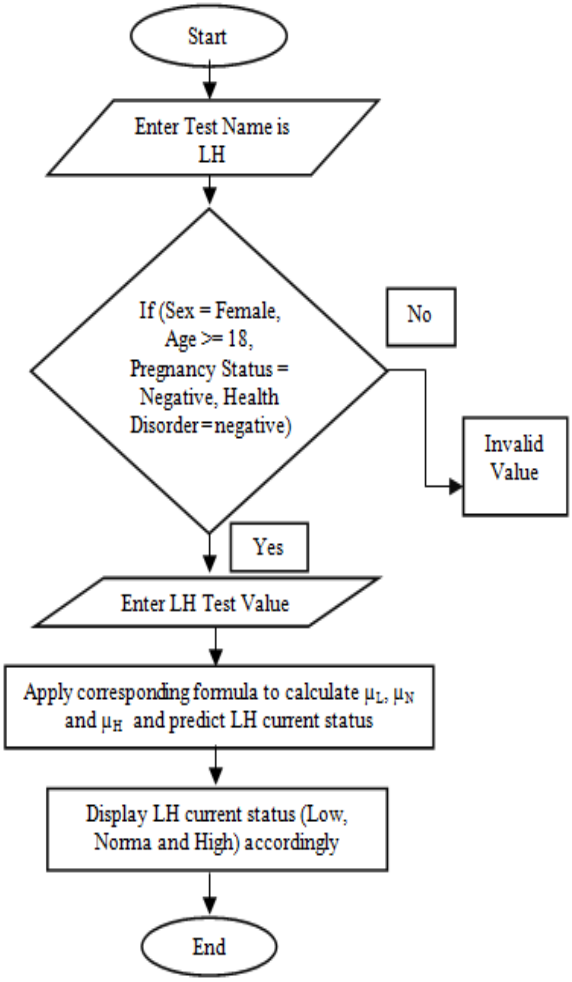

Fig. 2. Methodology of Proposed Fuzzy Model.

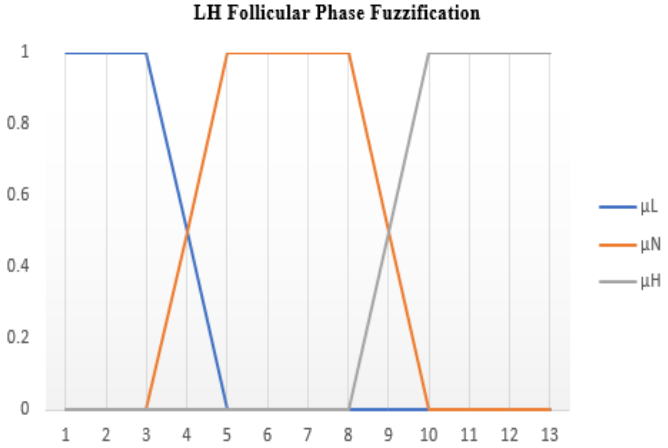

Fig. 3. Fuzzification of LH at Follicular Phase.

Fuzzy Membership Function

$$\mu_L(x_1) = \begin{cases} 1 & if \quad x_1 < 3 \\ \frac{(5-x_1)}{2} & 3 \le x_1 \le 5 \\ 0 & otherwise \quad x_1 > 5 \end{cases} \quad \dots (1)$$

$$\mu_N(x_2) = \begin{cases} 1 & if \quad 5 < x_2 < 8 \\ \frac{(x_2-3)}{2} & 3 \le x_2 \le 5 \\ \frac{(10-x_2)}{2} & 8 \le x_2 \le 10 \\ 0 & otherwise \quad x_2 < 3, x_2 > 10 \end{cases} \quad \dots (2)$$

$$\mu_H(x_3) = \begin{cases} 1 & if \quad x_3 > 10 \\ \frac{(x_3-8)}{2} & 8 \le x_3 \le 10 \\ 0 & otherwise \quad x_3 < 8 \end{cases} \quad \dots (3)$$

B. Fuzzification of Mid-Cycle Peak

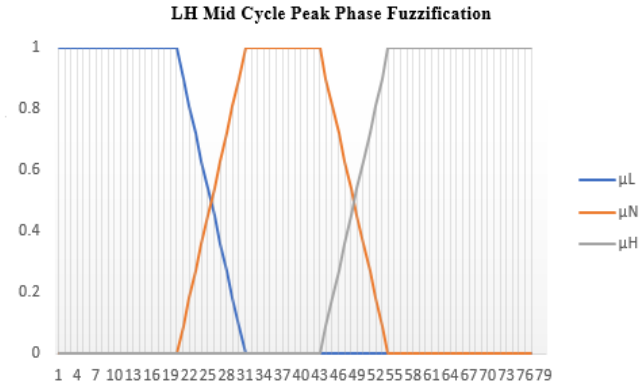

Fig. 4. Fuzzification of LH at Ovulation Phase.

Fuzzy Membership Function

$$\mu_L(x_1) = \begin{cases} 1 & if \quad x_1 < 20 \\ \frac{(31-x_1)}{11} & 20 \le x_1 \le 31 \\ 0 & otherwise \quad x_1 > 31 \end{cases} \quad \dots (4)$$

$$\mu_N(x_2) = \begin{cases} 1 & if \quad 31 < x_2 < 43 \\ \frac{(x_2-20)}{11} & 20 \le x_2 \le 31 \\ \frac{(54-x_2)}{11} & 43 \le x_2 \le 54 \\ 0 & otherwise \quad x_2 < 20, \ x_2 > 54 \end{cases} \quad \dots (5)$$

$$\mu_H(x_3) = \begin{cases} 1 & if \quad x_3 > 54 \\ \frac{(x_3-43)}{11} & 43 \le x_3 \le 54 \\ 0 & otherwise \quad x_3 < 43 \end{cases} \quad (6)$$

C. Fuzzification of Luteal Phase

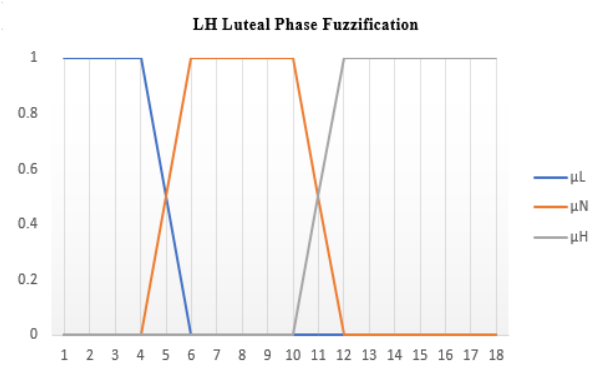

Fig. 5. Fuzzification of LH at Luteal Phase.

Fuzzy Membership Function

$$\mu_L(x_1) = \begin{cases} 1 & if \quad x_1 < 4 \\ \frac{(6-x_1)}{2} & 4 \le x_1 \le 6 \\ 0 & otherwise \quad x_1 > 6 \end{cases} \quad \dots (7)$$

$$\mu_N(x_2) = \begin{cases} 1 & if \quad 6 < x_2 < 10 \\ \frac{(x_2-4)}{2} & 4 \le x_2 \le 6 \\ \frac{(12-x_2)}{2} & 10 \le x_2 \le 12 \\ 0 & otherwise \quad x_2 < 4, x_2 > 12 \end{cases} \quad (8)$$

$$\mu_H(x_3) = \begin{cases} 1 & if \quad x_3 > 12 \\ \frac{(x_3-10)}{2} & 10 \le x_3 \le 12 \\ 0 & otherwise \quad x_3 < 10 \end{cases} \quad \dots (9)$$

D. Out Come of the Proposed Work

The result of the proposed work is mathematical prediction of Luteinizing Hormone.

For example, Let, LH Test Value = 6 and Day=11 then triggering function will be μ_N of "Follicular Phase" and interpretation will be your LH current status is" **Normal**".

V. CONCLUSION

This study introduces a new fuzzy equation-based model describes the Luteinizing Hormonal profile during the female menstrual cycle. This model is restricted for healthy, adult and non-pregnant female. Fuzzification methodology executed with trapezoidal membership function (μ_L, μ_N and μ_H) based on if-then rule. This technique will enable medical experts to predict LH profile more efficiently, accurately and generated a common prediction. Helpful while deciding either LH will increase or decrease and how much will increase or decrease. It improves prognosis of LH throughout female menstrual cycle and infertility management.

VI. FUTURE SCOPE

This research work is the part of impending fuzzy mathematical model to estimate percentage of female infertility. Future methodology will improve the infertility diagnosis via proposed technique, give straightforwardness and common interpretation of female infertility status.

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