MEDICAL EXPERT SYSTEM FOR MANAGEMENT OF MALARIA

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Abstract

This study is an attempt to develop a Medical Expert System for Management of Malaria (MESMMAL) which is capable of diagnosing and treating malaria exactly the way a human medical expert would do. It combines the expertise and experience of the human expert with the capabilities of a computer system to diagnose and treat malaria. The purpose of the study is to reduce the problems associated with conventional malaria treatment to the barest minimum. The researchers adopted the Structured System Analysis and Design Method (SSADM) and the Expert System Methodology to develop the system. Classical set model was employed to develop a reasoning mechanism for three clinical features of malaria, namely: symptoms, laboratory tests and medical histories while inference engine was used to derive a reasonable result. The process was implemented with MATLAB 7.6.0 (R2008a). Rudimentary rule-based systems were formulated using clinical features of malaria. Graphical User Interface (GUI) was constructed to present inputs and outputs. Conclusively, the System could be used by epidemiologists to make appropriate prescription for malaria patients and could also be used to reduce the problems associated with conventional malaria treatment to the barest minimum.

Keywords: *Medical Expert System, malaria, diagnoze, MATLAB, epidemiologists.*

INTRODUCTION

Malaria is an acute and chronic protozoan infection transmitted by Anopheles mosquitoes to humans. There are four species that cause human infection, namely: *Plasmodium falciparum*, *Plasmodium malariae*, *Plasmodium vivax* and *Plasmodium ovale*. Malaria is predominant at any age and equally predominant in both genders (Dambro, 1988).

Malaria is a tropical disease that has indeed assumed an endemic dimension within the tropics. Today, malaria and its related diseases are responsible for the avoidable death of a good percentage of Nigerians in particular and other people from the region of the tropics in general (Malaria Foundation International, 2003). In fact, the Nigerian government and other governments in the infested regions of the world had set out programs in order to fight the scourge, which include: the Roll Back Malaria (RMB); Multilateral Initiative on Malaria (MIM), Drive Against Malaria (DAM) etc.(Adams, 2005).

The Nigerian health care has suffered several down-falls. Despite Nigerian's strategic position in Africa, the country is greatly underserved in the health care sphere. Health facilities (health centres, personnel, and medical equipments) are inadequate in this country, especially in rural areas. While various reforms have been put forward by the Nigerian government to address the wide ranging issues in the health care system, they are yet to be implemented at the state and local government levels. According to the 2009 communiqué of the Nigerian national health conference, health care system remains weak as evidenced by lack of coordination, fragmentation of services, dearth of resources, including drug and supplies, inadequate and decaying infrastructure, inequity in resource distribution, and access to care and very deplorable quality of care. The communiqué further outlined the lack of clarity of roles and responsibilities among the different levels of government to have compounded the situation (Welcome, 2011).

Indeed some of the factors listed above have contributed to avoidable deaths, particularly the inadequacy of qualified medical personnel. One of the major problems confronting health in Nigeria is dearth of medical doctors; there are 30,000 doctors

which translate to a ratio of 1 doctor to 3,500 people of a population against the World Health Organization (WHO) standard of 1 doctor to 600 people of a population (WHO, 2012).

An Expert System is a set of programs that manipulate encoded knowledge to solve problems in a specialized domain that requires human expertise. It is a second area of applied Artificial Intelligence. The outcome is a system that can solve problems and obtains results that sometimes exceed the performance of a human expert. The source of its inference or reasoning process are from texts, journals, internet, articles, specialists and databases usually provided by the human experts e.g. MYCIN, EMYCIN and PROSPECTOR. An Expert System is a piece of software that is designed to duplicate the function of an expert in some special area of expertise (Wikipedia, 2010).

An expert system is software that attempts to provide an answer to a problem, or clarify uncertainties where normally one or more human experts would need to be consulted. Expert systems are mostly common in a specific problem domain; it is a traditional application and/or subfield of artificial intelligence. A wide variety of methods can be used to simulate the performance of the expert however common to most or all are: (i) the creation of a knowledge base which uses some knowledge representation formalism to capture the Subject Matter Expert's (SME) knowledge and (ii) a process of gathering that knowledge from the Subject Matter Experts and codifying it according to the formalism, which is called knowledge engineering (Wikipedia, 2010).
The field of Expert Systems in Artificial Intelligence is rapidly increasing as Expert Systems are being developed in various applications such as medicine, engineering, business etc. Computer application development tends now towards the direction of not only being processors of data, but intelligent processors of knowledge (Gwen and Clausen, 2002)

MATERIALS AND METHODS

The research method adopted is the Structured System Analysis Design (SSADM), which is an accepted software Engineering principle for designing software. Also adopted is the expert system methodology, which involved knowledge engineering (knowledge elicitation, knowledge acquisition and knowledge representation) process of Inference and Knowledge base.

Four domain experts (human medical experts), two medical laboratory scientists, one pharmacist and one medical record officer were randomly selected based on consent from Nasarawa State University Health Services, Keffi. Therefore, the domain experts used in the study were those who gave their consent to participate in the research work. The knowledge Engineering process involved building a knowledge base and an inference engine for the expert system. The relevant facts or information were elicited from the domain experts through tutorial sessions, interviews, observations, protocol analysis and structured questionnaires. The instrument entitled: Questionnaires for Eliciting of Information on Management of Malaria (QEIMM) was developed and subjected to known standard reliability and validity tests before being used for the study.

Working principle and design

The components of an Expert System are enumerated below:

- Knowledge base
- Database
- Inference engine
- User interface

The Knowledge base: This contains the domain knowledge of malaria acquired from the domain experts whose general representation is:

If CONDITION then CONSEQUENCE

or

If ANTECEDENT then CONSEQUENT

It is designed base on rules, which combine antecedents (clinical features of malaria) in order to arrive at conclusion (disease) as follows:

If patient has body/joint pains
And is weak
And has fever
And has evidence of headache
And tested positive to Malaria parasite test

And lives in mosquito infested area
Then the patient has malaria
Then treatment is Artesunat or Lumartem or Artemether injection etc.

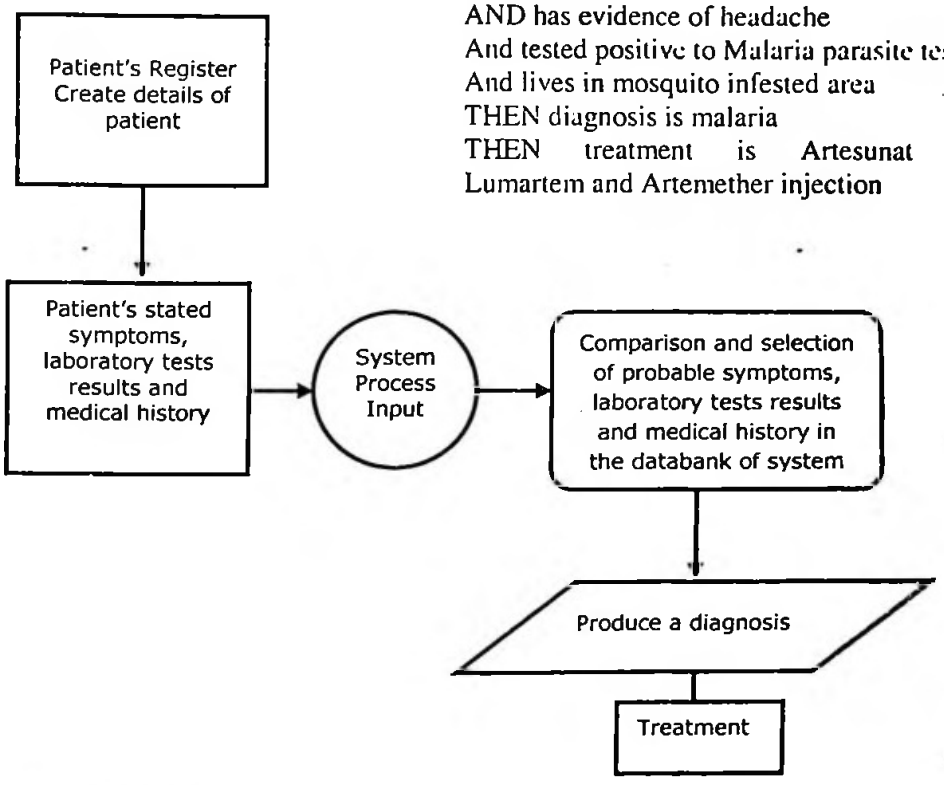


Figure 1: Block Diagram of User Interface

The Database

This contains all relevant data on the current situation for diagnosis. It is a dynamic database, which holds data about the patient whose medical problem is being diagnosed. Again, each patient complaint is designated as symptoms for signs and symptoms, test for laboratory test and history for medical history. The content of the Database is designated as follows:

Database:
symptom1(symptom name)
symptom2 (symptom name) etc
test1(test name)
test2(test name) etc
history1(history name)
history2(history name) etc

The inference engine

The inference engine uses the general rules of inference to reason. The software is concerned with techniques that are used to think and reason. With these capabilities. computer can draw inferences and make conclusions (goals) based on the knowledge it possesses.

Rule 1
IF patient has body/joint pains
AND is weak
AND has evidence of headache
And tested positive to Malaria parasite test
And lives in mosquito infested area
THEN diagnosis is malaria
THEN treatment is Artesunat or Lumartem and Artemether injection

The User Interface

This provides an environment for the user to interact with the computer hence it assists the user in consulting the expert system. The block diagram of the user interface is shown in Figure 1.

Clinical features

(i) Symptoms: The feelings or conditions a person reports about his sickness.

(ii) Signs: The things or conditions one looks for when examining a sick person, to find out what sickness he has.

(iii) Laboratory Test: Method of determining presence or absence of disease.

(iv) Medical History: What you can learn through asking questions about a person's sickness such as: how it began, when it began, when it gets better or worse, what seems to help, whether others in the family or neighbourhood have it, have you had this same trouble before, etc. The

questions are in order to learn the details of the illness (Werner, 1993).

In this study, three clinical features (or group of parameters) namely; symptom (S), laboratory test (T) and medical history (H) are used. The construction of the three clinical features (or group of parameters) is classified in Table 1.

Table 1: Three Medical Diagnostic Parameters Group

Parameter	Symbol
Symptom	S
Laboratory test	T
Medical History	H

Risk Factor: It is a variable associated with an increased risk factor of disease or infection (Werner, 1993).

Usually diagnosis should be based on a combination of the clinical features thereby representing various possible combinations of the variables in the cases that could lead to the diagnosis; thereafter the rules were used as the knowledge base.

Hardware and Software Specifications

The compiler was installed on a IBM compatible system meeting the following specifications:

(i) **Hardware:** The minimum hardware requirements for the system are stated below:
X86 or X64 Architecture Personal Computer (32-bit or 64-bit); Pentium 3; Processor speed: 1.0 GHz; RAM: 2 GB and 10 GB hard disc space.

(ii) **Software:** The minimum software requirements for the application are Windows XP Service Pack 3 operating system or later version and MATLAB 6.5 compiler or higher version.

MATLAB 7.6.0 (R2008a) compiler was used to develop and implement Medical Expert System for Malaria. Program modules were desk-checked for errors before being taken to the computer. After desk checking, the draft program modules were entered into MATLAB compiler. Lastly, the system was tested and debugged, in order, to be satisfied of its operation. The system (MESMMAL) developed in MATLAB was interfaced in Visual Basic.

Implementation

The following steps would allow access to system:

- Open malaria folder at drive C
- Type User Name and Password, this gives you access to the welcome page
- Click file management and enter patient diagnosis
- Complete the patient's details
- Enter symptoms
- Enter laboratory test result
- Enter medical history
- Go to Diagnose and click
- Disease is diagnosed and treatment is recommended
- Click save to generate result, etc.

RESULTS AND DISCUSSION

The researchers have developed a medical diagnostic system MESMMAL that is able to diagnose malaria and recommend treatment. The diagnosis and recommendation for treatment of malaria by the system developed are in agreement with the expected results as they compare favourably with discussion human domain experts (epidemiologists/malarialogists) would take in similar situations.

The authors also, have developed an inference search engine with the expertise of medical domain knowledge that can be used by a medical expert, paramedical staff and even computer literate patients or/and individuals for diagnosis and treatment of malaria disease.

If all the responses of a patient match one of the rules upon which malaria is diagnosed, the system will display that the patient is suffering from malaria, recommend certain medications and their various dosages. If the reverse is the case, the System will display a message to the effect that it is not capable to diagnose and treat the patient and consequently advises the patient to try another expert since an expert system is capable of providing solution in a specific problem domain.

To demonstrate the software, some sample runs of medical consultation sessions were carried out with the aid of the designer thus:

Malarial Diagnosis
First consultation

Do you have fever	YES
and headache	YES
and high temperature	YES
And Malaria parasite test was positive	YES
And live at mosquito -infested area	YES

Recommended Treatment

Tablet: Lumartem Tablet
Dosage: 4-2-2

(4 tablets on the first day and 2 tablets for the next two days)

Injection: Artemether injection
Dosage: 9.6 mg/Kg.
Remark: All the best.

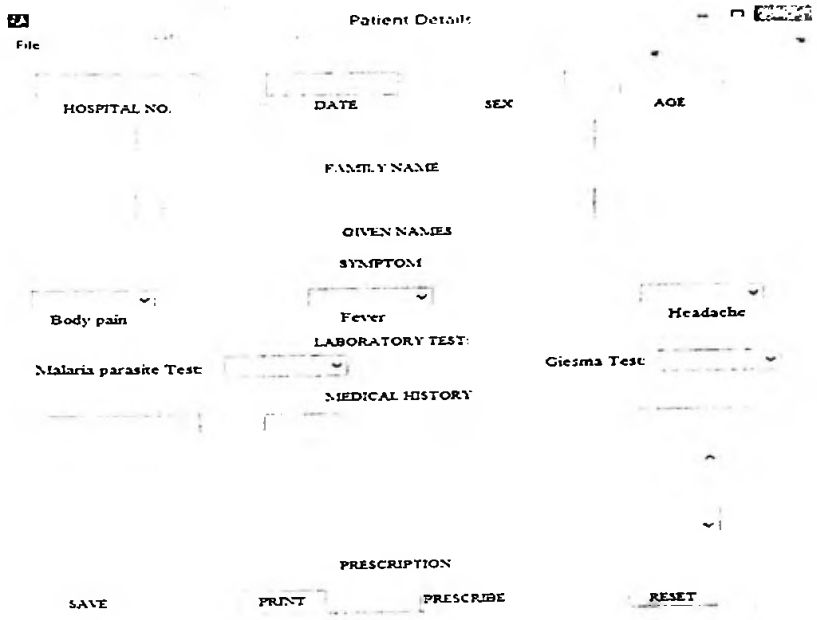


Fig 2: Patient Details Input Form

Diagnosis: You are suffering from Malaria.
Recommended treatment

Tablet: Artesunat tablet
Dosage: 4-2-2-2-2

(4 tablets on the first day and 2 tablets for the next four days)

Injection: Artemether injection
Dosage: 9.6 mg/Kg.
Remark: All the best.

Second Consultation

Do you have body/ joint pains?	YES
and high temperature	YES
and headache	YES
And Giesma test was positive	YES
And suffered from malaria in the recent past which was not properly treated	YES
and not on any anti-malarial drug	YES

Diagnosis: You are suffering from Malaria.

Third consultation

Do you have body/ joint pains	NO
and weak	NO
and high temperature	NO
And Malaria parasite test was positive	NO
and Giesma test was positive	NO
And live at mosquito-infested area	NO
and not on anti-malarial drug	NO

Diagnosis: You are not suffering from Malaria.

Remark: This Expert system is not capable to diagnose your ail ment hence you have to try another expert. All the best.

Figure 2 shows the Patient Details Input form while Figures 3 and 4 show Patient Details Output forms of the system as the results of two patients after consultations.

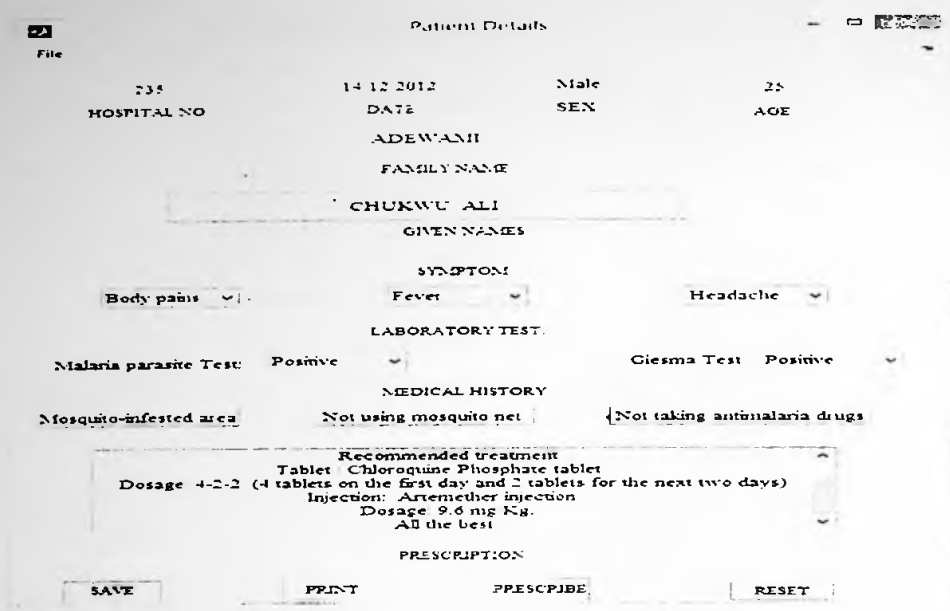


Fig 3: Patient Details Output Form

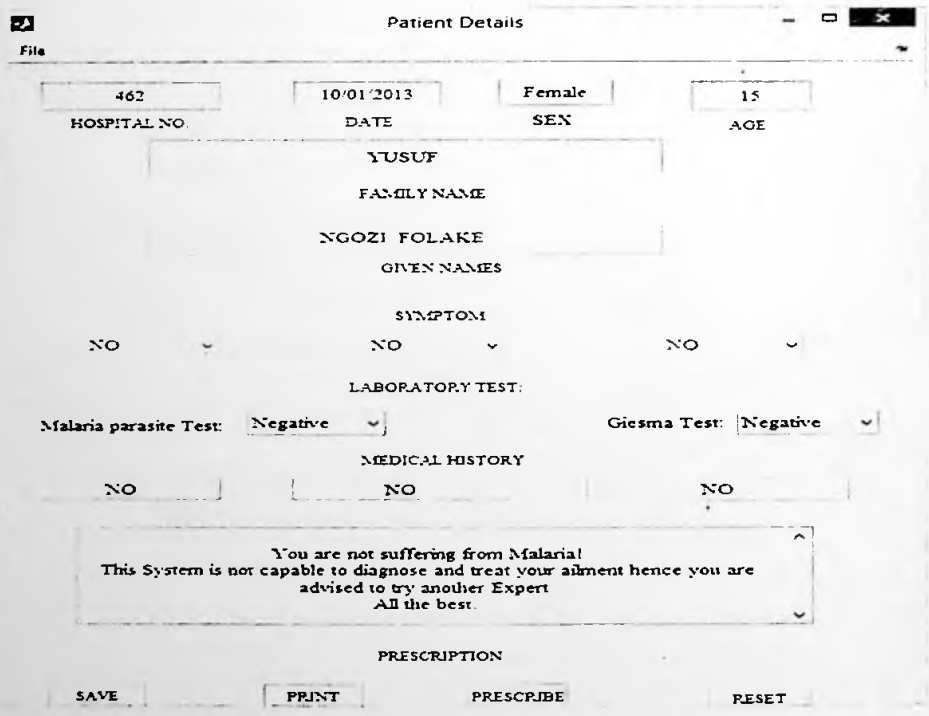


Fig 4: Patient Details Output Form

CONCLUSION

The field of Artificial Intelligence holds a greater sway for technological advancement and for development. This is because most of the drudgery presently requiring human labour will be better and more effectively handled by Artificial Intelligence Systems. The Expert System for diagnosing and treating Malaria will increase productivity, increases the number of medical consulting points in the hospital and save cost. It will also facilitate diagnosis and treatment of Malaria and as well assist the medical personnel in their duties by complementing their efforts. The medical diagnosis expert system MESMMAL developed in no doubt would enhance medical practice within the medical profession when adopted and implemented.

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