

Use And Abuse Of Fuzzy Logic: Ethical Implications And The Nigerian Medical Practices.

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Abstract

This research investigates the ethical implications of the use and abuse of fuzzy logic in medical practice from a Nigerian perspective. In order to address the aim of this research appropriately, expository and analytical methods of research are employed to understand the dynamisms of use and abuse of fuzzy logic among Nigerian medical practitioners. Expository method serves to uncover the use of fuzzy logic in medical practice while analytic method gives a critical appraisal of the ethical implications in the abuse of fuzzy logic. Fuzzy logic is a multi-valued logic which describes the possibility of many truth values beyond just two-valued logic of yes and no. Fuzzy logic is a dependable support to scientific investigations and it serves medical practices in the following; health data gathering, diagnosis and decision making, analysis of Computer Tomography Scan, Magnetic Resonance Imaging (MRI), segmentation, feature extraction, specimen examination, etc. The use of fuzzy logic in medical practice is evaluated minding the following ethical demands; benevolence, non-maleficence, autonomy and justice. The use of fuzzy logic in medical diagnosis and treatment encounters challenges as follows; medical decisions from indirect indications, imprecisions, generation of wrong fuzzy data from inefficient equipment, presumptuous diagnosis, scrupulosity, compensational treatment, etc. The implication of this research is a clarion call on health workers to shun the flagrant abuses in the use of fuzzy logic in medical practice and the government to strengthen medical legal system in order to regain the confidence of the society in the medical system.

Keywords: Fuzzy logic, Medicine, Ethics, Nigeria, etc.

Understanding Fuzzy Logic

Logic refers to the science of good reasoning. A formal discussions on logic developed from the time of Aristotle, the great and ancient philosopher. From this early time, logic was only interested in the basics of Aristotelian syllogism, laws of thought; identity, excluded middle and non-contradiction, etc. It was in the modern time that logic developed to other forms such as fuzzy logic. Fuzzy logic is one of the major areas of modern logic and it is popularly known as multi-valued logic. It is a multi-valued logic because it describes the possibility of many truth values about particular issues. Truth values here referred may be in truth variables of real numbers between 0 and 1 such that reality must not either be yes (1) or no (0)¹. This type of logic uses words like partial truth in cases where truth values may have ranges between completely true and completely false. Fuzzy logic is designed to solve problems by considering all available information within a defined range and making the best possible decision minding rule-based programming.

Fuzzy logic shows possibilities of values between 0 and 1 such as; 0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0. In logic, if 0 means 'no' and 1 means 'yes', then 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9 cannot be said to mean 'yes' or 'no' rather these numbers will either describe the degree of 'yes' or the degree of 'no'. Here variables ≥ 0.5 show different degrees of a 'no' answer while variables ≤ 0.5 show degrees of a 'yes' answer. This form of logic is a direct attack on absolutism of truth, hence leading to the possibility of many truths. Similarly, it attacks the absolutism of falsehood, hence leading to partial truth and partial falsehood. Quite unlike Fuzzy logic, Boolean logic gives truth values which have only two integers/values of 1 or 0 that is, yes or no.

Fuzzy logic was introduced as a type of logic by the Iranian mathematician, Lotfi Zadeh in 1965 in his study of fuzzy set theory². Fuzzy set was informally defined as uncertain sets. It is referred as uncertain set because it contains sets whose elements have different degrees of membership, hence making the set itself highly imprecise. Here the membership functions of a fuzzy set A is noted by μ_A . Thus μ_A implies all the different variables in numeric or textual forms that are components of the set of A. All the numeric or textual values that form a set are referred as the membership set. It is imprecise because the set can be defined from the different membership functions of the set, hence leading to ambiguity and indistinctiveness in set definitions. It is a form of generalized classical set having many membership functions. This can be referred as bioinformatics, bivalent or crisp set in which a range of domains of information is incomplete and imprecise.

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Sometimes, fuzzy logic is confused with probability logic. It ought to be noted that the degree of truth in fuzzy logic and probability logic are conceptually distinct³. While probability logic has only two outcomes of true or false; fuzzy logic handles linguistic information extending beyond just true or false to partial truth functions or variables. Fuzzy logic was developed from the background of the decisions people make based upon partial and imprecise data/information. Thus this form of logic represents, interprets, manipulates or recognizes vague or uncertain information.⁴ For instance, to the concept 'yes', one can say, "strongly yes" another would say, "perhaps yes" another may say, "I think yes". A typical numerical application of a fuzzy logic solution can be seen in the following weather description:

- ✓ Very sunny with rare clouds (0.9)
- ✓ Moderately sunny (0.8)
- ✓ Partly sunny and partly cloudy (0.7)
- ✓ Mildly sunny but very cloudy (0.4)
- ✓ Very cloudy but rare sunny (0.2)

This shows the possible values to be considered in order to develop an integral or holistic understanding of the weather situation in various conditions. Thus the range of numbers from 0.2 to 0.9 shows the range of possible outcomes of the weather. It is partially sunny and cloudy if the variable is up to 0.7 but moderately sunny if its reading 0.8 and very sunny and rare cloudy if the reading is 0.9. In all these situations, the weather can simply be said to be sunny but the degree of sun varies. These values describing the set of weather condition can be said to be the membership set of sunny weather condition.

Fuzzification and Models of Medical Diagnosis.

Over years, fuzzy logic has proven to be a dependable instrument in different areas of scientific study on ecology, nuclear science, stock market, weather, geography, behavioral sciences, ethics, etc. For the most part, fuzzy logic has become a veritable tool in medical practice. It has been of high medical support to diagnostic systems, monitoring of patients in overcrowded emergency rooms, decision making and treatment of different pathologies; typhoid, cancer, rheumatoid arthritis, osteoporosis, heart disease, anesthesia, blood pressure, insulin for diabetes, general monitoring, etc. Fuzzification implies the assignment of numerical values or linguistic variables/definitions to fuzzy set with degrees of membership. This degree of membership is any value or definitions between 0 to 1 such as 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, and 0.9. These values represent the degree of uncertainty or imprecision in fuzzy set. Thus fuzzification can be said to be the process that determines the degree of membership to fuzzy set. Fuzzification has become a veritable tool in the field of medical practice as medical practitioners apply numerical values or linguistic variables of fuzzy logic in medical diagnosis and analysis as follows:

Minor $0.1 < x < 0.4$

Moderate $0.4 < x < 0.6$

Severe $0.6 < x < 0.8$

Very Severe $0.8 < x > 1.0$

The transcription of the numerals above shows that when the value of x is between 0.1 to 0.4, the situation can be said to be minor and almost negligible. If it is between 0.4 to 0.6 then the situation is said to be moderate. Also, when the value of x is between 0.6 to 0.8 then it is said to be severe while any value of x above 0.8 is referred as a very severe situation needing emergency attention.

Fuzzy logic is an indispensable factor in medical diagnosis and decision making. Fuzzy logic based approaches could be applicable in medical and health data gathering, diagnosis, history taking, drug prescription, treatment method and decision making. Also, Fuzzy logic is a veritable tool in medical image computing and analysis. Medical image computing and analysis is an important interdisciplinary zone of medical diagnosis. It brings the intersection of computer science, information engineering, physics and medicines into mutual understanding⁵. Computational and mathematical methods are applied towards the analysis of medical images for biomedical research and clinical care. Thus medical image computing extracts clinical and relevant information for medical images for medical analysis⁶. These images and information/data are calibrated in fuzzy sets to aid medical interpretations. All result samples/data are represented in propositional/linguistic or numerical forms as applied in Computer Tomography Scan (CT Scan) machine for the acquisition of radiodensity values, Magnetic Resonance Imaging (MRI) values, segmentation, feature extraction, specimen examination, development of self-medical software agent⁷, ..etc.

Similarly, Computational and mathematical methods are applied in biomedical signal analysis or segmentation, feature extraction, etc. Here segmentation implies the partitioning of digital image into simpler images for easy analysis and data interpretation⁸. Similarly, feature extraction is useful in handling complex data analysis. It is interested in building derived values or features from a complex/large variables intended to be informative towards better medical diagnosis.

Ethical Implications in Fuzzy Logic and the Nigerian Medical Practice/Experience.

Medical ethics prescribes moral principles and conducts for medical and health practitioners. These principles provide a framework or moral compass to assess sound medical judgment, protect the patient and the medical

professionals/practitioners. On a general note, there are four pillars of medical ethics; benevolence, non-maleficence, autonomy and justice. Benevolence here means that medical practitioners have a moral duty to promote the course of action that they believe is in the best interest of the patient. Thus it means taking the best possible decision and action towards resolving patient's problem. Non-maleficence means that a medical practitioner has a duty to do no harm or allow harm to a patient through neglect or even when he presumes good intention. By patient's autonomy, it is supposed that the patient has right to decision-making for treatment following informed consent. Finally, by justice, medical ethics demands that practitioners show fairness, truthfulness and consistency in practice.

It should be understood that medical care in Nigeria has four major perspectives; traditional, healing ministries, complementary and western medical care services. The traditional medical care can be understood from three perspectives; divination, spiritualisms and herbalism. The practitioners provide medical care services on the grounds of culture, religion and herbal knowledge. They believe that sickness has both natural and supernatural causes, hence demand both physical and spiritual approaches such as divinations, incantations, sacrifices, exorcism, herbs, etc. No doubt they have contributed towards health restoration and other medical care services in Nigeria yet there are many unethical practices among the practitioners. Traditional medical care is most popular in Nigeria with greater popularity in the western part of Nigeria. Unfortunately, there are factors of abuses and unethical practices, hence debasing the acceptance and full integration of traditional medicine. These factors include; poor quality control, uncontrolled dosage in drug administration, poor scientific co-experimentation and diagnosis, ver spiritualization of diseases, unscientific imposition/assumption of causes to diseases, etc. However, the high cost of accessing western medications, lost of confidence in synthetic drugs, resistant of diseases to some modern drugs, etc have become current drives to traditional medicine.

Complementary medical care services are sometimes referred as supplementary or alternative medicine. This form of medical care originated among the Asians or Eastern world especially Chinese and Indians, hence it is more popular among the Easterners. Though this form of medical care originated from Asia, it is highly practiced in Nigeria but managed chiefly by Asians. Complementary medical services/practice include the following; acupuncture, biofeedback, chiropractice adjustment, massage therapy, meditations, music therapy, herbal supplements drugs, etc. Western medicine has its root from the Greek philosopher-physician and the father of western medicine, Hippocrates. This is the most popular medical practice which applies more scientific methods of medical services. The practitioners go a long process of medico-scientific and formal education or training than the other types of medical practitioners.

No doubt fuzzy logic has become an important toll in medical practice across the world. Fuzzy logic as introduced by the Iranian mathematician, Lotfi Zadeh in 1965 was intended to create opportunity for handling multi-valued truth functions⁹. As earlier stated, it is designed to solve problems by considering all available information within the membership function in order to make best possible decision minding rule-based programming¹⁰. This method of logic has become an important tool in medical practice. It supplies models or tools for medical and health data gathering, diagnosis and decision making. Notable is that fuzzy logic attacks the law of identity and absolutism, hence leading to partial truth and partial falsehood. Thus this form of logic creates a leeway for vagueness, uncertainties, impreciseness, bivalent or crisp set, hence evoking ethical implications in medical practice. The challenge of impreciseness in fuzzy logic is the bane of medical diagnosis in Nigeria among the four groups of medical practices; traditional, complementary, healing ministries and western medical care services.

In the attempt to apply fuzzy logic of analysis and treatment, medical practitioners fall victims of slippery slope fallacy. In logic, slippery slope fallacy is the type of fallacy where a small first step encourages a chain of related events or regress culminating to a significant and unusual or negative effect¹¹. Thus some medical practitioners fall into regress of imprecision and assumptions in the use of fuzzy set analysis. From a common sign/symptom, they make a chain of unrelated health conditions. For instance, for the reason that high fever is associated to malaria or/and typhoid and forms membership set of malaria symptoms, some medical practitioners do not care to confirm this situation rather immediately administer malaria and typhoid drugs. For them, the high fever is an indication that there is the possibility of typhoid, hence they also include typhoid drugs.¹² In this case, high fever becomes relational to typhoid and malaria such that all other chains of diseases who have similar symptoms are treated as malaria and typhoid.

It is obvious that one of the most difficult ethical challenges in medical practice today in Nigeria bothers on misapplication of fuzzy logic which gives birth to slippery slope conclusions leaving patients in unfavorable conditions. This situation compromises the basic medical ethical principles of benevolence, non-maleficence, autonomy and justice. Minding the fact that fuzzy logic allows wide range of data values, some medical practitioners base some diagnosis on indirect indications, imprecisions and presence of fuzzy symptoms, hence presume causes to observed effects. Unfortunately, little or no effort is made to confirm observed effects which is an abuse of fuzzy membership set acquired by observation. A typical example of this situation is the story told by a medical consultant to his medical students in the Southern Nigeria. According to him, a gynecologist was approached by a lady whom the gynecologist held in very high esteem and gave complaints that convinced the gynecologist that she had fibroid. Immediately he booked her for surgery. Unfortunately, on opening the lower abdomen, he discovered that the lady had no fibroid but

pregnant. In this case, the gynecologist was presented with symptoms belonging to the fuzzy membership set of fibroid. He drew the conclusion that these symptoms were indicator signs of fibroid which also are signs of pregnancy, hence he unfortunately applied unfavorable treatment to the patient.

In Nigeria, the most available test for typhoid fever is the Widal Test though with some abuses.¹³ This test considers the fuzzy numeric ranges of values of O and H antigens. This is carried out by serial dilution of the patient's serum within the ranges of 1:40 to 1:320. Thus when the values are less than 1:160, the widal test is considered negative and positive when a titer of O and H antigens have greater values above 1:160 to 1:320. Thus the severity of infection is according to the numerical increase from 1:160 and considered to be very acute when the numeric value increases towards 1:320. However, the most obvious abuse of widal test among Nigerian medical professionals is the use of a single widal test as a judgment standard especially in endemic areas like Africa, Asia, etc where single widal test is of little clinical relevance. Professionally, this test is supposed to be done at different developmental stages of infection and the agglutination of results offer better medical decision but practitioners draw their conclusions from a single widal test result.

Other ethical considerations following the effect of fuzzy logic are scrupulosity and compensational treatment. Scrupulosity is an ethical term that describes one whose conscience pays extraordinary attention to details, fears making mistakes and blames oneself for every offense even fears he might have committed an offense whereas he has not¹⁴. A female doctor narrated her experience leading to scrupulosity. According to her, a child of about ten years complained of chest pains. On getting to the hospital, she interviewed the child, prescribed some drugs to take care of the chest pains and discharged the patient. Unfortunately, the same child was rushed to the hospital the next day and could not survive it. Thus this experience created trauma in the doctor that made her develop some scrupulosity in matters of chest pains. In this case, chest pain becomes a membership set of grievous heart diseases. She became fixated on chest pains leading her to engage in extraordinary investigations and over treatment even with hard drugs for any chest related matters. Thus she sees herself going extra miles in matters of chest pains in an attempt to compensate for her carelessness in the previous experience.

More disheartening is the experience with some traditional medical practitioners. They pick and concentrate on symptoms that belong to a wide range of fuzzy membership set about a particular disease. There is always no effort towards confirming the symptoms rather, they offer treatments that in most cases lead to mortality as the major illness is undiscovered, hence untreated. Not only that there is no effort towards confirming observed symptoms, the traditional medical practitioners do not have the intellectual manpower for detailed scientific diagnosis or examinations. They concentrate on their limited knowledge about particular symptoms and appeal to divination as methods of diagnosis. Sometimes, for the reason of their limited diagnostic method, they treat diseases that do not actually exist rather presumed by their poor knowledge. In cases where their unscientific guess form fuzzy membership set of particular sickness, they either under treat or over treat a patient. This is because they do not have adequate knowledge of the herbs they apply especially as regards the dosage, side-effect and toxic content.

Unfortunately, some healing ministries in Nigeria apply similar diagnostic method where some conventional symptoms which form fuzzy membership set of diseases are given some weird interpretations and over spiritualized. There are many illnesses which have some psychological implication and need psycho-medical care but are diagnosed and interpreted as evil or spiritual possession, hence they subject the patient to exorcism and spiritual healing. Issues needing psychotherapy are branded as spiritual problems and the individual is left to the mercy of some self-acclaimed powerful men of God. Some of these men of God discourage their members from going to the hospitals as such is described as a lack of faith whereas they fly overseas themselves (and their families) for professional medical services in world-class hospitals. Some ministers go as far as beating sick persons in the name of exorcism and in their unorthodox method in order to drive away presumed evil spirit. In most cases, the harsh situation which these patients are exposed increases their trauma, mental challenges and mortality.

Worthy of note is that both the traditional and neo-Christian healing ministries share a common factor of blame gain. In some cases, when they fail in the treatment, they blame some spiritual forces or manipulations to be responsible for the illness. They may blame a friend or family member of the patient as being responsible of invoking some spiritual forces against the patient. Even when their promise of revoking the spiritual manipulations fails, they blame the patient. To avoid being blamed for failures, the practitioners blame the patient for some spiritual or moral commissions or omissions in the past as the responsible factor and cause of the illness. In such cases, the practitioner frees himself from every blame resulting from failure of proper diagnosis and treatment.

Conclusion

This research is an effort to show that fuzzy logic adds a new and powerful tool to the toolbox of medical analysis and decision making. Not just upholding the values of fuzzy logic as a valuable tool to medicine, this research is an investigation on the ethical implications of use and abuse of fuzzy logic in medical diagnosis and decision making in Nigeria. Fuzzy logic is a multi-values system of logic where truth variables have wide range of values¹⁵ such that

decisions are made in consideration of the variables in the fuzzy membership set. This system of logic has been of great value to medical practices such as; general diagnosis, analysis of Computer Tomography Scan (CT Scan), Magnetic Resonance Imaging (MRI), segmentation, feature extraction, specimen examination in numeric values, etc.

This research observed that medical care in Nigeria has four major sources; traditional, healing ministries, complementary and western medicine. Besides these sources is the self-medication syndrome¹⁶. Here patients presume causes of sickness from fuzzy membership set of previous treatment and treat themselves. Professionally, the primary responsibilities of a medical personnel before a patient begins with history taking, diagnosis, medical examination, analysis of results, decision making, prescription, treatment, etc. These services ought to be guided by some ethical foundations such as; benevolence, non-maleficence, autonomy and justice. It is regrettable that in spite of these ethical guides and numerous medical care facilities/systems in Nigeria, the system leaves much to be desired minding the gross compromise on ethical standards. This paper considers these abuses as it concerns the use/abuse of fuzzy logic in medical diagnosis and treatment.

No doubt, fuzzy logic is anchored on imprecision and vagueness. Thus imprecision of fuzzy values has been grossly abused in the Nigerian medical experience. The lack of exactness in fuzzy logic imposes lots of vagueness, ambiguity and indefiniteness in medical diagnosis, interpretation and decision making. Nevertheless, medical experts are encouraged to continue research on the necessary dynamisms of validating with exactitude matters of fuzzy logic¹⁷. Unfortunately, imprecision in fuzzy logic has provided some technical leeway for ethical interpretations in medical practice. For the reason of fuzzy value generated results in diagnosis, medical experts are faced with high ethical responsibility in medical interpretations, analysis and treatment. This compromise include; tardy assumptions from fuzzy membership set of diagnostic indicators, poor syllogistic analysis, compensational treatment, scrupulosity, fallacy of slippery slope, treatment on false cause, under treatment and over treatment, over spiritualization of diseases and causes, etc.

Therefore, it is of urgent need that medical practitioners embrace the ethics of their profession in order to achieve the desired aims which is mutual protection of the interest of the patient, practitioner and health institutions. Regarding traditional medicine, Nigerian would benefit immensely if practitioners and marketers observe and respect the ethical principles and in conscience shun deceit and lies for cheap gain¹⁸. More important is that there is urgent need to make concerted efforts towards scientific verification of traditional medicine.¹⁹ Similarly, Christian denominations and government regulatory bodies ought to place control measures on abuses and the excesses of some self-acclaimed prophets and healers who play on the ignorance and faith of Christians to extort money and gain cheap popularity. Western medical practitioners ought to hold firm to the ethics of the profession and shun unethical behaviors such as sales of expired drugs, use of unconfirmed fuzzy logic membership sets for treatment, compensational treatment, scrupulosity, etc.

More unfortunate and worthy of note is that this level of ethical compromise has been unabated because the medical legal control system is so weak and regrettably unattended. The content of the legal system which ought to protect patients is not duly implemented and as such discourages the patient from seeking redress in the court of justice. This lack of legal implementation is caused by corruption in legal system, poverty of adequate legal information by patients, high cost of accessing justice in the legal system, godfather syndrome, favoritism, intimidation, cliquism among medical practitioners especially when necessary evidence are require from the hospital during legal process, etc. This paper is a clarion call on the government to boost the medical legal system for better professionalism in practice.

End Notes

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