https://dx.doi.org/10.24001/eec.2.6.1 *ISSN: 2456-2319*

Fuzzy Logic means for Intelligent Diagnosis of Obstetrics Fistula Disease.

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Abstract *- Obstetrics fistula is one of the most serious and tragic childbirth injuries. It is a hole between the birth canal and bladder or rectum caused by prolonged, obstructed labour, without access to timely, high-quality medical treatment. It leaves women leaking urine, faeces or both and often leads to chronic medical problems, depression, social isolation and deepening poverty. The goal of this research is to develop a Fuzzy logic means for intelligent diagnosis of Obstetrics fistula disease. In the study we presented the architecture of the FCM system for the diagnosis of Obstetrics Fistula. It comprises of knowledge base system, fuzzy c-means inference engine and decision support system. The knowledge base system holds the symptoms for Obstetrics Fistula. The expert system is developed in an environment characterized by Microsoft XP Professional operating system, Microsoft Access Database Management System, Visual BASIC Application Language and Microsoft Excel.*

Keywords-fuzzy Logic, intelligent diagnosis, childbirth injuries, obstetrics fistula.

I. INTRODUCTION

Obstetrics fistula is one of the most serious and tragic childbirth injuries. It is a hole between the birth canal and bladder or rectum caused by prolonged, obstructed labour, without access to timely, high-quality medical treatment. It leaves women leaking urine, faeces or both and often leads to chronic medical problems, depression, social isolation and deepening poverty. Obstetric fistula is a condition that most frequently affects women living in resource poor countries where, for a variety of reasons, access to emergency obstetric care (EmOC) is difficult. In such settings, women living in rural areas and those from low socioeconomic households have fewer opportunities to obtain EmOC (specifically, a cesareansection) and are therefore more vulnerable to fistula. When not repaired, vaginal fistula causes incontinence, and for some women it can result in an inability to carry and bear children. Because of the physical consequences, fistula stigmatizes women, often forcing them to isolate themselves and remain silent about their condition [1]. The World Health Organization has estimated that more than 2 million women have untreated obstetric fistula and some 50,000 TO 100000 new cases develop annually. Globally, there were an estimated 289,000 maternal deaths in 2013[2]. Further statistical figures on obstetric fistula mortality are presented in [3-4]. However, this figure is thought to be an underestimate, because many women with fistula do not seek treatment. The overall rate of obstetric fistula in Africa is three to five cases per 1,000 deliveries; in rural Africa, however, the rate is five to 10 cases per 1,000 deliveries. The United Nations Population Fund estimates that, worldwide, fistulas occur in one or two of every 1,000 deliveries. The actual prevalence of fistula, however, is not known. Fistula from prolonged or obstructed labour can strike any pregnant woman, regardless of her age or gravidity. However, adolescents who marry early have unique characteristics that put them at increased risk for obstetric fistula. Most of these adolescents become pregnant before the pelvis is fully developed for childbearing[5].

The five types of obstetric fistula are: Vesicovaginal (VVF) fistula: Between the bladder and vagina,Rectovaginal fistula (RVF): Between the rectum and vagina, Urethrovaginal fistula: Between the urethra and the vagina, Ureterovaginal fistula: Between the distal ureter and vagina, Vesicouterine fistula: Between the uterus and the bladder, Vesicovaginal (VVF) is the most common type of obstetric fistula, A client may have both vesicovaginal and rectovaginal fistula at the same time—the combination of VVF and RVF is the second most commonly encountered type of obstetric fistula.The most common cause of obstetric fistula in developing countries is prolonged or obstructedlabour. Other physical causes of fistula include: Trauma caused by sexual violence, Accidental surgical injury, Unsafe abortions, Harmful traditional practices, Diseases or radiotherapy treatments, Most women who develop obstetric fistula during childbirth do so because they did not receive the health care they needed.

The problems in accessing timely obstetric care, which can lead to maternal death or complications (including fistula), are commonly referred to as the “Three Delays”: Delay in

https://dx.doi.org/10.24001/eec.2.6.1 *ISSN: 2456-2319*

deciding to seek care, Delay in reaching a health care facility, and Delay in receiving adequate care/attention at the facility. Other societal factors that contribute to obstetric fistula include: Poverty, Early marriage and childbirth, Gender discrimination, Poor nutrition and compromised development and Inadequate family planning information. Symptoms of Obstetrics fistula are; Flatulence, Foul-smelling, Repeated virginal/urinary infections, Irritation or pains in vagina areas and Pains during sexual activity [6-8].

1.1 Consequence of Obstetric fistula

Obstetric fistula, in conjunction with prolonged or obstructed labour, can lead to a range of physicaland mental health complications,[9-11]including: Gynecologic sequelae, Nerve damage, Dermatologic injuries, Bone abnormalities, Anxiety and Depression, Ancillary medical conditions (such as dehydration, bladder stones, malnutrition, anemia, urinary, tract infections, and kidney disease), The social consequences for women living with obstetric fistula include: Stigma related to stillbirth, Subjection to myths and misconceptions about fistula, Social isolation (Because of the unpleasant odour, women with fistula may be perceived as unclean and are often excluded, or exclude themselves, from participating in communityactivities), Marital breakdown/divorce, Shame, Self-esteem issues, and other psychological problems, Inability to make a living (Many women with fistula live for years without any financial or socialsupport and fall into extreme poverty),Suicide, "The understanding that one must treat the 'whole person' with the fistula—not just her injuredbladder or rectum—is the single most important concept in fistula care"[9]. The record of high mortality presented by WHO, coupled with the aforementioned consequences of Obstetrics fistula beckons for an intelligence system for early diagnosis of obstetrics fistula. The goal of this research is to develop a Fuzzy logic means for intelligent diagnosis of Obstetrics fistula disease.

II. RELATED WORKS

Studies on obstetric fistula closely follows maternal mortality; a recent longitudinal study of 230 parturient women in Nigeria found a cumulative prevalence rate of 12.2 %, 13.5% and 3% for urinary, anal and combined urinary and anal incontinence respectively [12].

Risk factors associated with Epidemiology of Obstetric Fistula in [13] can be caused by delay.Once a woman arrives at the facility, she may not have access to adequate care, due to a lack of staff or unfriendly staff, supplies, or electricity. Furthermore, insufficiently skilled staff may mean that the woman may not get the care that is needed or when provided, and which results in complications [14].

Factors that can lead to Obstetric fistula arepresented in [15]. A condition exclusive to women and gender has a big role in its genesis. Gender inequality and oppression of women are known to persist in regions where obstetric fistula occurs. In these regions, forced adolescent and teen marriages, low education levels for girls, male control of money, and the need for women in obstructed labor to get the permission of their husband or mother-in-law to seek care are common findings

Obstetric Fistula Community Based Assessment Tool (OF-COMBAT) is an enhanced verbal screening tool presented in[16]. The tool was designed to minimize the number of clients referred to treatment centres with conditions other than obstetric fistula. OF-COMBAT helps health facilities to minimize the screening of resources required and improvethe efficiency and cost-effectiveness of fistula programs by limiting transport and logistics costs for ineligible clients. Importantly, the tool enables the woman to receive a tentative diagnosis within the comfort of her home or community before she travels a very long distance, only to at times be turned back because her condition may not be covered through charitable fistula programs. OF-COMBAT is best used by a community outreach worker who has received basic training on verbal screening for fistula. The outreach worker is encouraged to listen to the client's story before he/she takes the client through the set of up to 27 questions, depending on the type of injury described by the client. The responses are then tallied and rated on the given scale to provide a tentative diagnosis. The OF-COMBAT is unique in that in utilizes a set of confirmatory questions in order to improve the rates of correctly diagnosing a fistula case. The limitation of the tool is that, it is a verbal screening tool.

Medical diagnosis involves identifying illness or disorder in a patient through physical examination, medical tests or other procedures while therapy is the treatment of physical, mental or behavioral problems and it is meant to cure or rehabilitate the sick [17-18]. However, the system lacks the capabilityfor global access due to its offline nature and could not handle vague (imprecise) data which are inherent in medical records.

The authors in [19] proposed a Fuzzy Expert System for the Management of Malaria which has been identified as a predominant environmental health problem in several parts of the world. While the authors in [20]presented a model for the diagnosis of Liver problems, both systemswere suitable to act as a decision support platform to researchers, physicians and other healthcare practitioners in malaria endemic and liver diseases respectively. The limitations of the conventional methods for the diagnosis of diseases call for the development of expert systems which will aid medical practitioners in delivering effective and efficient medical services to patients at affordable prices (cost)

https://dx.doi.org/10.24001/eec.2.6.1 *ISSN: 2456-2319*

irrespective of their geographical location. Due to the strength of Fuzzy Logic (FL) in the provision of accurate solutions to difficult real life problems and the advancement in Internet technology, there has been an increasing need to incorporate FL concept into medical diagnosis for a successful development of Internet-based expert system that will have a human-like reasoning capability[21].

III. RESEARCH METHODS

The process for the medical diagnosis of Obstetrics Fistula begins when an individual consults a medical expert (doctor) and presents a set of complaints (symptoms). The medical expert thenrequests further information that will further aid in the proper diagnosis of the disease. Data collected include patient's previous state of health, living condition and other medical conditions. During the diagnosis of Obstetrics Fistula, the medical expert looks at the patient's symptoms after which he conducts a physical examination. From the symptoms presented by the patient, the Medical expert narrows down the possibilities of the illness that corresponds to the apparent symptoms and make a list of the conditions that could account for what is wrong withthe patient. These are usually ranked in possibility order (Low, Moderate and High). When the list has been narrowed down to a single condition, it is called differential diagnosis and provides the basis for a hypothesis of what is ailing the patient. The examining physician accounts for possibilities of having Obstetrics Fistula through physical examination, interview, or laparoscopic test.

The expert system is developed in an environment characterized by Microsoft XP Professional operating system, Microsoft Access Database Management System, Visual BASIC Application Language and Microsoft Excel.

The research was carried out at the University Teaching hospital (UCH), Ibadan, Nigeria. Verbal informed consent was administered to all respondents before they participated in the study. International ethical standards were followed to ensure the confidentiality of the information collected and the anonymity of the respondents. Our dataset is made up of 5 clinical symptoms and 5 types of Obstetrics fistula diseases. We also performed training, testing and validation. The correct classified records are stored in the knowledge base. Rule extraction with the correct classified data was also performed.

3.1 Fuzzy C-Means Clustering (FCM)

The FCM algorithm is one of the most widely used fuzzy clustering algorithms. The FCM algorithm

attempts to partition a finite collection of elements X={X1, X2,...,Xn} into a collection of c fuzzy clusters withrespect to some given criterion. Given a finite set of data, the algorithm returns a list of c cluster centers V, such that;

V =Vi, i=1, 2,..., c

and a partition matrix U such that

U = Uij , i =1,..., c , j =1,..., n

whereUij is a numerical value in [0, 1] that tells the degree to which the element Xj belongs to the i-th cluster.

The fuzzy logic linguistic description of the typical FCM algorithm is presented below:

Start

Step 1: Select the number of clusters c ($2 \leq c \leq n$),

exponential weight μ ($1<\mu<\infty$), initialpartition matrix U0, and the termination criterion ε. Also, set the iteration index i to 0.

Step 2: Calculate the fuzzy cluster centers

{Vi 1| i=1, 2,..., c} by usi n g U1 .

Step 3: Calculate the new partition matrix U1+1 by using {Vi 1| i=1, 2,. .., c}.

Step 4: Calculate the new partition matrix = || U1+1 - U1|| = | Uij 1+1 – Uij 1 |. If >ε, then set l = l+ 1 and go to step 2. If ≤ε, then stop.

Stop

IV. MODEL OF FCM FOR OBSTETRICS FISTULA DISEASES

In this work, we present an architecture model of the fuzzy C-means expert system for the diagnosis of obstetrics fistula diseases as shown in Fig. 1. It consists of a Knowledge base system, Fuzzy C-means inference engine and decision support module. The knowledge base is made of the demographic details of the patients, the observed clinical symptoms and data. The values of the clinical symptoms are vague and imprecise hence the adoption of fuzzy logic as a means of analyzing these information. These values therefore constitute the fuzzy parameters of the knowledge base. The fuzzy set of the clinical symptoms characteristics is represented by 'P' which is defined as: P = {p1, p2… pn} where pi represents the jth parameter and n is the total number of parameters (in this study, n= 5).Neural network provides the structured intelligent learning for all forms of the symptoms of obstetrics fistula diseases, which serves as a platform for the inference engine. The inference engine consists of reasoning algorithms, driven by production rules. These production rules are evaluated by using the forward chaining approach of reasoning. The fuzzy logic and Fuzzy C-means algorithm provides the rules for the partitioning of patients into a number of homogenous clusters with respect to a suitable similarity measure. The patients were classified according to 5 types of obstetrics fistula diseases as given by a gynecologist (medical expert).

Fuzzy logic is a superset of the conventional Boolean logic with capability for handling imprecise (vague) and incomplete data that are commonly found in medical records.

https://dx.doi.org/10.24001/eec.2.6.1 *ISSN: 2456-2319*

It resembles human decision making with its ability to work from approximate reasoning and ultimately find a precise solution to a given problem. The process of diagnosing obstetrics fistula by the fuzzy logic involves the following stages:

a) Fuzzification of input variables (values of signs, symptoms, and laboratory test results).
b) Establishment of the fuzzy rule base.
c) Building the decision making logic of the fuzzy logic component (inference engine).
d) Defuzzification of the output of the inference engine into crisp values.

A fuzzy set of healthy, mild, moderate, severe, very severe for the input variables (signs, symptoms, and laboratory test results) are defined.The input variables are fuzzified and the membership functions defined for them are applied to their actual values to determine the degree of truth for each rule antecedent.

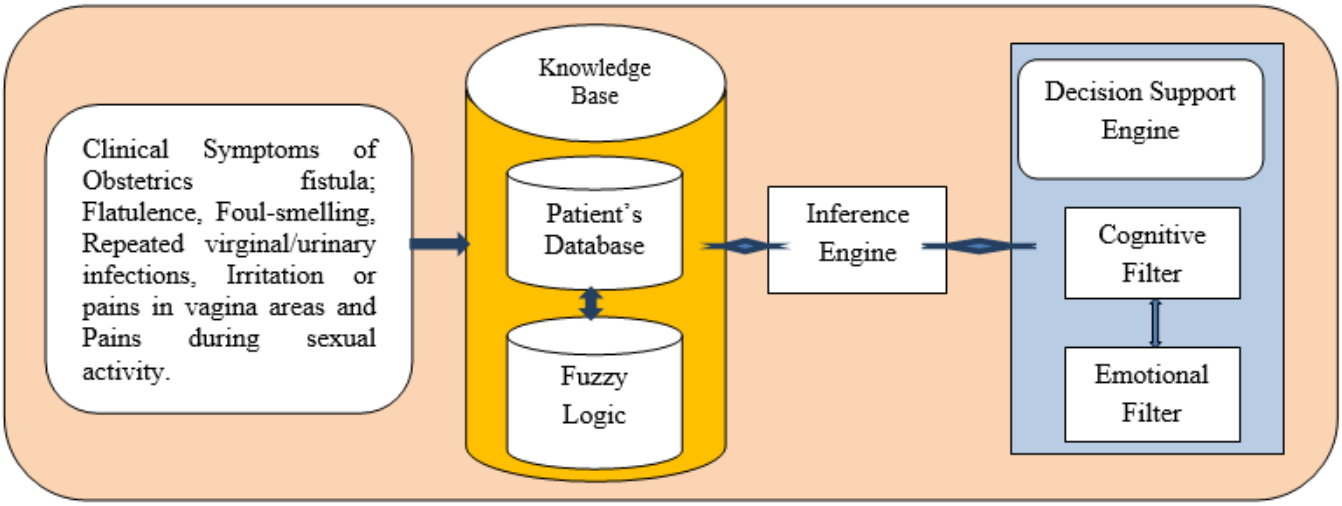

Fig 1: Architecture of Fuzzy Logic for Diagnosis of Obstetrics Fistula

V. RESULTS AND DISCUSSIONS

To design the FCM Knowledge Base System for diagnosis of Obstetrics Fistula, we design a system which consists of a set of parameters needed for diagnosis presented in Table 1, while types of Obstetrics Fistula is in Table 2.

Table.1: Clinical Symptoms of Obstetrics Fistula

SN	Input Field	Code
1	Flatulence	FT
2	Foul-smelling	FS
3	Repeated virginal/urinary infections	RF
4	Irritation or pains in vagina areas	IV
5	Pains during sexual activity	PS

In Figure 1 we presented the architecture of the FCM system for the diagnosis of Obstetrics Fistula. It comprises of knowledge base system, fuzzy c-means inference engine and decision support system. The knowledge base system holds the symptoms for Obstetrics Fistula. The values of the parameters are vague and imprecise hence the adoption of fuzzy logic as a means of analyzing these information. Those parameters therefore constitute the fuzzy parameter of the knowledge base.

The fuzzy set of parameters is represented by 'P' which is defined as P= P1, P2,…,Pn Where Pi represents the jth parameter and n is the total number of parameter (in this case n = 5). The set of linguistic values which is modeled as a linker scale denoted by 'L' is given as L = (Low, Average and High).

Table.2: Types of Obstetrics Fistula

No	Types of Obstetrics Fistula	Description	Cluster code
1	Vesicovaginal	Between the bladder and vagina	VV
2	Rectovaginal	Between the rectum and vagina	RV

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3	Urethrovaginal	Between the urethra and the vagina	HV
4	Ureterovaginal	Between the distal ureter and vagina	TV
5	Vesicouterine	Between the uterus and the bladder	VT

The clustering of the data is achieved using the typical FCM algorithm presented in Fig. 2. Neural networks provide the structure for the parameters which serves as a platform for the inference engine. The inference engine consists of reasoning algorithms driven by production rules. These production rules are evaluated by using the forward chaining approach of reasoning. The inference mechanism is fuzzy logic driven. The cognitive filter of the decision support engine takes as input the output report of the inference engine and applies the objective rules to rank the individual on the presence or absence of Obstetrics Fistula disease. The emotional filter takes as input the output report of the cognitive filter and applies the subjective rules in the domain of Obstetrics Fistula studies in order to rank individuals on the extent of the Obstetrics Fistula disease.

Table.3: FCM membership grade of all patients in all clusters

PNO	C_1 (VV)	C_2 (RV)	C_3 (HV)	C_4 (TV)	C_5 (VT)
P1	0.10	0.35	0.25	0.47	0.08
P2	0.63	0.40	0.17	0.57	0.71
P3	0.09	0.27	0.46	0.62	0.78
P4	0.51	0.44	0.00	0.88	0.05
P5	0.70	0.21	0.82	0.14	0.12

A typical FCM membership grade table (Table3) using 5 parameters and 5 clusters which shows thedegree of membership of each parameter of Obstetrics Fistula is represented in Figure 3. From Table3, it could be observed that from the various degrees of membership there are no unitary (crisp) coefficients, indicating that each data point belongs to more than one cluster. For example P3 = (0.10/c1 +0.03/c2+0.30/c3+0.52/c4+0.05/c5) where c1, c2, …, c5 are clusters, and in this study represents Vesicovaginal fistula (VV), Rectovaginal fistula (RV), Ureterovaginal fistula (TV),Urethrovaginal fistula (HV) and Vesicouterine fistula(VT) respectively. Each of the symptoms highlighted in Table1 is represented with P (starting from 1 – 5, i.e., P1-P5).

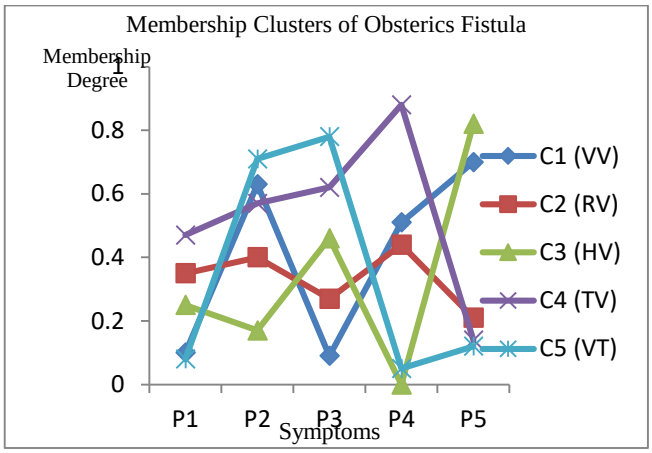

Fig. 2: Membership Clusters of Obstetrics fistula Disease

Finally, Table 3 presents membership grades of parameters in all clusters and the degree of membership of the clusters is presented in Figure 2.Cluster 1 has the highest degree (0.78) for symptom P3, Cluster 2 has the highest degree (0.88) for symptom P4, Cluster 3 has the highest degree (0.82) for symptom P5,and Cluster 4 has the highest degree (0.44) for symptom P4 while Cluster 5 has the highest degree (0.70) for symptom P5.

VI. CONCLUSIONS

The end to the problems associated with the medical diagnosis of Obstetrics fistula diseases is in view, with this research work where the application of fuzzy logic concept to medical diagnosis of Obstetrics fistula disease has been explored. The paper presents a diagnostic fuzzy cluster platform to help in diagnosis of Obstetrics fistula diseases using a set of symptoms and demonstrates the practical application of soft computing in the domain of diagnostic pattern appraisal by determining the extent of membership of individual symptoms. The classification, verification and matching of symptoms to the five groups of clusters was necessary especially in some complex scenarios. The proposed model as experimented can assist the medical experts in the diagnosis of Obstetrics fistula.

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