

Expert System for Polymyalgia Rheumatic

Massoud El Agha, Abdallah Jarghon

Department of Information Technology,
Faculty of Engineering & Information Technology,
Al-Azhar University, Gaza, Palestine

Abstract: Polymyalgia Rheumatica (PMR) presents with a broad spectrum of clinical manifestations and almost exclusively occurs in the population aged over 50 years. After rheumatoid arthritis, PMR is the second most common autoimmune rheumatic disorder. Visual loss is the most feared complication in temporal arteritis, and extracranial arteries. No specific laboratory parameter exists for diagnosis of PMR.

Imaging techniques such as ultrasonography, MRI or F-fluorodeoxyglucose PET may be helpful in the diagnosis and evaluation of the extent of vascular involvement in these diseases. This paper presents an expert system for classification criteria for PMR, recent advances of diagnostic and therapeutic procedures. This expert System was written using SL5 Object Expert System Language.

Keywords: PMR, temporal arteritis, SL5 Object Expert System Language

1. INTRODUCTION

PMR is characterized by pain and stiffness in the proximal regions of the extremities and neck, and elevated markers of inflammation [2]. GCA may present with a broad spectrum of clinical manifestations that are either attributable to a systemic inflammatory response, including fever, weight loss or anemia, or to local complications of vascular injury, such as headache, visual symptoms or limb claudicating.

Polymyalgia rheumatica is a typical disease of the elderly and are among the most common indications for prolonged corticosteroid therapy in this population. While treatment-associated complications are the most significant factors contributing to long-term morbidity of PMR patients.

Expert System is a computer application of Artificial Intelligence (AI), which contains a knowledge base and an inference engine, the main components and details are represented in figure[23-30].

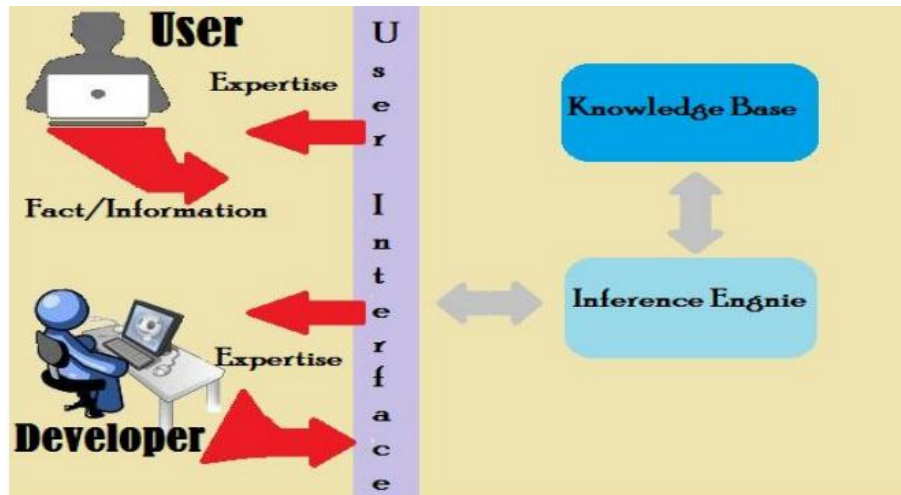


Figure 1: The figure presents the Main Components of an Expert System, Designed by the authors.

The proposed Expert System for polymyalgia rheumatica Diseases Diagnosis was implemented using SL5 Object language which stands for Simpler Level 5 Object [21]. It is a forward chaining reasoning expert system that can make inferences about facts of the world using rules, objects and take appropriate actions as a result. The SL5 Object engine is implemented in Delphi Embarcadero RAD Studio XE6 [22]. SL5 Object executes any Expert System looks like frames. It's easy for the knowledge engineer to build the Expert System and for the end users when they use the system.

2. KNOWLEDGE REPRESENTATION

Symptoms of polymyalgia rheumatic usually begin quickly and are worse in the morning. Most people who develop polymyalgia rheumatica are older than 65. It rarely affects people under 50 [1].

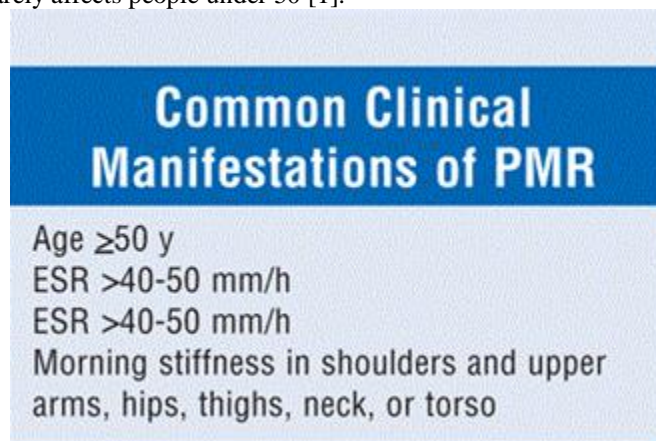


Figure 2: present common clinical manifestations of PMR

You may receive symptom relief by taking anti-inflammatory drugs called corticosteroids. But relapses are common, and you'll need to visit your doctor regularly to watch for serious side effects of these drugs [7].

Polymyalgia rheumatica is related to another inflammatory disorder called giant cell arteritis, which can cause headaches, vision difficulties, jaw pain and scalp tenderness. It's possible to have both of these conditions together.

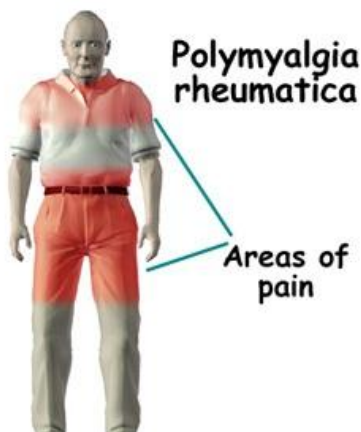


Figure 3: The figure presents the PMR area of pain

Symptoms:

The signs and symptoms of polymyalgia rheumatica usually occur on both sides of the body and may include [3]:

- Aches or pain in your shoulders (often the first symptom)
- Aches or pain in your neck, upper arms, buttocks, hips or thighs
- Stiffness in affected areas, particularly in the morning or after being inactive for a long time
- Limited range of motion in affected areas
- Pain or stiffness in your wrists, elbows or knees (less common)

You may also have more general signs and symptoms, including:

- Mild fever
- Fatigue

- A general feeling of not being well (malaise)
- Loss of appetite
- Unintended weight loss
- Depression

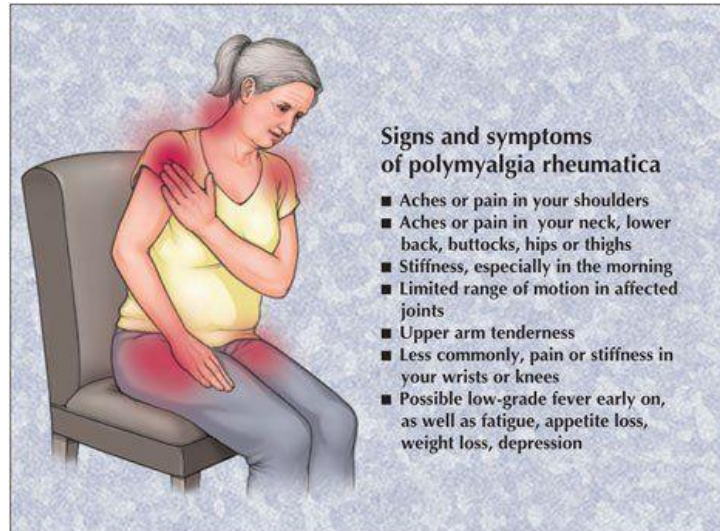


Figure 4: the figure present signs and symptoms of PMR

Causes:

The exact cause of polymyalgia rheumatica is unknown. Two factors appear to be involved in the development of this condition [18- 19]:

- Genetics. Certain genes and gene variations may increase your susceptibility.
- An environmental exposure. New cases of polymyalgia rheumatica tend to come in cycles and may develop seasonally. This suggests that an environmental trigger, such as a virus, might play a role. But no specific virus has been shown to cause polymyalgia rheumatica.

Giant cell arteritis

Polymyalgia rheumatica and another disease known as giant cell arteritis share many similarities. Giant cell arteritis results in inflammation in the lining of arteries, most often the arteries located in the temples. Giant cell arteritis can cause headaches, jaw pain, vision problems and scalp tenderness. If left untreated, it can lead to stroke or blindness.

Polymyalgia rheumatica and giant cell arteritis may actually be the same disease but with different manifestations. The overlap between the two diseases is significant:

- About 20 percent of people with polymyalgia rheumatica also have signs and symptoms of giant cell arteritis.
- About half of the people with giant cell arteritis may also have polymyalgia rheumatica.

Risk factors for polymyalgia rheumatica include:

- Age. Polymyalgia rheumatica affects older adults almost exclusively. The average age at onset of the disease is 73.
- Sex. Women are about two times more likely to develop the disorder.
- Race and geographic region. Polymyalgia rheumatica is most common among whites in northern European populations.

Complications

Symptoms of polymyalgia rheumatica can greatly affect your ability to perform everyday activities. The pain and stiffness may contribute to difficulties with tasks such as the following:

- Getting out of bed, standing up from a chair or getting out of a car
- Bathing or combing your hair
- Getting dressed or putting on a coat

These difficulties can affect your health, social interactions, physical activity, sleep and general well-being [2-3] .

In addition, people with polymyalgia rheumatica seem to be more likely to develop peripheral arterial disease EX giant cell arteritis [4].

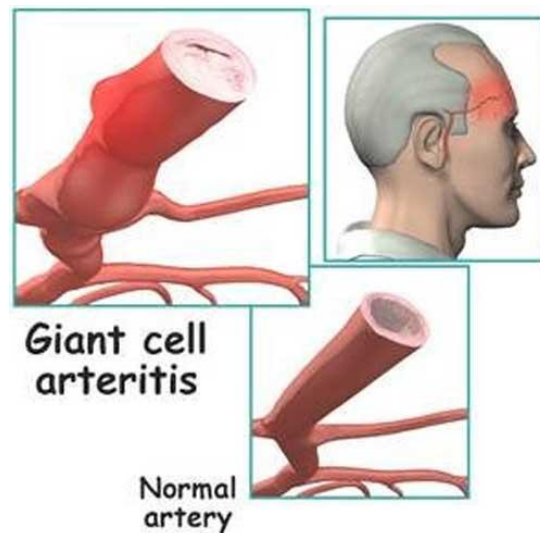


Figure 5: figure shows the difference between GCA & normal artery

Tests and exams

Your answers to questions, a general physical exam and the results of tests can help your doctor determine the cause of your pain and stiffness. This diagnostic process also helps your doctor rule out other disorders that have similar symptoms to polymyalgia rheumatica.

Your doctor may reassess your diagnosis as your treatment progresses. Studies show that 2 to 30 percent of people initially given a diagnosis of polymyalgia rheumatica were later reclassified as having rheumatoid arthritis.

Exam

Your doctor will conduct an exam to get an idea of your overall health, identify possible causes or rule out certain diseases. He or she may gently move your head and limbs to assess whether your symptoms affect your range of motion.

Blood tests

A nurse or assistant will draw a sample of your blood. This sample will be used for several laboratory tests that your doctor will order. Typically, your doctor will check the complete blood counts (CBC) and two indicators of inflammation — sed rate (erythrocyte sedimentation rate) and C-reactive protein.

Imaging tests

Increasingly, ultrasound is being used to distinguish polymyalgia rheumatica from other conditions that cause similar symptoms. Magnetic resonance imaging (MRI) can also identify other causes of shoulder pain, such as degenerative joint changes.

Monitoring for giant cell arteritis

Your doctor will monitor you for signs and symptoms that may indicate the onset of giant cell arteritis. Talk to your doctor immediately if you experience any of the following:

- New, unusual or persistent headaches
- Jaw pain or tenderness
- Blurred or double vision or visual loss
- Scalp tenderness

If your doctor suspects you may have giant cell arteritis, he or she will likely order a biopsy of the artery in one of your temples. This procedure, performed during local anesthesia, removes a tiny sample of the artery, which is then examined in a laboratory for signs of inflammation [12].

Treatments and drugs

Treatment usually involves medications to help ease your symptoms. Relapses are common.

Corticosteroids

Polymyalgia rheumatica is usually treated with a low dose of an oral corticosteroid, such as prednisone. A daily dose at the beginning of treatment is usually 12 to 25 milligrams a day [5].

You'll likely start to feel relief from pain and stiffness within the first two or three days. If you aren't responding to treatment, your doctor may refer you to a rheumatologist.

After the first two to four weeks of treatment, your doctor may begin to gradually decrease your dosage depending on your symptoms and the results of blood tests. The goal is to keep you on as low a dose as possible without triggering a relapse in your symptoms.

Most people with polymyalgia rheumatica need to continue the corticosteroid treatment for at least a year. You'll need frequent follow-up visits with your doctor to monitor how the treatment is working and whether you're having any side effects.

People who taper off the medication too quickly are more likely to have a relapse. Thirty to 60 percent of people with polymyalgia rheumatica will have at least one relapse when tapering off the corticosteroids. Relapses (flares) are treated by increasing your drug dosage for a while then tapering again.

Diagnosing PMR: the spectrum of classical vs atypical PMR.			
	History, examination, investigations	Trial of glucocorticoids: dose	Response to treatment
A safe diagnosis of PMR in primary care can be made in presence of ALL THREE of these	Classical clinical features	15 mg prednisolone	'Magic', 'miracle', within 3 days
Consider other diagnoses if ANY of these are present (but can be 'atypical PMR')	Atypical features	Need for >15 mg prednisolone to relieve symptoms	Incomplete or delayed response

Figure 6: The figure present diagnosing PMR, comprehension between classical & typical PMR

Monitoring side effects

Long-term use of corticosteroids can result in a number of serious side effects. Your doctor will monitor you closely for problems. He or she may adjust your dosage and prescribe treatments to manage these reactions to corticosteroid treatment. Possible side effects include:

- Weight gain
- Osteoporosis — the loss of bone density and weakening of bones
- High blood pressure (hypertension)
- Diabetes
- Cataracts — a clouding of the lenses of your eyes

Calcium and vitamin D supplements

Your doctor will likely prescribe daily doses of calcium and vitamin D supplements to help prevent bone loss induced by corticosteroid treatment. The American Academy of Rheumatology recommends the following daily doses for anyone taking corticosteroids:

- 1,200 to 1,500 milligrams (mg) of calcium supplements
- 800 to 1,000 international units (IU) of vitamin D supplements

Pneumonia vaccine

Your doctor may suggest you get a pneumonia vaccine if you are taking 20 milligrams or more of prednisone a day.

Methotrexate (Trexall)

Joint guidelines from the American Academy of Rheumatology and the European League Against Rheumatism suggest using Methotrexate with corticosteroids in some patients. This is an immune-suppressing medication that is taken by mouth. It may be useful early in the course of treatment or later, if you relapse or don't respond to corticosteroids.

Physical therapy

You may benefit from physical therapy if you've had a long stretch of limited activity owing to polymyalgia rheumatica. Talk with your doctor about whether physical therapy is a good option for you if you're trying to regain strength, coordination and the ability to perform everyday tasks.

Over-the-counter non-steroidal anti-inflammatory drugs, such as ibuprofen (Advil, Motrin, others) or naproxen (Aleve), are not usually recommended for easing the signs and symptoms of polymyalgia rheumatica.

Healthy lifestyle choices can help you manage the side effects that may result from corticosteroid treatment:

- Eat a healthy diet. Eat a diet of fruits, vegetables, whole grains, and low-fat meat and dairy products. Limit the salt (sodium) in your diet to prevent fluid buildup and high blood pressure.
- Exercise regularly. Talk to your doctor about exercise that is appropriate for you to maintain a healthy weight and to strengthen bones and muscles.
- Use assistive devices. Use luggage and grocery carts, reaching aids, shower grab bars and other assistive devices to help make daily tasks easier. Take steps to minimize the risk of falls, such as wearing low-heeled shoes. Talk to your doctor about whether the use of a cane or other walking aid is appropriate for you to prevent falls or other injury.

3. LITERATURE REVIEW

Many expert systems have been designed [23-52] to help facilitating diagnosing and managing a lot of diseases and medical problems which considered as a part of applying Artificial Intelligence and computer science in order to help doctors, hospitals and health care facilities decision making to enable them to offer their health services in the correct way. The current Expert System is designed for diagnosing Polymyalgia Rheumatic problems and recommends the proper treatment.

4. MATERIALS AND METHODS

The proposed expert system performs the diagnosis of Polymyalgia Rheumatic problems by asking questions that requires Yes/No answers. The proposed expert system will ask the user to choose the correct answer in each screen. At the end of the diagnosis session, the proposed expert system provides the proper diagnosis of the problem and gives a recommendation for the treatment to the users. Figure 2 shows the first screen of the expert system session. Figure 2 shows a question from the dialogue between the user and the expert system, and Figure 3 shows how the expert system displays the diagnosis of the problem and the recommendation for treating the patient.

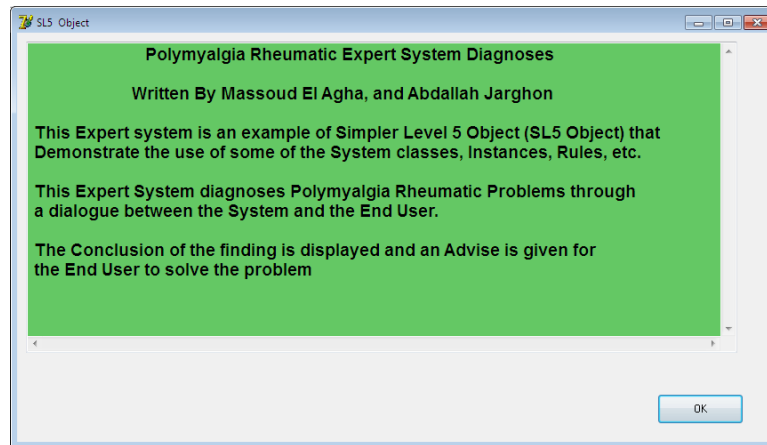


Figure 7: The figure shows the starting screen of the expert system.

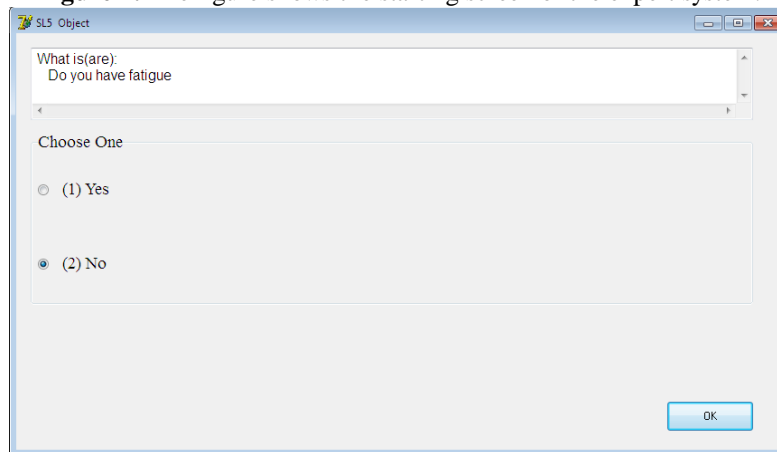


Figure 8: The figure shows when the system asks the user.

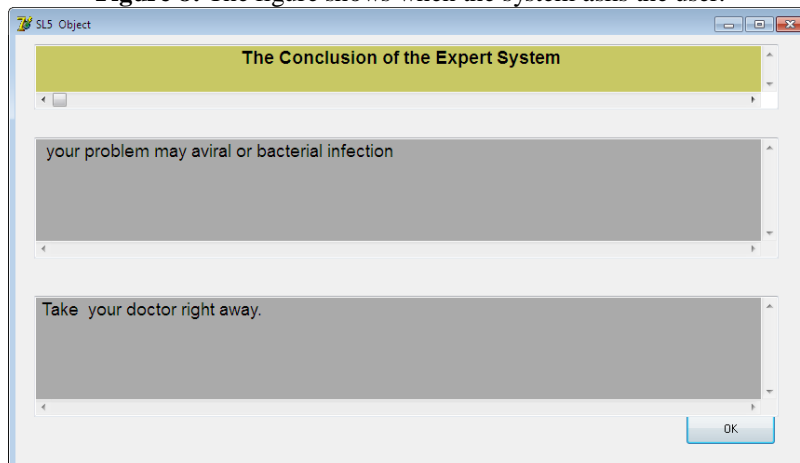


Figure 9: The figure shows diagnosis and recommendation of the expert system.

5. CONCLUSION

Polymyalgia rheumatica is a common disease in the elderly. New classification criteria for PMR have recently been presented and will facilitate future studies on treatment and outcome of this disease.

In this research we have tried our best to help people to diagnose themselves with the aid of specialized expert system for Polymyalgia rheumatic. This expert system is easy to use and has a user friendly interface.

6. EXPERT SYSTEM SOURCE CODE

! Polymyalgia Rheumatica

ATTRIBUTE Do you have fatigue ? COMPOUND

Yes, No

ATTRIBUTE Do you have malaise ? COMPOUND

Yes, No

ATTRIBUTE Did you feel any fever ? COMPOUND

Yes, No

ATTRIBUTE Did you have a sudden weight loss ? COMPOUND

Yes, No

ATTRIBUTE Did you have loss of appetite ? COMPOUND

Yes, No

ATTRIBUTE Did your red blood cell account low ? COMPOUND

Yes, No

ATTRIBUTE Did your ESR result high ? COMPOUND

Yes, No

ATTRIBUTE Did you have positive CRP & RF ? COMPOUND

Yes, No

ATTRIBUTE Did you feel a limited range of motion ? COMPOUND

Yes, No

ATTRIBUTE start SIMPLE

INSTANCE the domain ISA domain

WITH start := TRUE

INSTANCE the application ISA application

WITH title display := introduction

WITH conclusion display := Conc

WITH numeric precision := 8

WITH simple query text := "Is it true that:

WITH numeric query text := "What is(are):

WITH string query text := "What is(are):

WITH time query text := "What is(are):

WITH interval query text := "What is(are):

WITH compound query text := "

WITH multicomponent query text := "What is(are):

INSTANCE introduction ISA display


```
WITH wait := TRUE
WITH delay changes := FALSE
WITH items [ 1 ] := textbox 1
```

```
INSTANCE textbox 1 ISA textbox
WITH location := 10,10,800,350
WITH pen color := 0,0,0
WITH fill color := 100,200,100
WITH justify IS left
WITH font := "Arial"
WITH font style IS bold
WITH font size := 14
WITH text "=:
```

Polymyalgia Rheumatic Expert System Diagnoses Written By Massoud El Agha, and Abdallah Jarghon

This Expert system is an example of Simpler Level 5 Object (SL5 Object) that Demonstrate the use of some of the System classes, Instances, Rules, etc.

This Expert System diagnoses Polymyalgia Rheumatic Problems through a dialogue between the System and the End User.

The Conclusion of the finding is displayed and an Advise is given for the End User to solve the problem".

```
INSTANCE Conc ISA display
WITH wait := TRUE
WITH delay changes := FALSE
WITH items [1] := title textbox
WITH items [2] := problem textbox
WITH items [3] := advise textbox
```

```
INSTANCE title textbox ISA textbox
WITH location := 20,10,800,70
WITH pen color := 0,0,0
WITH fill color := 200,200,100
WITH justify IS center
WITH font := "Arial"
WITH font style IS bold
WITH font size := 14
WITH text := " The Conclusion of the Expert System"
```

```
INSTANCE problem textbox ISA textbox
WITH location := 20,110,800,130
WITH pen color := 0,0,0
WITH fill color := 170,170,170
WITH justify IS left
WITH font := "Arial"
WITH font size := 14
WITH text :=" --====--"
```

```
INSTANCE advise textbox ISA textbox
WITH location := 20,280,800,130
WITH pen color := 0,0,0
WITH fill color := 170,170,170
WITH justify IS left
WITH font := "Arial"
WITH font size := 14
WITH text :=" -----"
```

RULE R0

IF start

THEN ASK Do you have fatigue ?

RULE R1

IF Do you have fatigue ? IS Yes

THEN ASK Do you have malaise ?

RULE R1a

IF Do you have fatigue ? IS No

THEN ASK Did you feel any fever ?

RULE R2

IF Do you have malaise ? IS Yes

THEN ASK Did you feel any fever ?

RULE R2a

IF Do you have malaise ? IS No

THEN text OF problem textbox := "you are healthy but you may have general weakness"

AND text OF advise textbox := "Take your doctor right away."

RULE R3

IF Did you feel any fever ? IS Yes

THEN text OF problem textbox := " your problem may aviral or bacterial infection"

AND text OF advise textbox := "Take your doctor right away."

RULE R3a

IF Did you feel any fever ? IS No

THEN ASK Did you have a sudden weight loss ?

RULE R4

IF Did you have a sudden weight loss ? IS Yes

THEN ASK Did you have loss of appetite ?

RULE R4a

IF Did you have a sudden weight loss ? IS No

THEN text OF problem textbox := " your problem may be a gastric infection"

AND text OF advise textbox := "Take your doctor right away."

RULE R5

IF Did you have loss of appetite ? IS Yes

THEN ASK Did your red blood cell account low ?

RULE R5a

IF Did you have loss of appetite ? IS No

THEN ASK Did your ESR result high ?

RULE R6

IF Did your red blood cell account low ? IS Yes

THEN ASK Did your ESR result high ?

RULE R6a

IF Did your red blood cell account low ? IS No

THEN text OF problem textbox := " you must do some more test"

AND text OF advise textbox := "Take your doctor right away."

RULE R7

IF Did your ESR result high ? IS Yes

THEN ASK Did you feel a limited range of motion ?

RULE R7a

IF Did your ESR result high ? IS No THEN ASK Did you have positive CRP & RF ?

RULE R8

IF Did you have positive CRP & RF ? IS Yes

THEN text OF problem textbox := " you may have an arthritis"

AND text OF advise textbox := "Take your doctor right away."

RULE R8a

IF Did you have positive CRP & RF ? IS No

THEN ASK Did you feel a limited range of motion ?

RULE R9

IF Did you feel a limited range of motion ? IS Yes

THEN text OF problem textbox := " May be your problem is a polymyalgia rheumatica See your doctor , avoid efforts & aggressive physical motion , do ESR and RCs frequently...."

AND text OF advise textbox := "Take your doctor right away."

RULE R9a

IF Did you feel a limited range of motion ? IS No

THEN text OF problem textbox := " Your problem may be an anemia"

AND text OF advise textbox := "Take your doctor right away."

END

REFERENCES

1. Bakeer, H. and S. S. Abu Naser (2017). "Photo Copier Maintenance Expert System V. 01 Using SL5 Object Language." International Journal of Engineering and Information Systems (IJEAIS) 1(4): 116-124.
2. Baker, J., et al. "& Heller, R.(1996)." Information Visualization. Information Technology Journal 7(2).
3. Baker, J., et al. (1996). "Information Visualization." Information Technology Journal 7(2): pp: 403-404.
4. Chen, R.-S., et al. (2008). "Evaluating structural equation models with unobservable variables and measurement error." Information Technology Journal 10(2): 1055-1060.
5. El Agha, M., et al. (2017). "Polymyalgia Rheumatic Expert System." International Journal of Engineering and Information Systems (IJEAIS) 1(4): 125-137.
6. Hissi, H. E.-., et al. (2008). "Medical Informatics: Computer Applications in Health Care and Biomedicine." Journal of Artificial Intelligence 3(4): 78-85.
7. Kashkash, K., et al. (2005). "Expert system methodologies and applications-a decade review from 1995 to 2004." Journal of Artificial Intelligence 1(2): 9-26.
8. Khella, R. and S. S. Abu Naser (2017). "Rule Based System for Chest Pain in Infants and Children." International Journal of Engineering and Information Systems 1(4): 138-148.
9. Li, L., et al. (2011). "Hybrid Quantum-inspired genetic algorithm for extracting association rule in data mining." Information Technology Journal 12(4): 1437-1441.
10. Mrouf, A., et al. (2017). "Knowledge Based System for Long-term Abdominal Pain (Stomach Pain) Diagnosis and Treatment." International Journal of Engineering and Information Systems (IJEAIS) 1(4): 71-88.
11. Nabahin, A., et al. (2017). "Expert System for Hair Loss Diagnosis and Treatment." International Journal of Engineering and Information Systems (IJEAIS) 1(4): 160-169.
12. Abu Naser, S. S. (1993). A methodology for expert systems testing and debugging, North Dakota State University, USA.
13. Abu Naser, S. S. (1999). "Big O Notation for Measuring Expert Systems complexity." Islamic University Journal Gaza 7(1): 57-70.
14. Abu Naser, S. S. (2015). "SI5 Object: Simpler Level 5 Object Expert System Language." International Journal of Soft Computing, Mathematics and Control (IJSCMC) 4(4): 25-37.
15. Abu Ghali, M. J., et al. (2017). "Expert System for Problems of Teeth and Gums." International Journal of Engineering and Information Systems (IJEAIS) 1(4): 198-206.
16. Abu Naser, S. S. and A. E. A. El-Najjar (2016). "An expert system for nausea and vomiting problems in infants and children." International Journal of Medicine Research 1(2): 114-117.
17. Abu Naser, S. S. and A. O. Mahdi (2016). "A proposed Expert System for Foot Diseases Diagnosis." American Journal of Innovative Research and Applied Sciences 2(4): 155-168.

18. Abu Naser, S. S. and A. Z. A. Ola (2008). "AN EXPERT SYSTEM FOR DIAGNOSING EYE DISEASES USING CLIPS." *Journal of Theoretical & Applied Information Technology* 4(10).
19. Abu Naser, S. S. and B. G. Bastami (2016). "A proposed rule based system for breasts cancer diagnosis." *World Wide Journal of Multidisciplinary Research and Development* 2(5): 27-33.
20. Abu Naser, S. S. and I. S. Zaqout (2016). "Knowledge-based systems that determine the appropriate students major: In the faculty of engineering and information technology." *World Wide Journal of Multidisciplinary Research and Development* 2(10): 26-34.
21. Abu Naser, S. S. and M. A. Hamed (2016). "An Expert System for Mouth Problems in Infants and Children." *Journal of Multidisciplinary Engineering Science Studies (JMESS)* 2(4): 468-476.
22. Abu Naser, S. S. and M. H. Al-Bayed (2016). "Detecting Health Problems Related to Addiction of Video Game Playing Using an Expert System." *World Wide Journal of Multidisciplinary Research and Development* 2(9): 7-12.
23. Abu Naser, S. S. and M. I. Alhabbash (2016). "Male Infertility Expert system Diagnoses and Treatment." *American Journal of Innovative Research and Applied Sciences* 2(4).
24. Abu Naser, S. S. and M. M. Al-Hanjori (2016). "An expert system for men genital problems diagnosis and treatment." *International Journal of Medicine Research* 1(2): 83-86.
25. Abu Naser, S. S. and M. W. Alawar (2016). "An expert system for feeding problems in infants and children." *International Journal of Medicine Research* 1(2): 79-82.
26. Abu Naser, S. S. and M. Z. Shaath (2016). "Expert system urination problems diagnosis." *World Wide Journal of Multidisciplinary Research and Development* 2(5): 9-19.
27. Abu Naser, S. S. and R. M. AlDahdooh (2016). "Lower Back Pain Expert System Diagnosis and Treatment." *Journal of Multidisciplinary Engineering Science Studies (JMESS)* 2(4): 441-446.
28. Abu Naser, S. S. and S. H. ALmursheidi (2016). "A Knowledge Based System for Neck Pain Diagnosis." *World Wide Journal of Multidisciplinary Research and Development (WWJMRD)* 2(4): 12-18.
29. Abu Naser, S. S., et al. (2008). "A Proposed Expert System For Guiding Freshman Students In Selecting A Major In Al-Azhar University, Gaza." *Journal of Theoretical & Applied Information Technology* 4(9).
30. Abu Naser, S. S., et al. (2016). "Rule Based System for Diagnosing Wireless Connection Problems Using SL5 Object." *International Journal of Information Technology and Electrical Engineering* 5(6): 26-33.
31. Abu Naser, S., et al. (2010). "Knowledge management in ESMDA: expert system for medical diagnostic assistance." *Artificial Intelligence and Machine Learning Journal* 10(1): 31-40.
32. AbuEl-Reesh, J. Y. and S. S. Abu Naser (2017). "A Knowledge Based System for Diagnosing Shortness of Breath in Infants and Children." *International Journal of Engineering and Information Systems (IJEAIS)* 1(4): 102-115.
33. Abu-Naser, S. S. and A. N. Akkila (2008). "A Proposed Expert System for Skin Diseases Diagnosis." *Journal of Applied Sciences Research* 4(12): 1682-1693.
34. Abu-Naser, S. S., et al. (2010). "An expert system for endocrine diagnosis and treatments using JESS." *Journal of Artificial Intelligence; Scialert* 3(4): 239-251.
35. Abu-Naser, S. S., et al. (2010). "Developing an expert system for plant disease diagnosis." *Journal of Artificial Intelligence ; Scialert* 3(4): 269-276.
36. Abu-Naser, S., et al. (1995). "& Beattie, GA (2000)." *Expert system methodologies and applications-a decade review from: 9-26.*
37. Akkila, A. N. and S. S. Abu Naser (2016). "Proposed Expert System for Calculating Inheritance in Islam." *World Wide Journal of Multidisciplinary Research and Development* 2(9): 38-48.
38. Al Rekhawi, H. A., et al. (2017). "Rickets Expert System Diagnoses and Treatment." *International Journal of Engineering and Information Systems (IJEAIS)* 1(4): 149-159.
39. Anderson, J., et al. (2005). "Adaptation of Problem Presentation and Feedback in an Intelligent Mathematics Tutor." *Information Technology Journal* 5(5): 167-207.
40. Azaab, S., et al. (2000). "A proposed expert system for selecting exploratory factor analysis procedures." *Journal of the College of Education* 4(2): 9-26.
41. Naser, S. S. A. and H. A. A. Hasanein (2016). "Ear Diseases Diagnosis Expert System Using SL5 Object." *World Wide Journal of Multidisciplinary Research and Development* 2(4): 41-47.
42. Naser, S. S. A. and M. A. Al-Nakhal (2016). "A Ruled Based System for Ear Problem Diagnosis and Treatment." *World Wide Journal of Multidisciplinary Research and Development* 2(4): 25-31.
43. Naser, S. S. A. and M. M. Hilles (2016). "An expert system for shoulder problems using CLIPS." *World Wide Journal of Multidisciplinary Research and Development* 2(5): 1-8.

44. Ng, S., et al. (2010). "Ad hoc networks based on rough set distance learning method." *Information Technology Journal* 10(9).
45. Sulisel, O., et al. (2005). "Growth and Maturity of Intelligent Tutoring Systems." *Information Technology Journal* 7(7): 9-37.
46. Almurshidi, S. H. and S. S. Abu Naser (2017). "Design and Development of Diabetes Intelligent Tutoring System." *EUROPEAN ACADEMIC RESEARCH* 6(9): 8117-8128.
47. Almurshidi, S. H. and S. S. Abu Naser (2017). "Stomach disease intelligent tutoring system." *International Journal of Advanced Research and Development* 2(1): 26-30.
48. Abu Naser, S. S. (2008). "Developing visualization tool for teaching AI searching algorithms." *Information Technology Journal, Scialert* 7(2): 350-355.
49. Albatish, I., et al. (2018). "ARDUINO Tutor: An Intelligent Tutoring System for Training on ARDUINO." *International Journal of Engineering and Information Systems (IJEAIS)* 2(1): 236-245.
50. Aldahdooh, R. and S. S. Abu Naser (2017). "Development and Evaluation of the Oracle Intelligent Tutoring System (OITS)." *EUROPEAN ACADEMIC RESEARCH* 6(10): 8711-8721.
51. Alhabbash, M. I., et al. (2016). "An Intelligent Tutoring System for Teaching Grammar English Tenses." *EUROPEAN ACADEMIC RESEARCH* 6(9): 7743-7757.
52. Al-Hanjori, M. M., et al. (2017). "Learning computer networks using intelligent tutoring system." *International Journal of Advanced Research and Development*(2): 1.
53. El Agha, M. I., et al. (2018). "SQL Tutor for Novice Students." *International Journal of Academic Information Systems Research (IJAISR)* 2(2): 1-7.
54. Mahdi, A. O., et al. (2016). "An intelligent tutoring system for teaching advanced topics in information security." *World Wide Journal of Multidisciplinary Research and Development* 2(12): 1-9.
55. Shaath, M. Z., et al. (2017). "Photoshop (CS6) intelligent tutoring system." *International Journal of Academic Research and Development* 2(1): 81-87.