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# Literature Review on Medical Diagnosis Using Hybrid Fuzzy Logic

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## ABSTRACT

Leishmaniasis is neglected tropical a protozoan infection disease caused by Leishmania parasites. It is broadly classified into two major type such as Visceral Leishmaniasis (VL) and Cutaneous Leishmaniasis (CL). VL (also known as Kala-Azar) is the most severe form of Leishmaniasis, almost always fatal if untreated. In Africa, the worst VL affected region is East Africa especial Sudan and Ethiopia. The annual burden of visceral Leishmaniasis (VL) in Ethiopia is estimated to be between 4,500 and 5,000 cases, and the population at risk is more than 3.2 million. From the total estimation, 60% cases are found in areas of Northwest Ethiopia in Metema and Humera.

In a medical environment, incomplete information and imprecise are driving to making an incorrect medical decision and maximize the rate of morbidity and mortality. Fuzzy logic technology enables to provide a simple way to attain to a certain conclusion from vague, imprecise and ambiguous medical data. Hybridize fuzzy logic with soft computing algorithm recommended to overcome the weakness of one with the strength of the other. Such expert system has a successful tool for building intelligent decision making that would have a human like reasoning capability.

The aim of this article review researches working one hybrid fuzzy logic for medical diagnosis which influenced on maximizing the accuracy medical decision. All the related research work inspires us to design a novel hybrid fuzzy expert system, provide medical diagnosis on Visceral Leishmaniasis.

The researcher will conduct intensive observation at Northwest Ethiopia VL endemic areas such as Metema, Abdurafie and Humera and also we will use domain experts' interview, questionnaires and document review as data collection methods. Finally, the researcher will test a system through system testing and user acceptance to check whether a system gives a significant contribution to health care or not.

**Key word**: Fuzzy logic, Type-I fuzzy logic, Type-II Fuzzy logic, Visceral Leishmaniasis, Expert system

## 1. INTRODUCTION

Leishmaniasis, a parasitology disease caused by more than 20 species and subspecies of the protozoan Leishmania parasites [1]. It is transmitted between humans and other mammalian hosts by female phlebotomine sandflies. Over 90 sandfly species are known to transmit Leishmania parasites [2].

Leishmaniasis consists of four main clinical syndromes: cutaneous leishmaniasis, mucocutaneous leishmaniasis (also known as espundia), visceral leishmaniasis (VL; also known as Kala-Azar); and post-Kala-Azar Dermal Leishmaniasis (PKDL). In cutaneous leishmaniasis, the patient generally presents with one or several ulcer(s) or nodule(s) in the skin. Different species of Leishmania can infect the macrophages in the dermis, with variable clinical presentations and prognoses. Mucocutaneous leishmaniasis leads to a partial or total destruction of mucous membranes of the nose, mouth and throat. Over 90% of mucocutaneous leishmaniasis cases occur in Bolivia (the Plurinational State of), Brazil, Ethiopia and Peru [3] [4].

VL is a systemic disease that is fatal if left untreated and is caused by L. donovani. There are two types of VL, which differ in their transmission characteristics: zoonotic VL is transmitted from animal to vector to human and anthroponotic VL is transmitted from human to vector to human. In the former, humans are occasional hosts and animals, mainly dogs, are the reservoir of the parasite. Zoonotic VL is found in areas of L. infantum transmission whereas anthroponotic VL is found in areas of L. donovani transmission [3].

PKDL is characterized by a macular, maculo-papular or nodular rash and is a complication of VL that is frequently observed after treatment in Sudan and more rarely in other East African countries and in the Indian subcontinent. It can also occur in immunosuppressed individuals in L. infantum-endemic areas. The interval between treated VL and PKDL is 0–6 months in Sudan and 6 months to 3 years in India. PKDL cases are highly infectious because the nodular lesions contain many parasites, and such cases are the

putative reservoir for anthroponotic VL between epidemic cycles [3].

According to (WHO, 2015) report, Leishmaniasis is prevalent in 89 countries across the world, affecting an estimated 12 million people with approximately 2 million new cases per year. More than 350 million people live in disease risk area. The estimated yearly incidence is 0.6–1 million cases of cutaneous Leishmaniasis (CL). Above 95 % CL cases occur in the Americas, the Mediterranean basin, the Middle East and Central Asia. Over two-thirds of new CL cases occur in 6 countries: Afghanistan, Algeria, Brazil, Colombia, Iran and the Syrian Arab Republic. An estimation 0.2 – 0.4 million cases of visceral Leishmaniasis. It is associated with about 2,357,000 disability- adjusted life years (DALYs), 946,000 in men and 1,410,000 in women, representing a significant rank among communicable diseases. [5].

VL is the most severe form of leishmaniasis, almost always fatal if untreated and is characterized by a range of symptoms, including fever, weight loss, anemia, weakness, hepatomegaly, lymphadenopathy and splenomegaly. The incubation period ranges from three to eight months. Infected individuals are therefore unlikely to develop symptoms for several months after infection [3]. An estimated 500,000 to 900,000 new cases of VL occur worldwide each year, and from this, greater than 90% of VL human cases occur in seven countries, namely Brazil, India, Ethiopia, South Sudan, and Sudan, Kenya, Somalia. Eastern Africa has the second highest number of VL cases, after the Indian Subcontinent [4].

Available data from eastern Africa show that the leishmaniasis burden, especially that of Visceral leishmaniasis (VL), is a major problem to public health in the region. Every year, health facilities report thousands of cases and hundreds of deaths, and in epidemic years the toll can be much higher. VL epidemics during the 1980s and 90s killed 100,000 people in Sudan alone. With routine surveillance in the region mostly limited to passive case detection at a few health facilities equipped to diagnose and treat the disease, the current morbidity and mortality figures likely underestimate the regional leishmaniasis burden. Prevalence surveys in a few sites and epidemiological simulations indicate that there is a large underlying pool of infected and infectious individuals [6].

Ethiopia is one of the ten high burden countries for Leishmaniasis. VL is predominantly found in the lowlands with varying degrees of endemicity. It is estimated that the annual burden of VL ranges from 4,500 to 5,000 cases and population at risk is more than 3.2 million. Some of the factors found to be associated with the spread include population movements to and from endemic focus areas, poverty and malnutrition associated with presence of the sandfly vector and reservoirs [7] [8].

In Northwest, the most important VL endemic areas are found in Metema and Humera lowlands, which accounts for approximately 60% of cases in the country. These endemic areas lay in Amhara and Tigray regional states, bordering to Sudan and Eritrea that are known in agro ecological zones, with wide open plains covered by bush scrubs and Acacia woodland. The woodland cover is in process of being replaced by extensive commercial agriculture that produces sesame and cotton as the main cash crop.

VL remains endemic in Humera-Metema foci and even in recent years Medecins Sans Frontieres (MSF) treatment centre treated 2000 to 5000 VL cases per year at one point in time. Recent spread beyond the Metema and Humera plains to villages in Tahtay Adiabo district and Sheraro Kebeles, Welkaite and Armacheho districts in the Tigray and Amhara regional states have been reported. Especially in villages of Sheraro VL claimed the lives of hundreds and remains circulating since its first investigation. Returning daily labourers from VL endemic areas of Humera and Metema are believed to introduce the parasite in Sheraro focus . In 2007 around 2450 primary cases have been reported since the beginning of the outbreak with the majority of cases being treated at Addis Zemen health center, run by MSF. The rapid spread of the disease was attributed through misdiagnosis of cases with drug-resistant malaria, which is endemic in the area [9] [10] [11].

In recent years, an expert system has been used to solve many complex problems by developing intelligent systems and fuzzy logic has proved to be a powerful tool for decision-making systems, such as expert systems and pattern classification systems. Fuzzy set theory has already been used in some medical expert systems. In traditional rule-based approach, knowledge is encoded in the form of antecedent-consequent structure. When new data is encountered, it is matched to the antecedents clauses of each rule, and those rules were antecedent match a data exactly are fired, establishing the consequent clauses. This process continues until the desired conclusion is reached, of no new rule can be fired. In the past decade, fuzzy logic has proved to be wonderful tool for intelligent systems in medicine. Knowledge based systems at the department of medical computer sciences pursue methodological research in and practical development of knowledge based computer systems to assist in the decision making processes for all areas of medical application [12] [13].

Using fuzzy logic becomes the current trends of researchers. According to [11] fuzzy logic is useful for real world problem where there are different kinds of uncertainty. One kind of uncertainty is fuzziness that is no sharp transition from complete membership to non-membership. In human reasoning much of the logic is not based on two values, it is not even multi-valued but fuzzy truth. In conventional logic everything is considered true or false, black or white but nothing in between. Fuzzy logic on the other hand takes into consideration all values in between. This types of uncertainty

are mostly observed in medical cases during diagnosis, because the symptoms and related signs of the patients are subjective, which are not able to be expressed in the conventional logic. In one symptom, there are different levels of measurements in between. Because of this fuzzy logic is appropriate for medical cases. Fuzzy logic is based on fuzzy sets; a fuzzy set is a class of objects with continuum grades of membership" [13].

A fuzzy set is an extension of a conventional set. It has elements belonging to it to some degree of membership. This degree varies from 0 to 1. In conventional logic, the degree of membership is either 0 for non-membership or 1 for complete membership. Fuzziness results from imprecise boundaries of fuzzy sets. It is based on emulating human thinking where elements are linguistic variables. Linguistic variables are variables whose values are sentences not numbers. Fuzzy sets are actually properties and fuzzy logic provides a way of finding conclusions for ambiguous inputs. Fuzzy sets represent common sense linguistic labels like slow, fast, small, large, heavy, low, medium, high, tall, etc. A given element can be a member of more than one fuzzy set at a time [14].

Various types of fuzzy membership functions are used, including triangular, trapezoidal, generalized bell shaped, Gaussian curves, polynomial curves, and sigmoid functions. According to Siler and Buckley, fuzzy knowledge base systems are categorized into two types. First is fuzzy control system, which accepts inputs as numbers. The input number is then translated into a linguistic term. In fuzzy control systems, the application domain is defined. The second type is fuzzy reasoning, which is a system that attempts to emulate human thinking where the domain is not defined. Such a system deals with numbers and linguistic variables. So now a day fuzzy logic is an appropriate tool in order to develop knowledge base systems for conditions with different uncertainty or values in between, like linguistic variables [15].

Type-1 and type-2 fuzzy sets were introduced by Zadeh in 1965 and 1975 respectively. Both are handling the process/manipulate data and information affected by uncertainty/imprecision. In especially type-2 fuzzy sets were essentially 'fuzzy fuzzy' sets where the fuzzy degree of membership is a type-1 fuzzy set [16] [17].

Nowadays information communication technology grows rapidly and is being applied in different areas so as to increase the productivity, quality of service, efficiency and effectiveness of the organization. This proposal will show the importance of information communication technology on improvements of medical and health sectors of the country by modelling and developing a mobile-based knowledge base system to facilitate continuous healthcare service provision for identifying diseases and making intervention mechanism.

Leishmaniasis represents a complex and heterogeneous disease that emerged as epidemiologically important infection in Ethiopia. Over the years the burden is increasing and spreading out to new sites pausing several unanswered questions that make control of the disease more difficult [18]. Visceral Leishmaniasis is a higher priority than CL as it is a fatal disease if left untreated [1].

According to the FMoH [10], global Leishmaniasis estimate, Ethiopia is one of the ten high burden countries for VL. VL is predominantly found in the lowlands with varying degrees of endemicity. It is estimated that the annual burden of VL ranges from 4,500 to 5000 cases. Some of the factors found to be associated with the spread include population movements to and from endemic focus areas, poverty and malnutrition associated with the presence of the sandfly vector and reservoirs [10].

The endemicity of VL was recently extended to at least five administrative regions, namely, Amhara, Tigray, Southern Nations Nationalities and Peoples' Region, Oromia and Somali. In addition, there have been recent outbreaks in northern and southern parts of the country: Libo Kemkem Woreda in Amhara region, T/Adiabo Woreda in Tigray region and Imey in Somali region. The tendency of the disease to spread to new areas was also noted, as in the case of the Silte outbreak [10].

Currently, efforts are undergoing in risk mapping of the disease throughout the country. The most important VL endemic areas in Ethiopia are found in the northwest (Metema- Humera lowland), which accounts for approximately 60% of cases, and in southwest Ethiopia (Lake Abaya, Omo river plains and Segen and Woito valleys). The spread of VL to unusual highland habitats and new foci was hypothesized to have been due to the introduction of the parasite, probably on multiple occasions, by migrant agricultural labourers returning to their villages from seasonal work from VL endemic areas [19].

The government of Ethiopia, like other Leishmaniasis endemic countries, has been taken many steps pushing forward the response to disease and many lives saved as a result. However, there remains a great need for increased preventative measures and accessibility to early diagnosis and effective treatment if the disease is ever to be eliminated [10].

According to FMoH, 2013 report, in Ethiopia VL epidemiology remains complex because of the diversity of risk factors involved, and its control is becoming an increasing challenge. Information regarding Leishmaniasis is inadequate in developing countries and surveillance systems for Leishmaniasis are poorly established. Therefore, data collection and their analysis for monitoring and evaluation of the program is a crucial aspect.

According to "Visceral Leishmaniasis Diagnosis and Treatment Guideline for Health Workers in Ethiopia, 2013 the treatment of the disease is poorly established because of most of the rural health worker treats the Leishmaniasis like one of resistance tropical diseases like malaria and tuberculosis. In the result of this many people are died.

On the time of the researcher observation, at Metema and Abdurafie. There is the scarcity of senior experienced medical doctors, resident health workers are not capable enough to provide appropriate medical diagnosis and treatment for patients.

In addition to this, these health works are not well trained and experienced in this specific disease. Due to this, most of the patients prefer to come to Gondar where senior health works are available which costs the patient more money. The researcher also interviewed patients in the Research and Treatment Center of Visceral Leishmaniasis that founds in the University of Gondar Hospital by asking why they prefer to come to Gondar and they replied that the health care service in places where VL is endemic is not good enough to cure them.

In order to help health workers to upgrade their knowledge and experience and give high level medical health care services and treatment, developing a Knowledge Base System that gives advice about how to identify the VL disease among the common tropical disease and how to treat it, therefore, they would play a critical role to save many lives.

Developing a knowledge based system would reduce the repetition of task, the burden of human expert and waiting time of patient in the hospital. The knowledge based system could be used to assist human expert by providing the required knowledge at the right time for decision making.

According to Global health,2014 report [20] ,identify technology gap is one of the priority research area to eliminate Visceral Leishmaniasis. Therefore, this study is technological approach to solve the problem of VL diagnosis confusion and mange treatment track.

In medical problems, using fuzzy logic system is more recommended, because it can able to solve problems like which are more subjective. The symptoms of the patients are difficult to identify by using other reasoning mechanisms like rule based and case based. The problem is that those reasoning mechanisms depend on the specific rules given or on the specific cases developed. Conditions in between the two ranges cannot be identified by rule based and case based rather it is easy in fuzzy logic. Fuzzy logic is able to consider values in between and linguistic expressions [16].

Transformation of KBS into a mobile-based solution would extend their benefits, facilitate and integration into medical environments. It can also play a major role by providing support in common clinical problems like prediction of diseases, prevention of diseases, diagnosis of diseases, provision of patients with medical information [21].

Nowadays, mobile phones are the most popular and widely used means of communication for their compact size, versatility, wireless communication, increasing capabilities and ease of handling [21].

Hence, the proposed mobile based expert system will be supported tools to health care worker for diagnosis VL. The system primarily contains knowledge and experience of specialized doctors' full knowledge and make it real advancing system for those health workers which serves as means of easy ways of knowledge transfer. Therefore, the community of Ethiopia get timely diagnosis and treatment, this is a good opportunity to enhance the quality of health care who lives rural areas and achieving the goal of Millennium Goal.

This paper is organized as section 2 describes the literature review and related work for our research field. Section 3 summarizes the importance of our research and conclude the related work.

## 2. LITERATURE REVIEW

### 2.1 Nature And Feature Of Visceral Leishmaniasis

Leishmaniasis is one of the world's most neglected diseases and affects the poorest of the poor. It is reported from around 89 countries. Over 90% of cases of visceral Leishmaniasis (VL or kala azar, KA) are found in India, Bangladesh, Sudan, South Sudan, Brazil and Ethiopia; 350 million people are considered at risk of contracting Leishmaniasis, and some 2 million new cases occur yearly [22].

The Leishmaniasis are generally subdivided in Old World and New World Leishmaniasis, where the Old World represents all countries except the America's; Old World Leishmaniasis is caused by parasites of the subgenus Leishmania whereas in the America's it is mostly caused by parasites of a different subgenus (Viannia). Different parasite species are implicated in Old and New World Leishmaniasis [23].

Sandflies feed on animals or man. While taking blood meals, the female sand flies may ingest Leishmania amastigotes from the skin or blood of infected animals or man. Within the sandfly the parasite develops in approximately one week into an infective promastigote (flagellate form). Female sandflies, needing protein for their eggs, also take a nocturnal blood meal and this is when Leishmania infections are acquired and transmitted [24].

The VL foci from which clinical cases are reported differ in their eco-epidemiology and the sandfly vectors involved. Currently, VL transmission is known to occur in three different ecological settings, spanning from lower Kola to the Woina Dega ecological zones (Figure 1)[25].

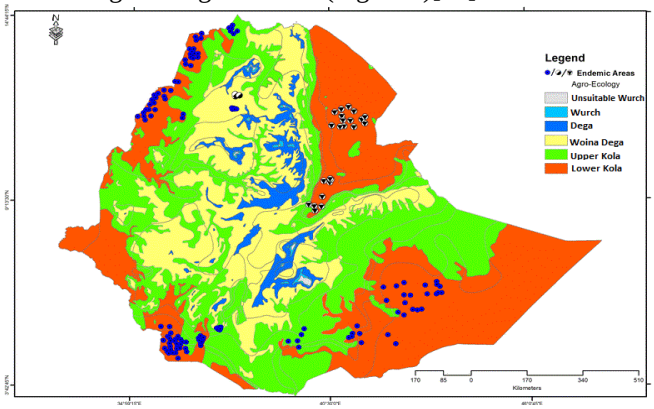


***Figure 1***:-Endemic foci of visceral Leishmaniasis. *[25]*

### 2.2 Risk Factor For VL Infection In Ethiopia

Studies shown that most of east African VL is more closely related to the movement of seasonal workers and new settlements to endemic or highly risk transmission zones [1]. This is hampered by poor working conditions and infrastructures provided for labourers [11]. It generally result humans into contact with natural vectors and increased infection rates. East African VL caused by L. donovani is being considered as anthroponotic [26].

Studies in VL the soil (black cotton soil), vegetation type (Acacia-Balanite vegetation), presence of termite hills and migration to endemic foci for seasonal agricultural work, different behavioural, household and environmental factors have been implicated as risk factors for VL in Ethiopia. All these factors increase the contact between man and sand flies [27] [28] [29].

There is not clear cut studies in Ethiopia about the information on a different transmission route of VL. According to Yared et al., 2014 study that conducted in Northwest Ethiopia, Humera endemic focus similar scenario documented that goat ownership and sleeping near dogs was among the odds for clinical VL [30]. In neighbouring country Sudan where VL due to L. donovani is one of a public health problem, dogs and rodents are considered as risk factors for disease transmission [31] [32] [33].

### 2.3 Diagnosis and Treatment of VL

Most medical diagnosis are includes clinical and laboratory diagnosis. VL clinical diagnosis has been demonstrated to be highly unspecific, imprecision and uncertain. According to FMoH, 2013 VL clinical diagnosis based on case definition “a person who presents with fever for more than two weeks and an enlarged lymph nodes (lymphadenopathy), or either loss of weight, anemia or leucopena while living in a known VL edemic area or having travelled to an endemic area”. Therefore, clinical suspicion of KA /VL must always be followed by a demonstration of the presence of the parasite either directly (microscopy) or indirectly (serology) [10].

Laboratory test will be able to make distinction between acute or asymptomatic infections. Test include different kinds such as non-Leishmanial tests, parasite detection, antibody detection, antigen detection and molecular techniques [34].

VL treatment have different kinds based on the patient severity. They are First-Line Treatment Regimens for Primary VL, Second-Line Treatment for Primary Visceral Leishmaniasis and Treatment of VL Relapse. The First-Line treatment is applied by combines Sodium Stibogluconate (SSG) & Paromomycin therapy or Sodium Stibogluconate (SSG) or Meglumin Antimoniate (Monotherapy) or Liposomal Amphatericin B (LAmB,AmBisome). The second-line VL treatment are strong idecations like drug toxicity, relapse, treatment failure and very severe illness but treatment should be stop when see sever vomiting. Liposomal Amphotericin B (AmBisome), Miltefosine and Paromomycin (Aminosidine) are drugs treatment in second line treatment. Final treatment is VL Relapse treatment. It is treatment which applied when a patient does not cure from parasite at time of check-up, after having been successfully treated from first and second line treatment [10] [1] [35].

### 2.4 Fuzzy Logic

Fuzzy logic theory was formalized by Professor Lofti Zadeh at the University of California in 1965 [36].Theory of sets is one of the important tools in modern mathematics. A set is a collection of similar type of distinct objects known as the element of the set. It deals with “degrees of truth” rather than absolute values of “0 and 1” or “true/false”. Fuzzy logic is not like a computer software which understands only binary functions or real values like 2.5, 2.8, etc; instead, it is like to human intelligent and clarification and gives meaning to expressions like “often”, “smaller” and “higher”.

Fuzzy logic takes into account that real world is complex and there are uncertainties; everything cannot have absolute values and follow a linear function [37]. On one hand, logic is more than bi-valued logic. In fact, many-valued logic is part of logic and allows infinite truth values. On the other one fuzziness measures the range of values of truth-ness that we can assign to some sentence and this range can be given a credibility so there is always a set of values that we can trust. Together we talk about fuzzy logic, logic that can be used to reason about fuzzy information and provide results with a credibility.

According to Zadeh in 1992 [38], fuzzy logic has the following principles:-

- Exact reasoning is viewed as a limiting case of approximate reasoning.
- Everything is a matter of degree.
- Knowledge is interpreted as a collection of elastic, fuzzy constraints on a collection of variables.
- Inference is viewed as a process of propagation of elastic constraints.
- Any logical system can be "fuzzified".

In medical environment /diagnosis precise and certain are driving force to come up an actual decision. Fuzzy logic technology provides a simple way to arrive at a definite conclusion from vague, imprecise and ambiguous medical data. Visceral Leishmaniasis clinical diagnosis symptoms are very related to many types diseases such as malaria, hyperactive tropical splenomegaly, Typhoid fever, Typhus, Brucellosis, Schistosomiasis, Military tuberculosis, HIV/AIDS, Leukaemia.

The cases that are defined in VL clinical diagnosis case definition are not consider value /degree between the ranges rather it considers yes and no. Therefore, the diagnosis is so difficult to make medical decision but Fuzzy logic is able to consider values in between and linguistic expressions.

Fuzzy logic allows handling much of uncertainty. The amount of uncertainty in a system can be reduced by using type-2 fuzzy logic because this logic offers better capabilities to handle linguistic uncertainties by modelling vagueness and unreliability of information [39] .

### 2.4.1. Type-1 Fuzzy Logic

Type-1 fuzzy set introduced by Zadeh in 1965 [40]. It is successful method of modelling uncertainty, vagueness and imprecision more than forty years. The use of type-1 fuzzy sets in real computer systems is extensive, particularly in consumer products and control applications.

Type-1 fuzzy logic using crisp input and precise fuzzy set for model the user behaviour under specific conditions. Type-1 fuzzy sets can handle uncertainty by utilizes precise membership functions which is uncertainties for user as them believes. As soon as the type-1 membership functions had been selected, all the uncertainties disappears, due to the type-1, membership functions are totally precise. Even if, It has been applied more than forty years and success full many different applications. It has limitation to cope with large amounts of uncertainties of the real world. Real world applications are characterized by high levels of linguistic and numerical uncertainties. Hence, the traditional type-1 using type-1 sets cannot directly handle such uncertainties to produce a new generation of fuzzy controllers with improved performance for many applications, which require high level of uncertainties [41].

Type-1 FLSs cannot fully handle the high level of uncertainties available in the vast majority of real world applications. This is because type-1 FLSs employ crisp and precise type-1 fuzzy sets. A type-2 FLS can handle higher uncertainty levels to produce improved performance [41] [42].

### 2.4.2. Type-2 Fuzzy Logic

Type-2 fuzzy sets, introduced again by Zadeh in the year 1975, are used for modelling levels of uncertainty and imprecision in a better way which traditional fuzzy logic(type-1) struggles [43]. Later in the year 2001, Mandel introduced a new concept which type-2 fuzzy set can be characterized with an upper membership function and a lower membership function [44]. The interval between these two functions represents the footprint of uncertainty (FOU). It is used to verbalize the shape of type-2 fuzzy sets it implies that there is a distribution that sits on top of that shaded area as sown on figure 2. The FOU provide additional degree of freedom that can make it possible to directly model and handle the uncertainties. Hence, type-2 fuzzy sets have the potential to handle high uncertainty levels than their type-1 fuzzy sets [45].

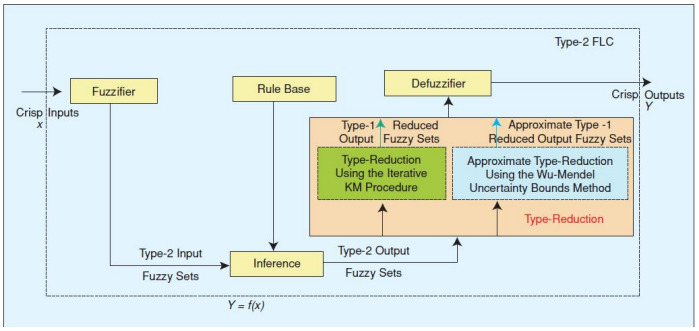


**Figure 2**: The interval type-2 FLC [41]

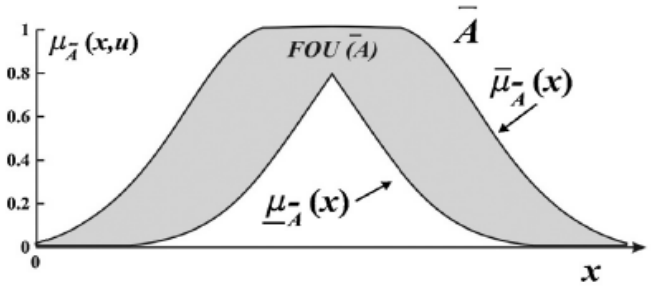


**Figure 3**: Interval type-2 fuzzy set [45]

### 2.5 Overview Fuzzy Expert System

The Expert system is derived from the field of artificial intelligence as well as one of the main family members. Artificial intelligence intends to understand human

intelligence behaviour like cognitive skill thinking, problem solving, learning, understanding, emotion, consciousness, intuition and creativity and building of computer programs that are capable of simulation or acting one or more of those behaviours [46].

Expert systems are designed to solve complex problems at the level of a human expert by using specialized knowledge represented a set of rules. A fuzzy expert system (FES) is an expert system which include set of fuzzy rules and membership functions [47].

A fuzzy expert system is an expert system, which consists of fuzzification, fuzzy logic inference, knowledge base (combination of fuzzy rules and database), and defuzzification subsystems [48].

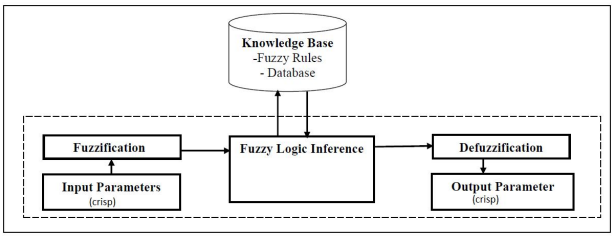


**Figure 4:** Architecture of fuzzy expert system [48]

### 2.6 Related work

Several numbers of researches have been conducted on design fuzzy expert model for the diagnosis and treatment of diseases. Some of them that are related to the proposed problem discussed here below:

In [49] this study attempts to do a case comparison of the fuzzy and Analytic Hierarch process (AHP) methods in the development of medical diagnosis system, which involves basic symptoms elicitation and analysis. The fuzzy logic is able to handle vagueness and unstructured in decision making, while the AHP has the ability to carry out pairwise comparison of decision elements in order to determine their importance in the decision process [50]. AHP is good in processing multidimensional and hierarchically structured data which calls for the relative importance of criteria groupings. This feature is not found in fuzzy logic methodology, which handles vague and imprecision of data and moreover it resembles human decision making with its ability to work from approximate reasoning and ultimately find a precise solution. The study conducted for malaria diagnosis. Final the study concluded that the fuzzy logic shows a better but non-statistically significant performance over the AHP methodology, and is better utilized in the building of the entrant module in a hybrid system involving both methodologies.

Many intelligent systems have been developed by applying the hybrid algorithm. In [51] this research proposes a Hybrid Intelligent System driven by Neural Network and Fuzzy Logic to provide a decision support platform that will assist medical practitioners in the efficient diagnosis of Typhoid Fever. Fuzzy logic (FL) handles imprecise and incomplete medical data where as a Neural Network (NN) component which automatically generates the parameters that drive the Membership Functions of Typhoid Fever diagnosis variables for the Fuzzy Inference System. Hybridization of NN and FL provides a solution that is capable of integrating the strength of both techniques and eliminating their weaknesses. The hybrid technique provides a method that allows the NN modelling procedure to learn certain information about a given dataset in order to automatically compute the MF parameters that best drives the associated FIS [52]. However, each of them has advantages and disadvantages. It is therefore appropriate to hybridize these two techniques so as to overcome the weakness of one with the strength of the other. There has been an increasing need to combine NN and FL for a successful development of an ES that would have a human like reasoning capability [53]. NNs derive their strengths from the ability to generalize data relationship and their ability to handle data with non-linear relationship as those found in medical records while FL help in handling uncertainty found in medical data.

Importantly, medical diagnosis system classification have been widely utilized for explore patient's data and predictive model. Mostafa F. and Mohammed S. developed a new hybrid fuzzy classification algorithm, which was obtained by utilized Ant colony optimization classification algorithm and fuzzy logic for diabetes disease diagnosis, called FCS-ANTIMINER. This model more efficient for diabetes disease classification related problems, they obtained 84.24 % accuracy. Being medical decision, it is generally acceptable to maximizing the accuracy. Hence, One of the challenge of this study score low accuracy [54].

From few fuzzy diagnosis systems on tropical disease [51] study conducted diagnosis of Typhoid Fever (TF). This study applied a hybrid Intelligent System engineered by Neural Network and Fuzzy Logic techniques for the diagnosis of TF. Fuzzy logic handles imprecise and incomplete medical data, a Neural Network (NN) component which automatically generates the parameters that drive the Membership Functions of TF diagnosis variables for the Fuzzy Inference System. The limitation of Neural Network has lack of specific methods to determine the optimal number and connection weights for hidden layers and their respective nodes necessary for a particular problem. Hence, optimization techniques recommended for improve the performance of the proposed system.

[47] presents a Particle Swarm Optimization (PSO) with fuzzy logic system for the diagnosis of Coronary Artery Disease (CAD). PSO was applied to tune the fuzzy membership functions for enhance the performance. They

used Decision Tree (DT) to select important attribute from large datasets and also used for convert crisp rules into fuzzy values. However, the study selected 13 attribute from 76 attributes via many published experiment literatures, it will be recorded better performance to applying machine learning techniques on filtering important attributes from large dataset.

A work on fuzzy expert system for the management of malaria (FESM) was executed in [48]. The concerned system was described as capable of providing decision support platform to malaria researchers, medical doctors and other healthcare practitioners in malaria endemic regions. This developed system was composed of knowledge based, the fuzzifier, the inference engine and defuzzifier. The developed used a triangular typed membership function for the fuzzification of scalar inputs, a fuzzy inference method of root sum square (RSS) and finally, the defuzzifier employed the popular and effective center of gravity method of defuzzification. In this study 35 selected patients of malaria were diagnosed.

In [45], an interval Type-2 fuzzy were used to recognized patterns of Fatal Heart Rate (FHR) for predicting fatal well-being in medical antenatal care system. The output of the study is a system that used for classifying diagnosis of fatal health. As per researcher knowledge, few kinds of researches are conducted on the combination of soft computing techniques (hybrid) that play vital role in the improvement of the system performance of IT2FLS. For example, Najafi et al. [55] used fuzzy C-means (FCM) clustering algorithm to improve the performance of IT2FLS in the classification of Celiac Disease (CD). Rahil et al. [56] was employed genetic algorithm for tuning of the Membership Function (MF) parameters and footprint of uncertainty in order to improve the performance of IT2FLS classifier which is a lung computer aided detection (CAD) system for classification of nodules

## 3. DISCUSSION

As we have discussed on related work, fuzzy logic and soft computing are playing great role on medical decision like VL that have uncertainty physical medical diagnosis manifestation and high fatal disease. Therefore, due to high uncertainty in the medical data, Type-2 fuzzy (IT2FLS) is able to consider much linguistic uncertainty and considering the uncertainty in the membership functions. In addition, it is a new and current method in medical diagnosis.

Hence, the proposed mobile based expert system will use Novel Hybrid Type-II Fuzzy logic (NHIT2FLS) approach. The approach combinations of Type-II, Neural Network and Ant Colony techniques. The system will be supported tools to health care worker for diagnosis VL. The system primarily contains knowledge and experience of specialized doctors' full knowledge and make it real advancing system for those health workers which serves as means of easy ways of knowledge transfer. Therefore, the community of Ethiopia get timely diagnosis and treatment, this is a good opportunity to enhance the quality of health care who lives rural areas and achieving the goal of Millennium Goal.

We researchers proposed new mobile based VL disease diagnosis with noble hybrid fuzzy approach which is mention on below figure 4.

## 4. CONCLUSION

The main objective of this article is written to discuss the power hybridize fuzzy logic with other soft computing algorithm in medical diagnosis. The paper also proposed a

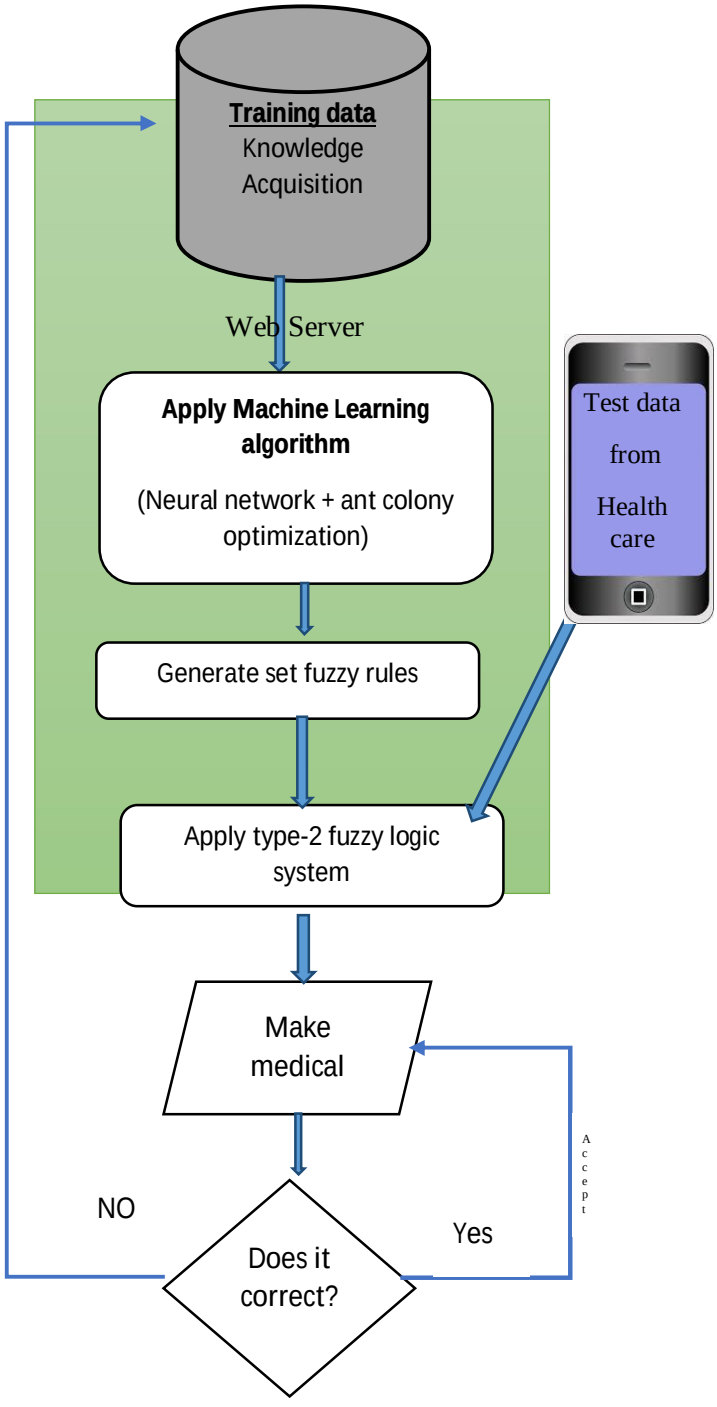


**Figure 4**: The proposed design

novel approach on hybrid fuzzy logic expert system on disease diagnosis of Visceral Leishmaniasis.

Ethiopia is one the ten high burden countries for VL, estimated 2,000-4,500 annual cases. Above 60% VL endemic areas are remote or rural areas as well as the VL is disease transmitted human to human via female sanyfile. Still now there is not mechanize to protect /handle the vector reproduction [19].

Ethiopia, almost Africa has very limited senior human doctors. Even though they are short in number, many educated man powers particularly senior doctors and nurses are not willing to go to places where VL is endemic due to the above problems, persons who are infected with VL are left untreated. In addition to this, patients could not go to places where VL diagnosis and treatment is available because it costs them huge amount of money.

Due to this, Health education or promotion is a core element of any disease prevention and control program. The target group for health education might include public health managers, health staff, community health workers and leaders, people living in endemic areas and patients. In Ethiopia, the introduction of the health extension program is quite helpful for disease control programs with strong activities on the community level [10].

However, these health workers who are included in the health extension program are not capable enough to give appropriate medical health care services and treatment for patients because the knowledge of these persons about how to diagnosis a person with VL and give treatment is not adequate enough to give high level medical health care services and treatment. Due to this, most of the patients prefer to come to Gondar where senior health works are available.

Therefore, in order to combat this problem developing and implementing an expert System that provides advice to health workers would play a great role because expert system provides the high-quality performance which solves difficult problems in a domain as good as or better than human experts and can possesses vast quantities of domain specific knowledge to the minute details [57] [58] which can in turn serve as means of knowledge and experience transfer because the ability of the intelligent systems to capture and redistribute expertise has significant implications on development of a nation, commodity or population. In addition to this, such systems allow documentation of one or more expert knowledge and utilize the knowledge for problem solving in cost effective way. It allows for, in a controlled manner, the import of expertise in various areas that the nation lacks, the export of knowledge relating to domestic areas of expertise, and the duplication and redistribution of scarce knowledge in a cost effective manner. Thus areas of expertise that the selected domain/region/nation is deficient in or possesses exclusively are potential candidates of the knowledge-based systems [58].

Nowadays the technology shift into mobile because the mobile device is no longer an island device but is rather fully connected to other personal devices [such as a personal computer (PC), tablet, or television (TV)] and data/information, enabling seamless and continuous transition between devices, where each device simply provides a different modality and view into a central repository of data/information in the cloud.

Generally, most of the mobile devices are more appropriate tools and have become an inseparable part of our life, so as the need for mobile-based healthcare service becomes substantial as it integrates healthcare more seamlessly to our everyday life. Finally, this paper expected to address its long run aims provided mobile based expert system to health worker.

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