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Developing an Expert System for Diabetics Treatment Advices

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Abstract

Today, expert systems are widely applied in medicine for prognosis, diagnosis, checkup, and treatment of various kinds of diseases. A comprehensive system for the checkup and treatment of different types of diabetes is still lacking. This paper reports development of such a system, its validation, and its utility in facilitating medical decision-making and supporting self-care.

Keywords: Diabetes, Expert system, Checkup, Treatment

Background and Objectives

Rapid prevalence of diabetics, the patients' need for continuous referral to different medical specialists, overpayments, and time wasting mandate search for new scientific instruments and software systems for reduction of such problems.

Information and Communication Technology (ICT) has found a wide variety of applications in medicine, particularly in the development of expert systems applied in diagnosis, treatment and provision of advices to the physicians and patients [1-10].

Diabetes is a fatal disease, which can lead to many other dangerous illnesses such as blindness, hypertension, loss of kidney, heart attacks, and gangrene. Hence, developing a consulting system capable of helping prevention or reduction of these patients' problems and diabetes side effects is valuable. The main purpose of this research was to develop a knowledge-based expert system, to help the diabetics with scientific treatment advices.

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Results and Discussion

Components of the Expert System

Most expert systems have similar basic components. They include a knowledge base, an inference engine, and a user interface, as shown in Figure 1.

The knowledge base is the programmed knowledge of the expert, both the "book knowledge" and the "practical knowledge" or heuristics. This holds all of the pertinent facts and relationships about the subject as well as the rules of thumb to effectively search to solve the problems. The inference engine is the "know how" of an expert system that can apply the knowledge from the knowledge base to solve the problem(s). It is the part of the program responsible for how to get from the initial information to the final solution [12].

Developing the Expert System

Our expert system was developed in 10 stages, as demonstrated in Figure 2.

A) Knowledge Acquisition

The knowledge acquisition stage was done through direct interviewing with the medical specialists and nurses in the field of diabetes, and studying the related scientific resources.

Table 1 Test Decision Table

Decision	Test
(Need for referring to Nephrologist)	**Na-K-BUN-CT= Normal and U/A= Normal and Last Refer to Nephrologist <12 Months**
No	Yes
Yes	No

B) Knowledge Representation

The proposed system is rule-based; therefore, for knowledge representation, we used rules in the form of IF…THEN, where IF identifies the situation, and THEN provides the suggestion. Transmission of the experts' knowledge into these rules has been carried out by using 1) Block Diagram, 2) Mockler Charts, and 3) Decision Tables.

For treatment advices we designed the block diagram comprising of three attributes including patient's condition, patient's information and tests. Different combinations of these attributes lead to various advices (Figure 3).Each part sends the final answer to the system based on the related questions asked from the user. In the patient's condition part, information related to blood pressure, blurred vision and some tests including Complete Blood Count (CBC), Low-Density Lipoprotein Cholesterol (LDL), High-Density Lipoprotein Cholesterol (HDL) and Triglyceride (TG) and other conditions of the patients are considered. In the patient's information part, the patient's age, background of training on diabetes, and referral to nutritionist are accounted for. Finally, in the Tests part, Sodium-Potassium-Blood-Urea Nitrogen-Creatinine (Na-K-BUN-CT), and Urine Analysis (U/A), as well as the last referral to nephrologist are checked. Based on this information, the system will decide and declare the final advice.

When the Block Diagram is drawn, the related Mockler Charts should be developed. Questions and alternative answers, which the system should ask from the user for inferring their situation, are mentioned in the Mockler Charts. For each part of the Block Diagram, a Mockler Chart is specified; also one Mockler Chart is specified for treatment advices. The Mockler charts of patient's condition, patient's Information and tests gives back an output to the system, and based on these outputs, the system offers the final decision. For example, in the patient's condition Mockler chart (Figure 4), according to the answers received from the user, one of the outputs (Internist and Ophthalmologist, Internist, Ophthalmologist or None) will be sent to the system.

Finally, the decision tables are derived from the Mockler charts to determine the expert system's rules. In the test decision table, the need for referring to a nephrologist based on the related tests is determined (Table 1).

The condition-decision table (Table 2) is devoted to determining the necessity of referring the patient to the internist and ophthalmologist based on special tests, as well as the patient's conditions.

Table 3 is a sample of the information-decision table with three attributes, including age, referral to nutritionist and attending in diabetes classes, together with the relevant recommendation.

Final treatment decision table is advice-condition table, which shows different combinations of tests, conditions, and information, and leads to 64 advices to the patients who are indexed from A1 to A64. Each row of this table represents a rule. Each of these indices relates to a row of the User Guide's table (Table 5) where the user can refer to and find suitable advices related to their situation.

Table 2 Condition Decision Table

Test	Decision on the need for referring the patients to:		
	Internist and Ophtalmologist	Internist	Ophtalmologist
Blood Sugar Level>= 120 or Last refer to internist>=2 Months or Diabetic Foot or Blood Pressure>= 140/90 Mm Hg or CBC or LDL or HDL or TG= Abnormal	Yes	yes	No
Blurred Vision or Last Refer to Ophthalmologist >=6 Months	Yes	No	Yes

Table 3 Information Decision table

Decision	Information		
	Age	**Referral to Nutritionist**	**Attending in Diabetes Classes**
Pediatrician and Nutritionist and Attend Diabetes Classes	<10	No	No
Pediatrician and Nutritionist	<10	No	Yes
Pediatrician and Attend Diabetes Classe	<10	Yes	No
Pediatrician	<10	Yes	Yes
Nutritionist and Attend Diabetes Classes	>=10	No	No
Nutritionist	>=10	No	Yes
Attend Diabetes Classes	>=10	Yes	No
None	>=10	Yes	Yes

Table 4 Part of the Treatment Advices Table

Advices	Situation		
	Tests	**Condition**	**Information**
A1	Nephrologist	Internist and Ophtalmologist	Pediatrician and Nutritionist and Attend Diabetes Classes
A2	Nephrologist	Internist and Ophtalmologist	Pediatrician and Nutritionist
A3	Nephrologist	Internist and Ophtalmologist	Nutritionist and Attend Diabetes Classes
⋮	⋮	⋮	⋮

Table 5 User Guide Table

Advice Index	Nephrologist	Internist	Ophthalmologist	Nutritionist	Pediatrician	Attend in Diabetes Classes
A1	Yes	Yes	Yes	Yes	Yes	Yes
A2	Yes	Yes	Yes	Yes	Yes	No
A3	Yes	Yes	Yes	Yes	No	Yes
⋮	⋮	⋮	⋮	⋮	⋮	⋮

C) Coding

This expert system has been coded using VP-Expert Shell, which is a specific tool for coding expert systems. VP-Expert uses backward reasoning for inference. This tool has an inference engine for consulting the knowledge base to answer queries, an editor for writing rules of the knowledge base, and a user interface for handling the queries, asking questions from the user, and presenting traces and explanations, where needed. It also has limited graphical capabilities [14]. Table 6 shows a sample of the expert system rules.

Table 6 A Sample of the Expert System's Rules

```
Rule condition_4
if blood_sugar_rate=no and
last_refer_to_internist=no and wounds_in_feet=no and
blood_pressure=no and CBC=normal and LDL=normal and
HDL=normal and TG=normal and
blurry_vision=no and last_refer_to_ophtalmologist=no
then condition= none;
```

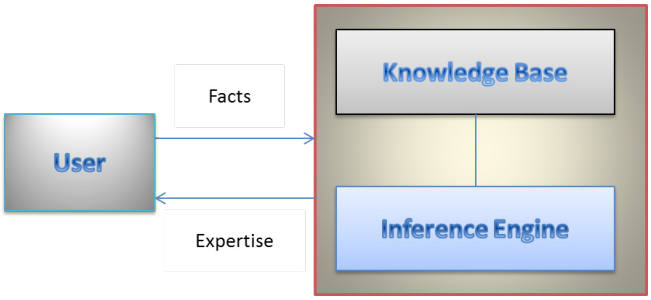

Figure 1 Main Components of an Expert System [11]

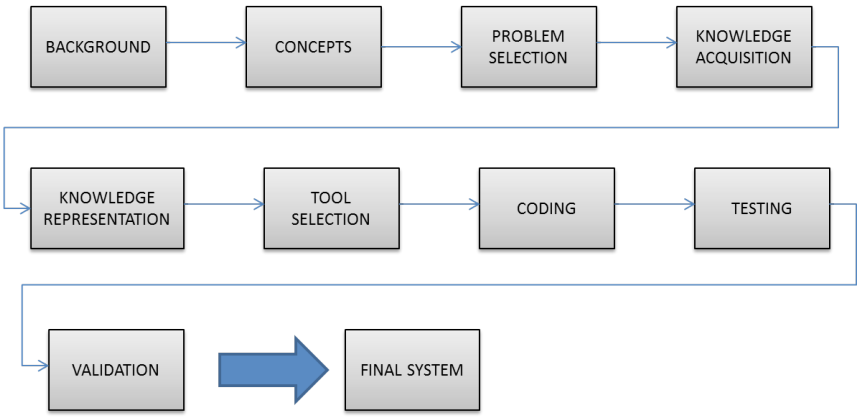

Figure 2 Stages of the Expert Systems Development [13]

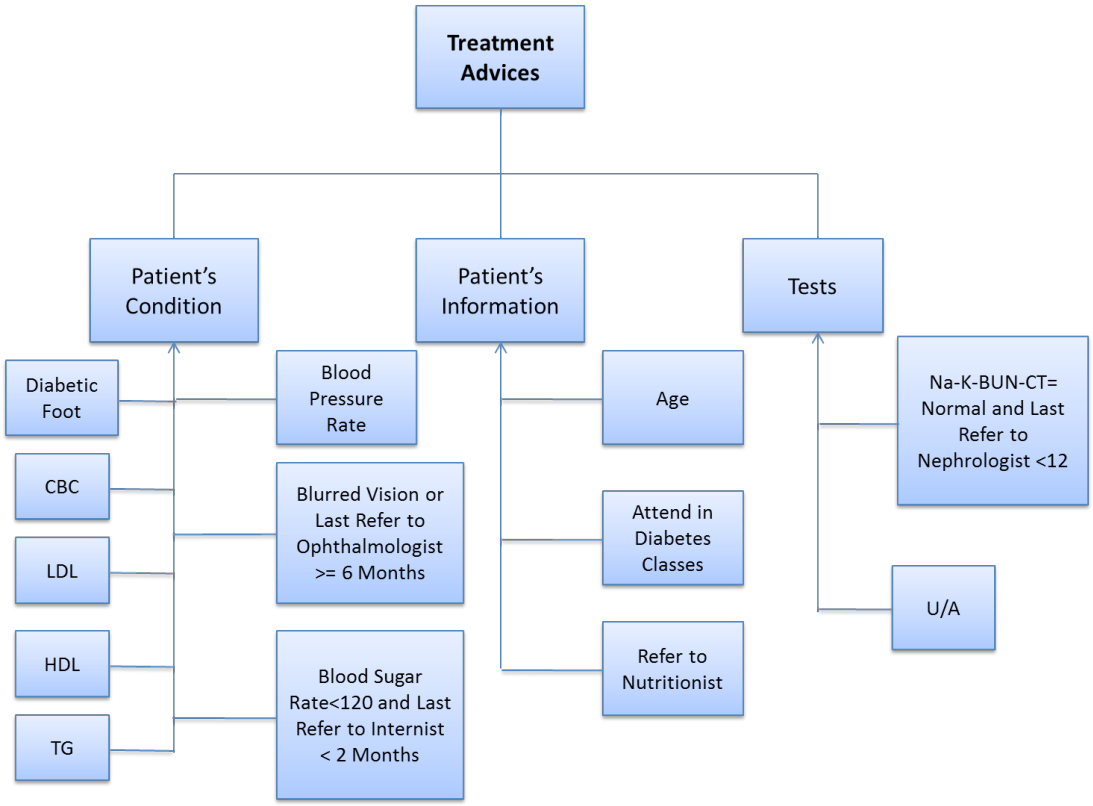

Figure 3 The Block Diagram of Treatment Advices

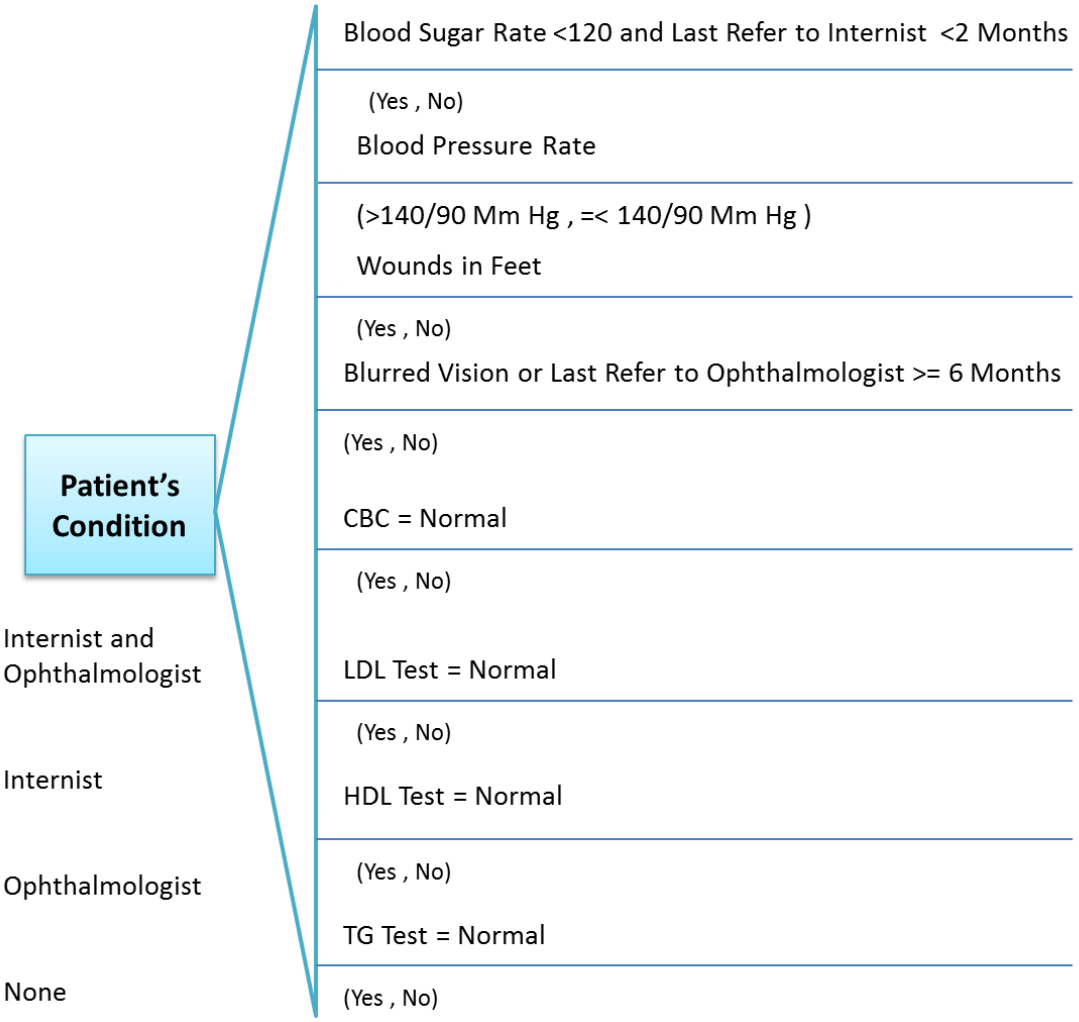

Figure 4 The Mockler Chart of Patient's Condition

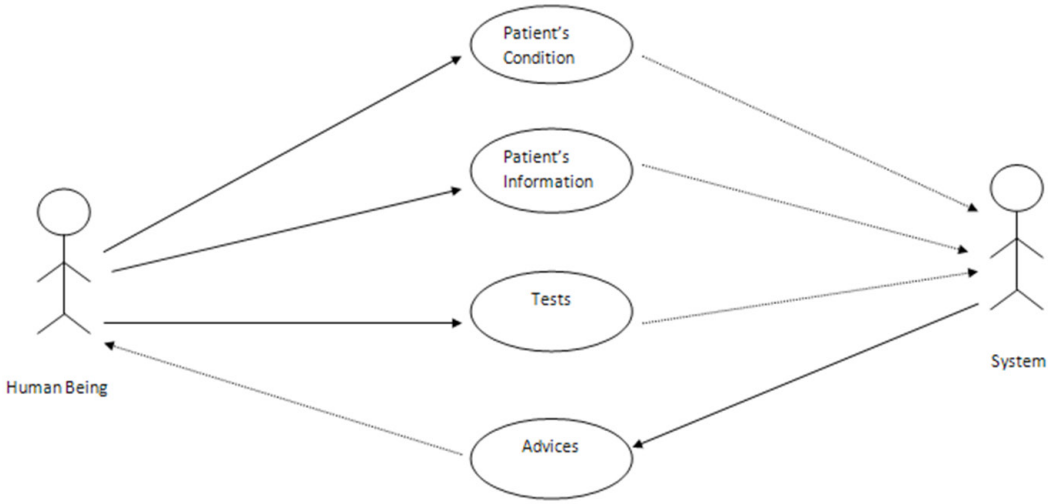

Figure 5 Treatment Advices Use-Case Diagram

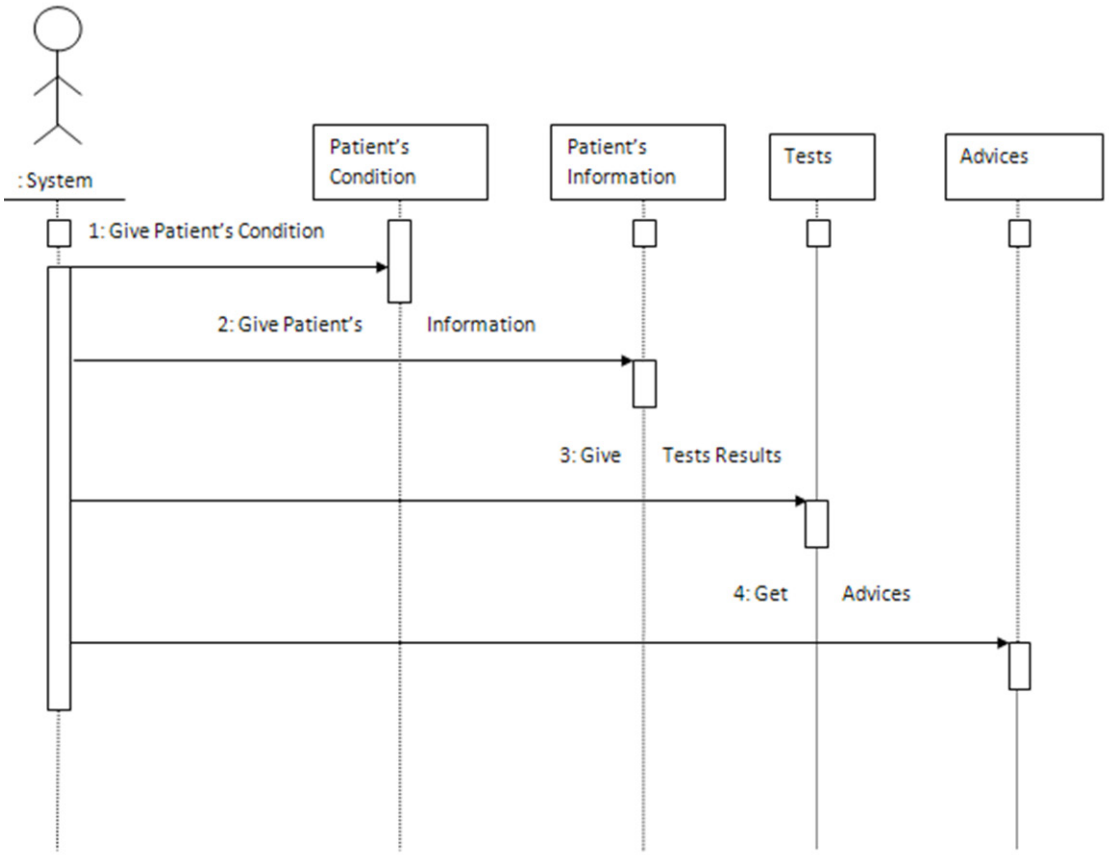

Figure 6 Treatment Advices Sequence Diagram

What is the answer U/A test?
normal abnormal

Have you referred to nephrologist less than 12 months?
yes no

Is your blood sugar rate equal or greater than 120?
yes no

[Rules]
LDL = abnormal or
HDL = abnormal or
TG = abnormal and
Blurred_vision = yes or
Last_refer_to_ophthalmologist = yes
THEN
Condition = c1 CNF 100
Finding blood_sugar_rate

[Facts]
Na1K = normal CNF 100
UA = abnormal CNF 100
Last_refer_to_Nephrologist = yes CNF 100

Test = Nephrologist CNF 100

Figure 7 Some Questions System Asks from User

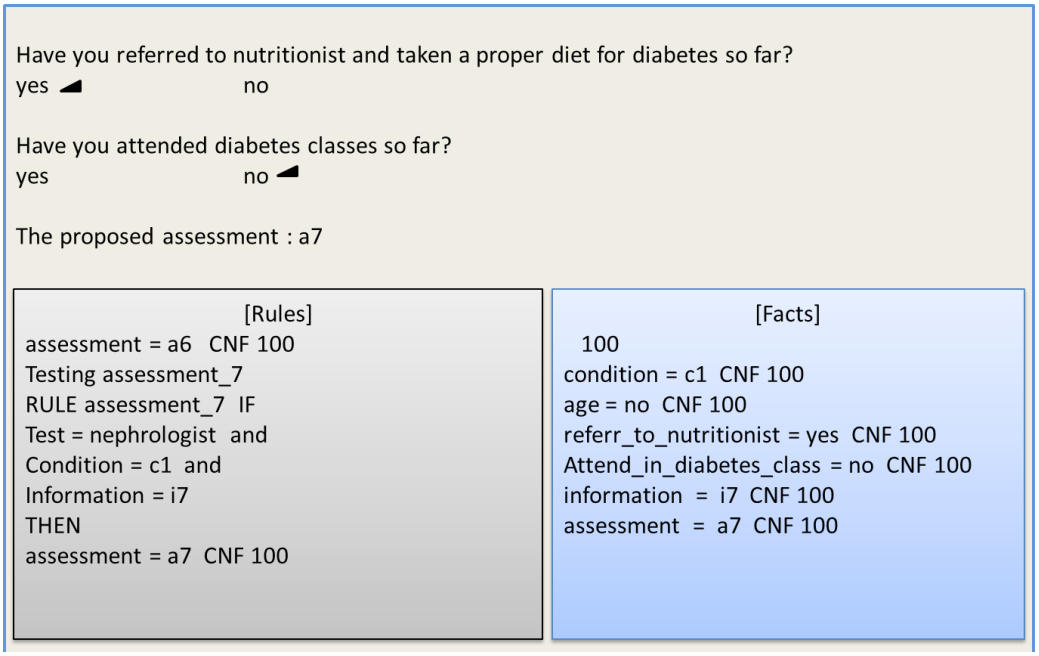

Figure 8 Sample of the System Treatment Advices

D) Testing and Validation

During the system development, all rules, paths, and relationships between the attributes were tested, and the necessary changes were made. Then the system was evaluated by the internists and diabetes specialists of Hasheminezhad Teaching Hospital, and the relevant comments and recommendations were used in the final development stage. The final system was tested on 30 diabetics of various types, and the results were compared with the specialists' diagnosis and advices. The consistency of the two methods was approved by the related internists.

Sample Running of the Expert System

Before representing a sample running of the expert system, it is necessary to show UML diagrams, including use case and sequence diagrams for better understanding how the system runs. Use case diagram (Figure 5) illustrates the interaction between the user and the expert system. Sequence diagram (Figure 6) shows the schedule of running the expert system.

Figures 7 and 8 illustrate the execution environment of VP-Expert (User Interface). During the execution, the system interacts with the user by the user interface. The user interface has three windows: "Questions Window", "Rules Window" and "Facts Window". In the questions window, the questions system should ask from the users, and their alternatives are demonstrated. Rules window presents the rules, which have been used based on the users' answers. Facts window shows the users' answers, which may affect the system's final decision. The advantage of facts and rules windows is that the user can see an implicit explanation for the system's decision-making.

After receiving the facts, the system presents the final answer (in the current example: the proposed assessment = a7). The user can refer to the Index Table and see the related treatment advices.

The expert system designed by Kumar-Jha and Singh [8] is only related to the natural treatment of diabetes, and offers some relevant advices to the patients. The expert system developed by Kara [15] was designed to guide diabetic patients by receiving the data of daily glucose consumption and insulin dosage and then producing a graph from the insulin history and recommending the insulin dosage for the next day. The diabetes expert system, presented in this work, is not only for diabetic patients, but also for the people who are suspected of being diabetic. For this purpose, the authors developed a diabetes estimation module by employing prolog server pages (PSP) as a web-based artificial intelligence language. In another attempt, Azian *et al.* [16] developed an expert system for diagnosis of hypertension using fuzzy logics. Tolooei *et al.* [1] designed an expert system for diagnosis of blood cancer and proposal for its treatment using VP-Expert shell. They concluded that intelligent and semi-intelligent expert systems can be used as co-decision making tools; however, they can never be substitute of the experts, at least at the present time.

When compared with the similar previous works our system seems to be different, addressing all types of diabetes in relation to treatment advices and checking up of the patients.

Summary

In this study, we developed an expert system for obtaining advices for diabetics' treatment. Through direct interview with medical specialists and nurses of diabetics department, the necessary knowledge was acquired, and then the related rules were derived. The system was designed in a rule-based fashion and coded by VP-Expert Shell.

As a conclusion, such an expert system can facilitate treatment of diabetic patients by offering expert advices. The system also can be used in the checkup and prevention of the severe side effects of diabetes, and the physicians and nurses can make use of it as a helpful tool in the process of curative decision-making.

Abbreviations

(Na-K-BUN-CT): sodium-potassium-blood urea nitrogen-creatinine; (U/A): urine analysis

Competing Interests

The authors declare no competing interests.

Authors' Contributions

STT collected information, contributed to the information analysis, and designed the expert system, and drafted and revised the manuscript. TSZ and MVM supervised the progress of the project, and contributed to information analysis. YA were involved in provision of medical instructions necessary consultation, and medical evaluation the proposed system. All authors read and approved the final manuscript.

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