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Clinical Expert System Model for Diagnosing Dengue Infection

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Abstract*: Expert system is a system that emulates experts to aid in decision-making. This system can be applied in various categories such as diagnosis, prediction, interpretation, and others. This research is to design a model along with prototype of clinical expert system for diagnosing dengue infection based on the indication of disease, theory and expert knowledge. The result of the system includes all aspects of dengue infection. The Model of clinical Expert system for diagnosing dengue infection (CESMDDI) developed through using ESTA as a development tool with both backward and forward chaining techniques and used decision tree for hierarchal classification, the system provide basic knowledge for questioning user to decide the infection and measures necessarily to be taken. This system is very useful for doctors, doctor candidates as well as students of medicine faculty who use it as a tool to start diagnosing a disease/infection. The system has classified the disease structure based on basic information gathered from literature study and medical expert interview. Medical experts evaluated the proposed system and they were happy and satisfied with its performance and ease of use.*

Keywords—Dengue Infection, Diagnosis, Expert System, Decision Tree, Model, CESMDDI

1. INTRODUCTION

Expert system is a system with human intelligence that is used to solve real-world problems. According to [1] Expert system is a rule-based system, where results obtained from the rules are similar to human knowledge in specific areas. Expert system can be applied in many areas, such as industries, commercial problems, financial decision-making, and diagnosis of diseases. In this study, expert system to diagnose dengue was developed. Dengue (DENG-gey) fever is a mosquito-borne disease that occurs in tropical and subtropical areas of the world. Mild dengue fever causes a high fever, rash, and muscle and joint pain. A severe form of dengue fever, also called dengue hemorrhagic fever, can cause severe bleeding, a sudden drop in blood pressure (shock) and death [2]. Dengue was first introduced in Pakistan at Karachi seaport through the importation of tyres containing eggs of infected mosquitoes [3]. Dengue virus infection was first detected in 1982 from serum samples that were collected in 1968 and 1978 Punjab province [4]. Health authorities in Pakistan are responding to an ongoing outbreak of dengue fever. The Khyber Teaching Hospital in Peshawar, Khyber Pakhtunkhwa (KP) province, first reported this outbreak on 8 July 2019. Since then, three other provinces (Punjab, Baluchistan, and Sindh), as well as Islamabad Capital Territory (ICT), and Azad Jammu and Kashmir (AJK; one of the two autonomous territories) have also reported cases of dengue fever. From 8 July to 12 November 2019, 47,120 confirmed cases of dengue fever, including 75 deaths, were reported from the four provinces (KP, Punjab, Baluchistan, and Sindh), Islamabad, and AJK [5]. The increasing number of dengue cases and the wider infected areas are caused by the improvement in public transportation; rapidly growth of new housing complex, lack of public awareness on cleaning mosquitos breeding places, spreading out of mosquito vectors in almost all parts of area in Pakistan. To solve the above-mentioned condition, it is necessary to create a model of expert system for diagnosing dengue infection. This system can manage the problem of the limited numbers of expert in giving preliminary diagnose, and the expert knowledge can reach more areas widely. Moreover, the expert knowledge and experience can be stored to help giving accurate and effective result of the disease. The objectives of this research are to study the problem domain and other expert systems related to dengue infection and other illnesses, and to design and build an expert system model that can identify dengue infection to help users diagnose themselves. The scope of this research was specific to dengue infection.

2. LITERATURE REVIEW

Many Expert Systems was developed to diagnose the problem of plants and dengue [6-11]. However, there is no specialized Expert System model for diagnosing dengue infection available free also cannot found the exact methodology or approach, which is adopted in this study to solve the problem. The proposed Expert System CESMDDI diagnoses the dengue infection free of cost, it was developed not specifically to help Pakistani peoples but the peoples of other countries specially living in rural or semi urban areas can be facilitate with it for diagnosing dengue infection.

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3. METERIAL AND METHODS

In order to get the objective of this research study, the methodology of design science research was used. Design science research methodology is the most adopted and recommended methodology to find the solution of identified problems. The model of Expert System was developed by using knowledge acquisition process. The whole research work and proposed methodology is divided in different phases as shown in Figure 1.

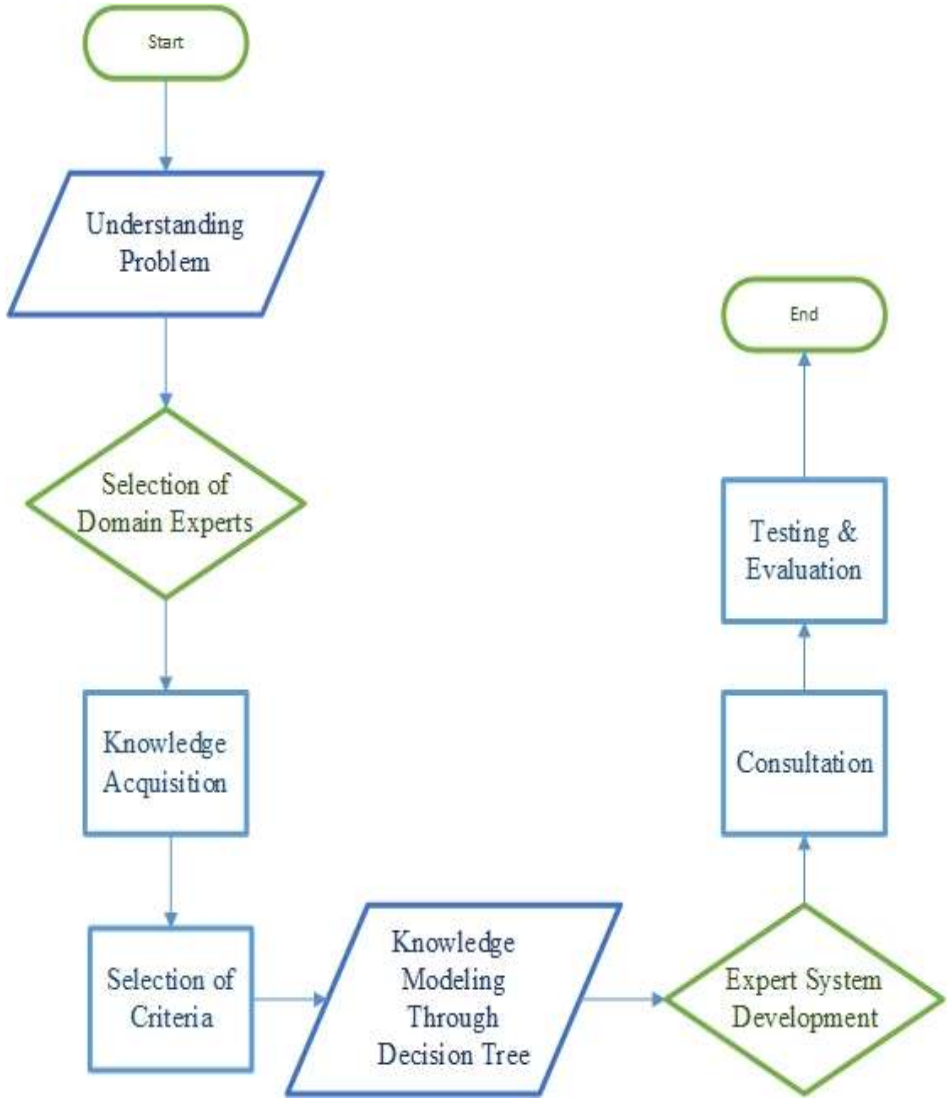

Figure 1: Research Methodology

3.1 Understanding Problem

Our approach is to develop the model with clinical expert system for mosquito born disease like dengue. Especially we have designed this clinical expert system for rural areas or remote areas where pathological labs and experts are not available. This system makes diagnosis easier for medical personnel and even any person carry out diagnosis by answering the question with respect to the disease.

3.2 Selection of Domain Experts

For the selection of domain experts, the purposive sampling technique was used. The selection of domain experts for this research study based on the expertise level in diagnosing dengue infection. Moreover, the specific objective of this research study was to extract tacit knowledge. For this reason, total 3 domain experts was selected.

3.3 Knowledge Acquisition

We gathered all the relevant and acquired knowledge/ information from medical experts, manuals, research papers, books and articles. Both structured and unstructured interviews were conducted to elicit tacit knowledge also, a questionnaire was developed to acquire all the symptoms of dengue infection. After getting all the required knowledge, we select 14 symptoms (Criteria) for this research study to diagnosing dengue infection i.e., Fever, Joint Pain, Muscle Pain, Pain Behind Eyes, Skin Rash, Loss of Appetite, Nausea and vomiting, Headache, Convulsion, Bleeding, Sleepiness, Temperature, Yellowish, Cold Hot & Sweating.

3.4 Knowledge Representation

In this phase after acquiring all the required knowledge, all the acquired knowledge was modeled using decision tree, and then developed an Clinical Expert System for consultation using IF…THEN rules. The knowledgebase of CESDDI has more than 200 rules. Sample rule base for dengue diagnosis is shown in Table 2 below.

Symptom's abbreviations are shown in Table 1.

Table 1: Representation of Disease Symptoms with letters

Represented with —Letters	Disease Symptoms
F	Fever
JP	Joint Pain
MP	Muscle Pain
PBE	Pain Behind Eyes
SR	Skin Rash
LOA	Loss of Appetite
N/V	Nausea and vomiting
H	Headache
C	Convulsion
B	Bleeding
S	Sleepiness
T	Temperature
Y	Yellowish
CHS	Cold Hot & Sweating

Table 2: Sample IF…Then Rules for CESMDDI

F	JP	MP	PBE	SR	LOA	N/V	H	C	B	S	T	Y	CHS	Results
High	Severe	Yes	Yes	Yes	No	Yes	Severe	No	Yes	Yes	104	No	No	**Sure Dengue**
High	Moderate	Yes	No	Yes	Yes	Yes	Severe	No	No	No	104	No	No	**Sure Dengue**
High	Low	Yes	Yes	Yes	No	No	Low	No	Yes	Yes	104	No	No	**Sure Dengue**
High	Low	Yes	Yes	No	No	Yes	Moderate	No	No	No	103	No	Yes	**May be Dengue**

Short	Low	Yes	Yes	No	Yes	Yes	Low	No	No	Yes	102	No	No	**May be Dengue**
No	Low	Yes	No	Yes	No	Yes	Moderate	Yes	No	No	99	No	No	**Not Defined**
No	Severe	Yes	No	No	Yes	No	Low	No	No	No	99	No	No	**Not Defined**

3.5 Knowledge Modeling Through Decision Tree

Knowledge Modeling is a cross disciplinary approach to capture and model knowledge into a reusable format for purpose of preserving, improving, sharing, substituting, aggregating and reapplying it. In the computer world, it is used to simulate intelligence. Decision trees are widely recognized to be useful tools for the knowledge engineer in prototyping knowledge representations. Models are the best information carriers in terms of symbols or numbers rather than with actual tangible objects in an abstract way to depict the imaginations and thoughts of decision makers about their areas of domain [12]. Model of decision tree was developed for diagnosing dengue infection.

Figure 2 depicts the sample decision tree for diagnosing sure dengue infection.

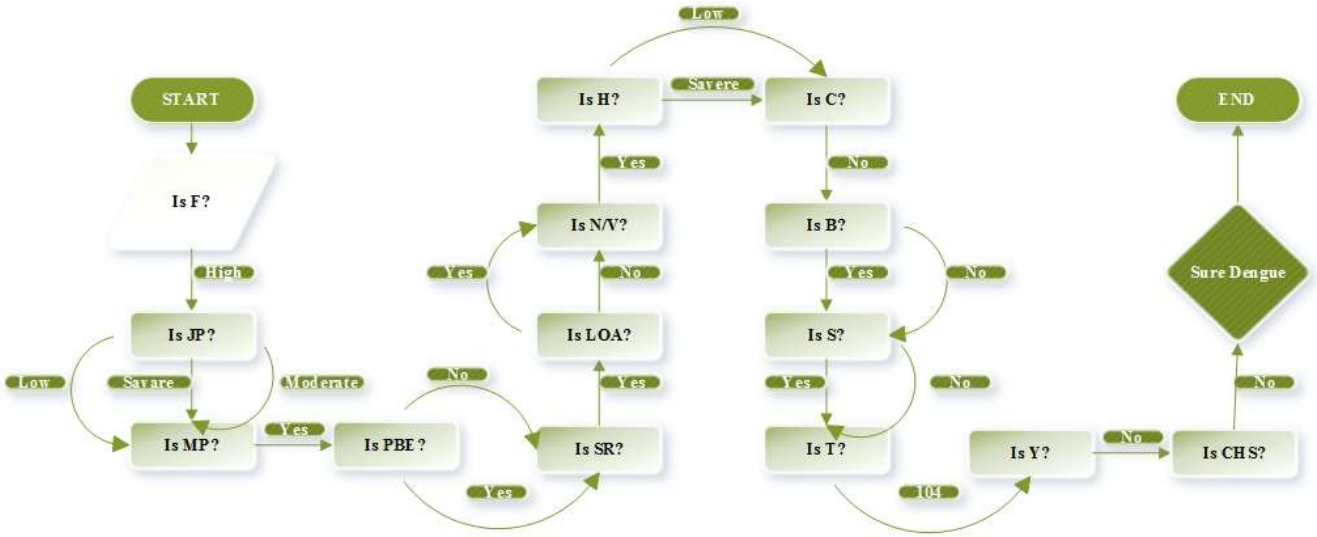

Figure 2: Decision Tree for Diagnosing Sure Dengue Infection

Figure 3 depicts the sample decision tree for diagnosing maybe dengue infection.

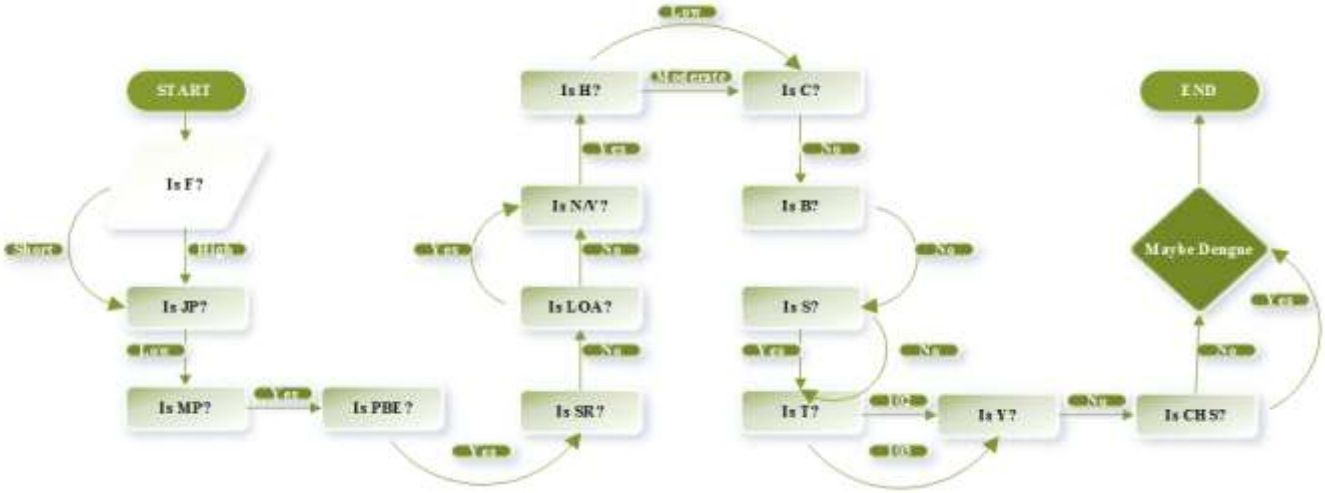

Figure 3: Decision Tree for Diagnosing Maybe Dengue Infection

Figure 4 depicts the sample decision tree for diagnosing not defined dengue infection.

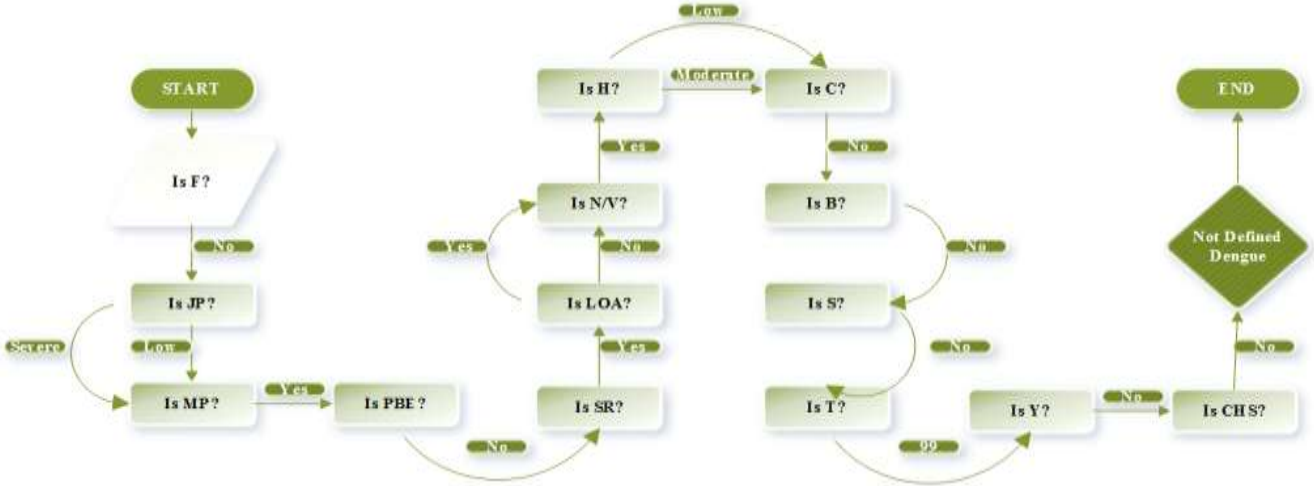

Figure 4: Decision Tree for Diagnosing Not Defined Dengue Infection

3.6 Architecture of Clinical Expert System Model for Diagnosing Dengue Infection (CESMDDI)

As shown in the Figure. 5 the knowledge engineer acquires knowledge from domain expertise along with searching the required knowledge in different repositories like; books, journal articles, technical reports, case histories and agricultural manuals. The acquired knowledge is represented in the form of IF -THEN or Production rules to be coded in the Knowledge Base using ESTA as a development platform by Knowledge Engineer.

Figure. 5 shows the architecture of the proposed rule based Expert System named as CESMDDI. The knowledge base holds essential information about the problem domain, which is the symptoms of the dengue infection stored as facts and rules in the Knowledge Base. The Inference Engine then provides a mechanism to control the overall processing of the Expert System according to the instructions being provided by the Knowledge Engineer. This part of the Expert System derives new knowledge from results achieved through the fact and rules of the knowledge base. The inference engine is also used to allow the generation of new conclusions from existing knowledge in the knowledge base. The Expert System user can interact with the Expert System through User Interface. User can provide input information to the Expert System and Expert System provides the consultation in the form of results along with giving answers to the questions, like; EXPLAIN and WHY.

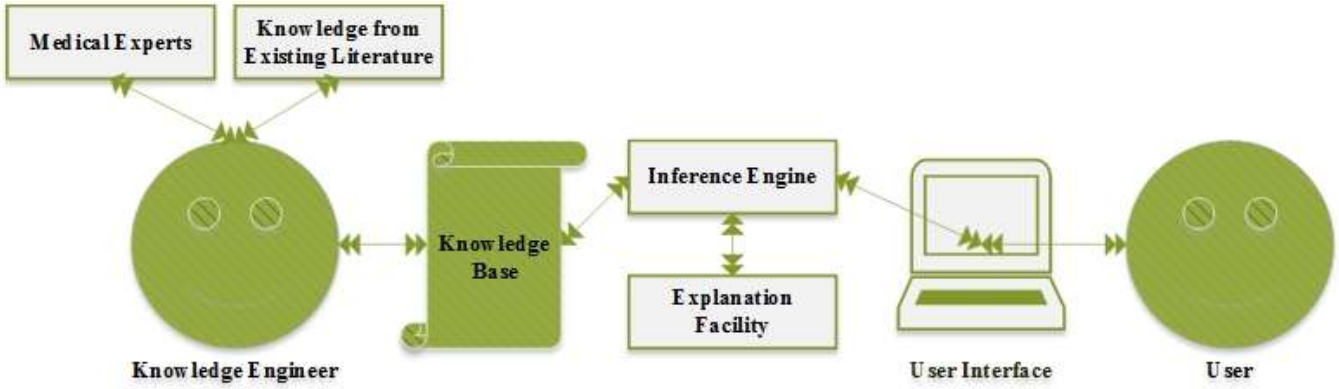

Figure. 5: Proposed Expert System Architecture

3.7 How CESMDDI Works?

The main elements of the ESTA are Titles, Sections, and Parameters. Title are used for different titles in the Expert System. Sections are used to store facts regarding problem main using forward chaining and Parameters uses variables with backward-chaining process for reasoning. The user interacts with the system by responding for the series of question as "yes" or "No" or "Unknown" till the knowledge base system decided to take action. The ESDMINDP open session of conversation by clicking on "Begin Consultation" in the Expert System.

3.8 Consultation Session of CESMDDI

Figure 6 and 7 shows the consultation session for diagnosing dengue disease. Similarly, the system ask about all the symptoms of dengue infection and finally shows the results of consultation session as shown in figure 8.

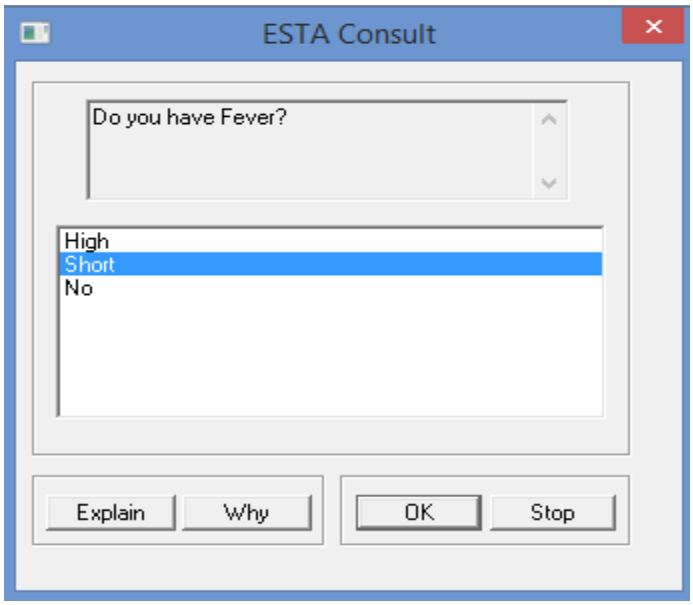

Figure 6: Select Fever.

Figure 7: Select Join Pain.

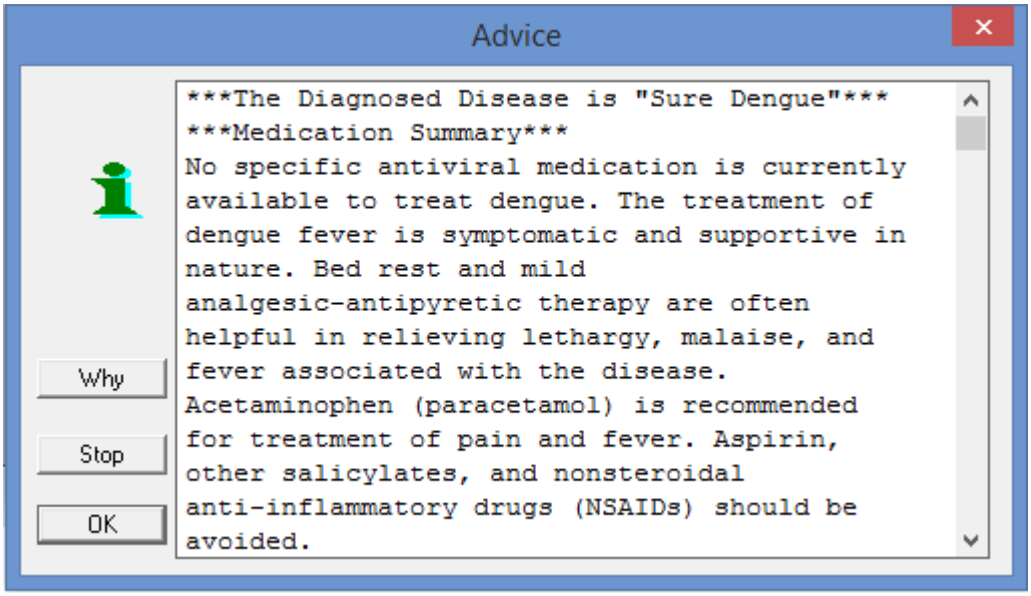

Figure 8: Final Advice of CESDDI.

3.9 Testing & Evaluation of CESMDDI

At an initial evaluation stage, Medical experts, tested and evaluated the proposed Expert system who were satisfied with its performance and ease of use. They were asked to evaluate the following features of the proposed Expert System:

- Is the Expert system easy to use?
- Is the system more efficient in time?
- How does accurately a system reach a decision in diagnosing Dengue infection?

3.10 Conclusion & Future Work

In rural or semi urban areas of Pakistan and other countries, the availability of medical experts is very low compare to the total number of patients that are trained in the field of medical. Different factors are identified such as shortage of skilled work force in

the domain area, the skill level of the experts, shortage of budget and the complexity of identifying dengue infection. To address the above-mentioned problems in this research paper, the proposed the model and expert system named as CESMDDI was introduced to support infected patients of the rural and semi urban areas to timely diagnose the dengue infection. The poor patients of rural and semi urban areas get faster and more accurately diagnosis of dengue infection. This expert system does not need extensive training to use; it is easy to use and update.

In this study the actual physical symptoms images cannot directly manipulate to the modeled prototype. Therefore, it will be better for researchers to develop an image based diagnostic expert system that might predict the dengue infection based on the responded symptoms from the patient. The approach, which we adopted in this research study to solve the problem, can be used to develop expert systems in other medical problems to reduce dependence on human experts to save time, effort and money.

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