An Expert System for Mouth Problems in Infants and Children

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Abstract— **Infants and children suffer from a lot of mouth problems with a wide range of severity, and usually physicians have difficulties dealing with these problems due to their similarities. In this paper an expert system was designed to help users to correctly diagnose mouth problems in infants and children(teething, gingivitis, impetigo, inflamed papillae, mucocele, oral thrush, allergic reaction, chickenpox, hand-foot-mouth disease, strep throat, cold sores, canker sores, gingivostomatitis) with some information about the disease and how to treat it. SL5 Object expert system language was used to design and implement this expert system.**

Keywords— *Artificial Intelligence; Expert Systems; SL5 Object; Mouth problems; infants and children*

I. INTRODUCTION

Mouth is known as the oral cavity, which is the hollow cavity that permits food and air to enter the body. The mouth has lots of additional organs - for example the teeth, tongue, and the ducts of the salivary glands - that work together to assist in the ingestion and digestion of food. Furthermore, the mouth plays a major role in making of speech through the activities of the tongue, lips and cheeks[3] .

There are several functions of the mouth: Eating, breathing, drinking, Speaking and in infants sucking reflex as seen in Figure 1.
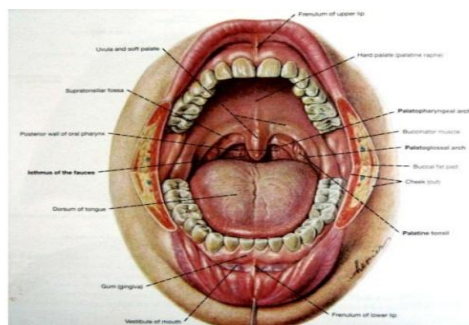

Fig. 1 Mouth.

II. EXPERT SYSTEM LANGUAGE

Expert Systems language is a set of programs which allow the building of an expert system through the creation of knowledge and rules. See figure 2 for details. Expert systems have three essential components:

1. User interface : presents questions to the user and accepts inputs from them
2. Knowledge base: contains data and facts, rules and objects in a specific knowledge domain. The knowledge base obtained from the human expert is prepared by a knowledge engineer as most human experts are not skilled at computer programming
3. Inference engine: this is software that matches the users input with data contained in the knowledge base to reach appropriate answers. This is done using inference rules e.g. If conditions Then rules.
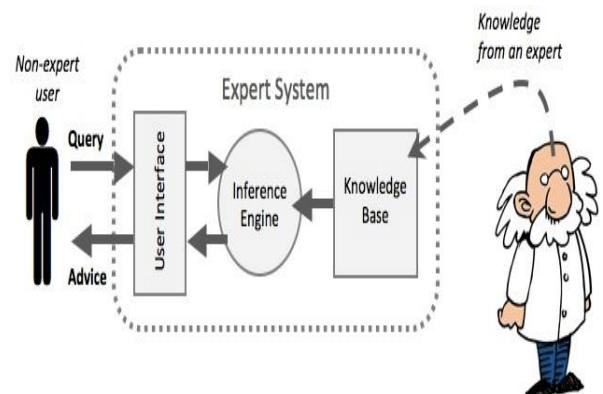

Fig. 2: Components of an expert system

The propped Expert System for mouth problems in infants and children diagnosis was designed and implemented using, SL5 Object expert system language[2] which is influenced by OPS5 and L5 Object implemented in Delphi Embarcadero RAD Studio XE6[11] for efficiency and portability. SL5 Object Language was developed by Prof. Dr. Samy S. Abu Naser for educational purposes and runs on PC. SL5 Object provides mechanisms for expert systems production rule interpreter object oriented programming language.

SL5 Object stands for Simpler Level 5 Object expert system language which is forward-chaining starting from the facts, a solution is developed.

III. MATERIALS AND METHODS.

The proposed expert system will ask the user to answer the questions about the symptoms of the patient and end up with the diagnosis. Then this expert system shows the user some information about the disease and some advices telling him/her how to deal with the baby. Figure 3 shows the decision tree of the expert system for diagnosing the mouth problems in infants and children.
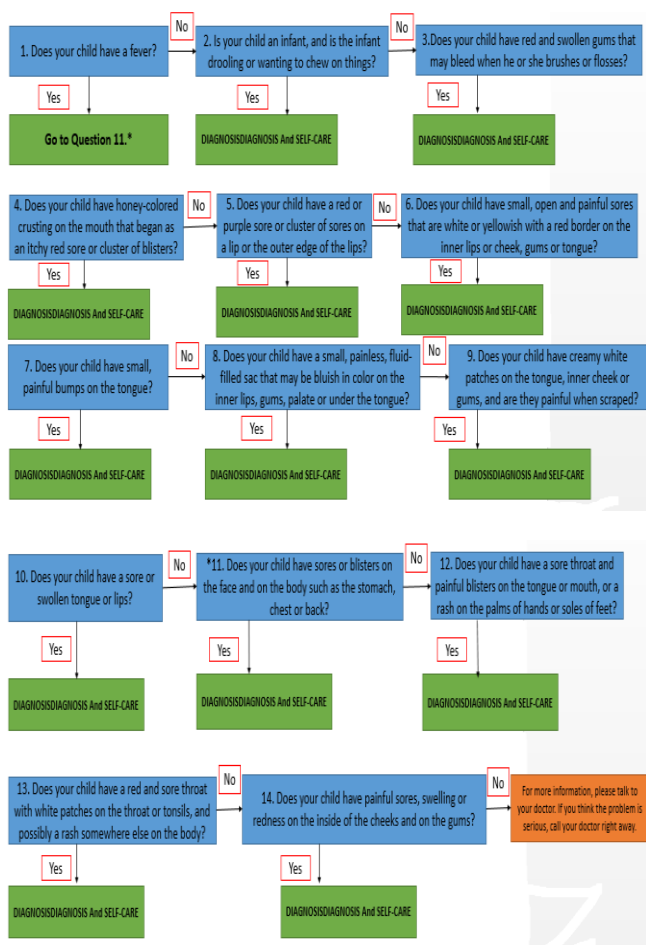

Fig. 3: Decision tree of the expert system.

IV. BACKGROUND

Many expert systems have been designed [1,7-9,12-21] 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 right way. Some of them are listed below.

An expert system for diagnosing skin diseases in farmworkers designed by [6] . An expert system for

skin diseases diagnosis were designed by [1] to be used in diagnosing nine skin diseases. A Proposed Diagnostic Expert System for High Blood Pressure during Pregnancy have been designed by[14]. Fuzzy expert system (FES) have been designed for back pain diagnosis designed by[15].

Our expert system here is offering an easy way, helping people to know how to diagnose and deal with their infants and children mouth problems by giving them some advices about what to do and when to ask for medical help. We give a description and management for 13 mouth problems affecting infants and children worldwide (teething, gingivitis, impetigo, inflamed papillae, mucocele, oral thrush, allergic reaction, chickenpox, hand-foot-mouth disease, strep throat, cold sores, canker sores, gingivostomatitis).

V. KNOWLEDGE REPRESENTATION

The main source of the knowledge for this expert system are physicians. The captured knowledge have been converted into SL5 Object Knowledge base syntax (facts and rules and Objects). Currently the expert system has about14 rules which cover 13mouth problems. Here is a brief identification of each of the13 mouth problems that the expert system can help the user with[3-5,10]:

A. Teething

Teething typically starts approximately 6 months of age. However it is common for teething to begin at any time between 3 months and 12 months of age. A number of babies are finickier than normal when they are teething. This might be because of tenderness and inflammation in the gums before a tooth comes up. These symptoms frequently begin about 3 to 5 days prior to the tooth shows, and they vanish as soon as the tooth crack the gum. Many babies dribble throughout teething, which can cause a rash on the chin, face, or chest. A baby's mouth who's teething is shown in figure 4.

Fig. 4: Teething

B. Gingivitis

Gingivitis is an ordinary and mild form of gum disease that causes irritation, redness and swelling (inflammation) of your gums. The main widespread cause of gingivitis is weak oral hygiene. An infected mouth with gingivitis is shown in figure 5.

Fig. 5: Gingivitis

C.   Impetigo

Is a bacterial skin infection. It causes red sores that can break open, ooze fluid, and build up a yellow-brown layer. These sores may happen anywhere on the body particularly around the mouth. Impetigo is infectious and may be spread to others through close contact or by sharing towels, sheets, clothing, toys, or other stuff. Scratching may also spread the sores to other parts of the body. An infected baby with impetigo is shown in figure 6.

Fig. 6: Impetigo

D.   Inflamed papillae

General painful inflammatory situation affecting one or some fungi form papillae on the tongue. The main cause is confined irritation by food or trauma. It lasts one to two days then fades away. A baby's tongue with inflamed papillae is shown in figure 7.

Fig. 7: Inflamed papillae

E.   Mucocele

A cyst-like bump. moveable and painless , flexible, round, dome-shaped, pearly or semi-clear surface bluish in color, two to ten millimeters in diameter happen when the salivary duct has become blocked

and mucus leaks out, pools, turns into walled off. This mainly happens if you repeatedly bite off or suck on your lower lip or cheek. A mucocele of the mouth is shown in figure 8.

Fig. 8: Mucocele

F.   Oral thrush

Thrush is an infection of the mouth caused by the candida fungus. It is caused by a type of illnesses, stress, or medications can bother the delicate stability, causing the fungus candida to develop out of control and causing thrush. An ordinary sign of thrush is the existence of soft white, slightly raised lesion in the mouth, tongue, and inside the cheeks. A baby mouth with oral thrush is shown in Figure 9.

Fig. 9: Oral thrush

G.   Allergic reaction

Allergies are an overreaction of the body's normal resistance system. The immune system begins fighting substances that are typically harmless (food, medicine). This overreaction may cause a rash, scratchy eyes, swollen lips, a runny nose, problems inbreathing, nausea, and diarrhea. A baby with signs of allergic reaction is shown in Figure 10.

Fig. 10: Allergic reaction

H. *Chickenpox.*

It is also known as varicella, is an extremely infectious disease caused by the preliminary infection with varicella zoster virus.

The disease consequences is in a characteristic skin rash that shapes tiny, itchy blisters. Additional symptoms may include fever, feeling worn-out, and headaches. A baby with chicken box around his mouth is shown in Figure 11.

Fig. 11: Chickenpox.

I. *Hand-foot-mouth disease.*

Hand-foot-and-mouth disease is one that may cause sores in or on the mouth and on the hands, feet, and occasionally the legs and buttocks. The sores may be painful. The disease frequently doesn't last over a week. It is caused by a virus named anentero virus. A baby with hand-foot-mouth disease is shown in Figure 12.

Fig. 12: Hand-foot-mouth disease

J. *Strep throat.*

Strep throat is a bacterial contagion that may make throat feel sore and rough. The cause of strep throat is bacteria recognized as Streptococcus pyogenes. Patient strep throat is shown in Figure 13.

Fig. 13: Strep throat.

K. *Cold sore.*

Are sets of tiny blisters on the lip and around the mouth. The skin around the blisters is frequently sore, swollen, and red. The blisters may perhaps break open, leak an apparent fluid, and then scab over after few days. They typically heal in more than a few days to two weeks. Cold sores are caused by the herpes simplex virus. A baby's mouth with cold sore is shown in Figure 14.

Fig. 14: Cold sore.

L. *Canker sores.*

Tiny, thin lesions that grow on the soft tissues in one's mouth or at the base of one gums. It different cold sores, canker sores don't happen on the surface of ones lips and they aren't infectious. They may be painful, nevertheless, can make eating and talking not easy. The majority of canker sores get away on their own in a week or two. A child's mouth with canker sore is shown in Figure 15.

Fig. 15: Canker sores.

M. *Gingivostomatitis.*

Gingivostomatitis is a wide spread contagious of the mouth and gums. The primary signs are mouth or gum swelling, and lesions in the mouth that resemble canker sores. This contagion may be the result of a viral or bacterial contagion, and is often related to improper care of one's teeth and mouth. Gingivostomatitis is particularly widespread between children. Children with gingivostomatitis can drool and refuse to eat or drink due to the discomfort (often severe) caused by the sores. They might also develop fever and swollen lymph nodes. An infected mouth with gingivostomatitis is shown in Figure 16.

Fig. 16: Gingivostomatitis.

VI. EXPERT SYSTEM INTERFACE

Figure 17, shows a few screen shots about the execution of the Mouth problems in infants and children diagnosing expert system. The first one contains some information about the purpose of the expert system. The second one contains how could a user interact with expert system by choosing an answer for the questions asked. The last one contains the conclusion showing windows for the title of the expert system, window for the diagnosed problem, and a window for the advice to the user telling him/her how to treat a problem.
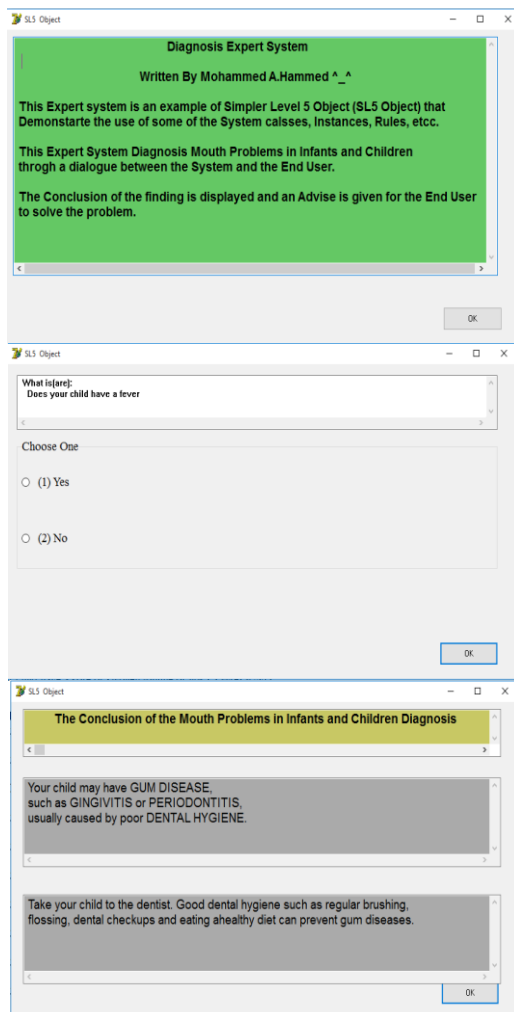

Fig. 17 Some screen shots between the expert system and the end user

VII. CONCLUSION

In this paper, a proposed expert system was designed and developed using SL5 Object expert systems language in order to help physicians and parents in diagnosing their kid's mouth problems in an easier and more precise way than before. This expert system is simple, fast and easy to use.

VIII. EXPERT SYSTEM SOURCE CODE:

ATTRIBUTE start SIMPLE
ATTRIBUTE Does your child have a fever COMPOUND Yes, No
ATTRIBUTE Does your child have sores or blisters on the face and on the body such as the stomach chest or back COMPOUND Yes, No
ATTRIBUTE Is your child an infant and is the infant drooling or wanting to chew on things COMPOUND Yes, No
ATTRIBUTE Does your child have red and swollen gums that may bleed when he or she brushes or flosses COMPOUND Yes, No
ATTRIBUTE Does your child have honey colored crusting on the mouth that began as an itchy red sore or cluster of blisters COMPOUND Yes, No
ATTRIBUTE Does your child have a red or purple sore or cluster of sores on a lip or the outer edge of the lips COMPOUND Yes, No
ATTRIBUTE Does your child have small open and painful sores that are white yellowish with a red border on the inner lips COMPOUND Yes, No
ATTRIBUTE Does your child have small painful bumps on the tongue COMPOUND Yes,No
ATTRIBUTE Does your child have a small painless fluid filled sac that may be bluish in color on the inner lips gums palate COMPOUND Yes, No
ATTRIBUTE Does your child have creamy white patches on the tongue inner cheek or gums and are they painful when scraped COMPOUND Yes, No
ATTRIBUTE Does your child have a sore or swollen tongue or lips COMPOUND Yes, No
ATTRIBUTE Does your child have a sore throat and painful blisters on the tongue or mouth or a rash on the palms of hands COMPOUND Yes, No
ATTRIBUTE Does your child have a red and sore throat with white patches on the throat or tonsils COMPOUND Yes, No
ATTRIBUTE Does your child have painful sores swelling or redness on the inside of the cheeks and on the gums COMPOUND Yes, No

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
 * "

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 :="
                 Diagnosis Expert System

        Written By Mohammed A. Hammed ^_^

This Expert system is written in   Simpler Level 5
Object (SL5 Object) .

This Expert System diagnoses Mouth Problems in
Infants and Children through a dialogue between the
Expert 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] := diagnosis textbox
 WITH items [3] := selfcare 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 Mouth Problems
in Infants and Children Diagnosis "

INSTANCE diagnosis 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 selfcare 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 Does your child have a fever

RULE R1
IF Does your child have a fever IS Yes
THEN ASK Does your child have sores or blisters on
the face and on the body such as the stomach chest or
back

RULE R2
IF Does your child have a fever IS No
THEN ASK Is your child an infant and is the infant
drooling or wanting to chew on things

RULE R3
IF Is your child an infant and is the infant drooling or
wanting to chew on things IS Yes
THEN text OF diagnosis textbox := "Your child may be
TEETHING."
AND text OF selfcare textbox := "Use teething rings or
let your baby chew on a wet washcloth. Rub your
baby's gums with a clean finger.Wipe off drool to
prevent rashes on the baby's face.Use children's
acetaminophen to relieve discomfort, but call your
doctor if the baby develops a fever."

RULE R4
IF Is your child an infant and is the infant drooling or
wanting to chew on things IS No
THEN ASK Does your child have red and swollen
gums that may bleed when he or she brushes or
flosses

RULE R5
IF Does your child have red and swollen gums that
may bleed when he or she brushes or flosses IS Yes
THEN text OF diagnosis textbox := "Your child may
have   GUM   DISEASE,such   as   GINGIVITIS   or
PERIODONTITIS, usually caused by poor DENTAL
HYGIENE."
AND text OF selfcare textbox := "Take your child to the
dentist. Good dental hygiene such as regular brushing,
flossing, dental checkups and eating a healthy diet can
prevent gum diseases."

RULE R6
IF Does your child have red and swollen gums that
may bleed when he or she brushes or flosses IS No
THEN ASK Does your child have honey colored
crusting on the mouth that began as an itchy red sore
or cluster of blisters

RULE R7
IF Does your child have honey colored crusting on the
mouth that began as an itchy red sore or cluster of
blisters IS Yes
THEN text OF diagnosis textbox := "Your child may
have IMPETIGO, a contagious skin infection."

AND text OF selfcare textbox := "Wash the area 3 or 4 times a day and apply an over-the-counter antibiotic ointment. If the sores spread or don't get better, call your child's doctor."

RULE R8
IF Does your child have honey colored crusting on the mouth that began as an itchy red sore or cluster of blisters IS No
THEN ASK Does your child have a red or purple sore or cluster of sores on a lip or the outer edge of the lips

RULE R9
IF Does your child have a red or purple sore or cluster of sores on a lip or the outer edge of the lips IS Yes
THEN text OF diagnosis textbox := "Your child probably has a COLD SORE caused by a virus called HERPES."
AND text OF selfcare textbox := "Cold sores will usually go away on their own. Apply an over-the-counter cold sore ointment for comfort. If the sores are painful, give your child an analgesic such as acetaminophen. Avoid pinching, picking or squeezing the blisters."

RULE R10
IF Does your child have a red or purple sore or cluster of sores on a lip or the outer edge of the lips IS No
THEN ASK Does your child have small open and painful sores that are white yellowish with a red border on the inner lips

RULE R11
IF Does your child have small open and painful sores that are white yellowish with a red border on the inner lips IS Yes
THEN text OF diagnosis textbox := "These may be CANKER SORES. They may be caused by viral infections."
AND text OF selfcare textbox := "Canker sores usually heal on their own. To relieve discomfort, have your child rinse his or her mouth with salt water or diluted hydrogen peroxide, or apply an over-the-counter oral gel. You may also want to give your child an analgesic such as acetaminophen or ibuprofen to relieve pain. See your child's doctor if there is no improvement."

RULE R12
IF Does your child have small open and painful sores that are white yellowish with a red border on the inner lips IS No
THEN ASK Does your child have small painful bumps on the tongue

RULE R13
IF Does your child have small painful bumps on the tongue IS Yes
THEN text OF diagnosis textbox := "These bumps are probably PAPILLAE (where the taste buds are) that have become INFLAMED due to an injury from a burn caused by hot food or drink or a self-inflicted bite."

AND text OF selfcare textbox := "The inflammation and bump will usually go away on its own. Avoid feeding the child hot, spicy and acidic foods. Give your child an analgesic such as acetaminophen or ibuprofen to relieve pain."

RULE R14
IF Does your child have small painful bumps on the tongue IS No
THEN ASK Does your child have a small painless fluid filled sac that may be bluish in color on the inner lips gums palate

RULE R15
IF Does your child have a small painless fluid filled sac that may be bluish in color on the inner lips gums palate IS Yes
THEN text OF diagnosis textbox := "These may be MUCOCELES, harmless cysts that may be caused by sucking mouth tissue between the teeth."
AND text OF selfcare textbox := "These cysts will usually go away on their own. To avoid infection, do not try to open the cyst. See your child's doctor if the cysts don't go away."

RULE R16
IF Does your child have a small painless fluid filled sac that may be bluish in color on the inner lips gums palate IS No
THEN ASK Does your child have creamy white patches on the tongue inner cheek or gums and are they painful when scraped

RULE R17
IF Does your child have creamy white patches on the tongue inner cheek or gums and are they painful when scraped IS Yes
THEN text OF diagnosis textbox := "This may be ORAL THRUSH caused by a fungus growing out of control."
AND text OF selfcare textbox := "This condition usually goes away on its own. Feed your child unsweetened yogurt with live cultures to restore the natural balance of bacteria in the body. Have your child gargle with salt water or use an analgesic such as acetaminophen to relieve pain. If the symptoms get worse or don't get better, see your child's doctor. He or she may prescribe an antifungal medicine."

RULE R18
IF Does your child have creamy white patches on the tongue inner cheek or gums and are they painful when scraped IS No
THEN ASK Does your child have a sore or swollen tongue or lips

RULE R19
IF Does your child have a sore or swollen tongue or lips IS Yes
THEN text OF diagnosis textbox := "Your child may have CHICKENPOX, a contagious infection caused by the varicella-zoster virus."

AND text OF selfcare textbox := "URGENT Call your child's doctor right away."

RULE R20
IF Does your child have a sore or swollen tongue or lips IS No
THEN ASK Does your child have sores or blisters on the face and on the body such as the stomach chest or back

RULE R21
IF Does your child have sores or blisters on the face and on the body such as the stomach chest or back IS Yes
THEN text OF diagnosis textbox := "Your child may have CHICKENPOX, a contagious infection caused by the varicella-zoster virus."
AND text OF selfcare textbox := "Give your child acetaminophen to relieve pain and reduce fever. Call your child's doctor if fever gets worse or doesn't go away, if blisters look infected, or if new symptoms such as headache or nausea appear."

RULE R22
IF Does your child have sores or blisters on the face and on the body such as the stomach chest or back IS No
THEN ASK Does your child have a sore throat and painful blisters on the tongue or mouth or a rash on the palms of hands

RULE R23
IF Does your child have a sore throat and painful blisters on the tongue or mouth or a rash on the palms of hands IS Yes
THEN text OF diagnosis textbox := "Your child may have HAND-FOOT-AND-MOUTH DISEASE or HERPANGINA, viral infections caused by the COXSACKIE VIRUS."
AND text OF selfcare textbox := "These illnesses must run their course Avoid giving the child food and drinks that irritate blisters such as spicy, salty or acidic foods. Have your child drink plenty of cold fluids such as milk and ice water. Feed your child non-irritating foods such as ice cream. Have your child gargle with salt water to relieve discomfort and give your child an analgesic such as acetaminophen to relieve pain and reduce fever. Call your child's doctor if symptoms get worse or don't get any better."

RULE R24
IF Does your child have a sore throat and painful blisters on the tongue or mouth or a rash on the palms of hands IS No
THEN ASK Does your child have a red and sore throat with white patches on the throat or tonsils

RULE R25
IF Does your child have a red and sore throat with white patches on the throat or tonsils IS Yes
THEN text OF diagnosis textbox := "Your child may have STREP THROAT, a bacterial infection."

AND text OF selfcare textbox := "See your child's doctor. He or she may want to do some tests and prescribe antibiotics. Allow your child to get plenty of rest and drink plenty of fluids. Give your child an analgesic such as acetaminophen or ibuprofen to relieve pain and reduce fever. Gargling with salt water may relieve some discomfort."

RULE R26
IF Does your child have a red and sore throat with white patches on the throat or tonsils IS No
THEN ASK Does your child have painful sores swelling or redness on the inside of the cheeks and on the gums

RULE R27
IF Does your child have painful sores swelling or redness on the inside of the cheeks and on the gums IS Yes
THEN text OF diagnosis textbox := "Your child may have GINGIVOSTOMATITIS, a condition caused by a viral infection of the HERPES or COXSACKIE VIRUSES."
AND text OF selfcare textbox := "This condition usually gets better on its own. Allow your child to drink plenty of fluids and offer cold, soothing foods such as ice cream or frozen yogurt. Give your child acetaminophen to relieve pain and reduce fever. Gargling with salt water may also relieve discomfort."

RULE R28
IF Does your child have painful sores swelling or redness on the inside of the cheeks and on the gums IS No
THEN text OF diagnosis textbox := "For more information, please talk to your doctor. If you hink the problem is serious, call your doctor right away."
AND text OF selfcare textbox := "For more information, please talk to your doctor. If you think the problem is serious, call your doctor right away."

END

REFERENCES

1. Abu Naser S.S, A. N. Akkila, 2008, A Proposed Expert System for Skin Diseases Diagnosis. INSInet Publication, Journal of Applied Sciences Research. 2008; 4(12): 1682-1693.

2. Abu Naser S.S., SL5 Object: the Simpler Level 5 Object Expert System Language, International Journal of Soft Computing, Mathematics and Control (IJSCMC). 2015; 4(4) ,25-37.

3. http://www.mayoclinic.org/ . Date visited 1-3-2016.

4. http://familydoctor.org/familydoctor/en/health-tools/search-by-symptom/mouth-problems-infants-children.html, Date visited 1-3-2016.

5. http://www2.gsu.edu/~wwwitr/docs/esshells/, Date visited 1-3-2016.

6. Thomas,F., Quirina A., Steven F., Feldman F. and Sara Q., 2006. Treating Skin Disease: Self-Management Behaviors of Latino Farm workers. Journal of Agromedicine: 11(2): 27-35, DOI: 10.1300/J096v11n02-06.

7. Abu-Naser S.S., El-Hissi H, Abu-Rass M, El-Khozondar N, An expert system for endocrine diagnosis and treatments using JESS, Journal of Artificial Intelligence. 2010; 3(4), 239-251,.

8. Abu Naser S.S., Al-Dahdooh R., Mushtaha A., El-Naffar M., Knowledge Management in ESMDA: Expert System for Medical Diagnostic Assistance, AIML Journal. 2010.

9. Abu Naser S. S., and Ola A. Z. A.,. An expert system for diagnosing eye diseases using Clips. Journal of Theoretical and Applied Information Technology. 2008; 4 (10).

10. http://www.ijaim.org/administrator/components/com_jresearch/files/publications/IJAIM_273_Final.pdf, Date visited 1-3-2016.

11. Embarcadero Technologies, Inc., Users Manual, Version 20.0.15596.9843. 2014.

12. Abu Naser S.S., Baraka M. and Baraka A. A Proposed Expert System For Guiding Freshman Students In Selecting A Major In Al-Azhar University, Gaza,Journal of Theoretical and Applied Information Technology. 2008;4(9).

13. Abu Naser S. S., Kashkash K, Fayyad M. Developing an Expert System for Plant Disease Diagnosis, Journal of Theoretical and Applied Information Technology. 2008; 1(2).

14. Gudu, J.; Gichoya, D.,A Proposed Diagnostic Expert System for High Blood Pressure during Pregnancy using SWI-Prolog, IJAIM, 2(6), 161-163, 2014.

15. Mohammed A. K., Afshar A., Harleen K., Design and Implementation of Fuzzy Expert System for Back pain Diagnosis, INTERNATIONAL JOURNAL OF INNOVATIVE TECHNOLOGY & CREATIVE ENGINEERING, VOL.1 NO.9. 2011.

16. Abu Naser S., Alhabbash M., Male Infertility Expert system Diagnoses and Treatment, American Journal of Innovative Research and Applied Sciences. 2016; 2(4).

17. Abu Naser S., Mahdi, A., A proposed Expert System for Foot Diseases Diagnosis, American Journal of Innovative Research and Applied Sciences. 2016; 2(4).

18. Abu Naser S., and ALmursheidi S. A Knowledge Based System for Neck Pain Diagnosis, World Wide Journal of Multidisciplinary Research and Development(WWJMRD). 2016; 2(4):12-18. http://wwjmrd.com/vol%202/issue%204/pdf/13.2.pdf

19. Abu Naser S., and AlDahdooh R. Lower Back Pain Expert System Diagnosis and Treatment, JMESS, 2016; 2(4).

20. Abu Naser S. and Al-Nakha M. A Ruled Based System for Ear Problem Diagnosis and Treatment. World Wide Journal of Multidisciplinary Research and Development(WWJMRD). 2016; 2(4).

21. Abu Naser S. and Abu Hasanein H. Ear Diseases Diagnosis Expert System Using SL5 Object. World Wide Journal of Multidisciplinary Research and Development(WWJMRD). 2016; 2(4).