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Expert System of Kawasaki Disease Diagnosis

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Abstract: Kawasaki disease that usually affects children is rare in Malaysia. However, awareness and diagnosis are important to know because they have cardiac involvement that can lead to death. It is also possible that the disease is not diagnosed as a result of lack of awareness of the disease and also symptoms similar to other diseases. Therefore, knowing the cause and effect of this disease is important. like most diseases, information is usually obtained from media sources and direct consultation from a health center. although good, the delivery of information is sometimes difficult to understand because users need to analyze or study for themselves whether there are symptoms or not. Thus, in this project a system that can perform self-diagnosis to identify the possibility of suffering from Kawasaki disease has been developed using an expert system approach. In addition to providing expert knowledge for public sharing, the system also acts as an alternative tool to raise awareness among the population. The Expert System Development Methodology (ESDLC) methodology is used as a system development guide. The front chain method is used to draw conclusions for the diagnosis process. Meanwhile, PHP and MySQL programming are used to develop the system. The system has the function of performing diagnostic tests for Kawasaki Disease through the interactive implementation of the system interface, database, knowledge base, and user communication. This system is expected to help in the process of self-diagnosis that can be done by individuals who resemble the actual process of diagnosis with a specialist.

Keywords: Kawasaki Disease, Expert System, ESDLC

1. Introduction

Kawasaki disease (KD), or mucocutaneous lymph node syndrome, is an illness that causes artery, vein, and capillary inflammation [1]. It also stimulates the lymph nodes and causes the nose, mouth and throat signs. It is the most prevalent cause of heart disease in children. The Kawasaki Disease Foundation (KDF) reports that every year it affects more than 4,200 children in the United State [2]. In Malaysia, no cases have been recorded with this Kawasaki disease. The disease is prevalent in Europe and North America where a small number of children can be detected in intensive care units (ICUs) with multiple systemic inflammation as well as some features similar to Kawasaki disease and toxic shock syndrome [3].

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The recent existence in Malaysia of COVID-19 has led to discussions about the disease of Kawasaki affecting children affected by COVID-19. Dr Tedros Adhanom Ghebreyesus , Director General of the WHO, estimates that a small number of children are admitted to intensive care units (ICUs) in Europe and North America because they have similar characteristics to Kawasaki disease [4]. However, Dr Noor Hisham Abdullah, Director General of Health, said that there are no more cases of Kawasaki disease infecting positive Covid-19 children in Malaysia so far. Because of that, many people get notices about Kawasaki disease on the internet, television or radio, newspapers, advertisements and so on.

Even though Malaysians rarely hear or know about Kawasaki disease because it may be rare in this country, it is important for the people to know and have information or knowledge about this disease. Kawasaki disease is almost identical to or appears to be high fever, rash, conjunctivitis, swelling of the lymph nodes, and rash on the mouth and lips. Therefore, parents or guardians are sometimes unaware that this disease is a dangerous disease for their children. In addition, there is a shortage of doctors who deal with the disease and only perform examinations if there are more serious symptoms. It also takes a long time to identify the disease as there are many stages for these children to be diagnosed with Kawasaki disease.

Hence, in this project, a web-based expert system for diagnosing Kawasaki disease is developed. This is to enable the citizens to conduct a self-diagnosis to identify the symptom through the system and ways in which patients seek treatment and can make it easier for users to take early steps to overcome the disease. In this system user can know many information about the Kawasaki disease from the symptoms and treatments. In this system, the expert's knowledge is managed in the knowledge base.

Stakeholders for this expert system is a Dr. Mohd Aizuddin Bin Mohd Zulastri from Pusat Perubatan Universiti Malaya, Malaysia. The main purpose of this project is to develop a system to identification of Kawasaki diseases where the child is the main sufferer. The system also very easy to use for parents or users. The system can determine which symptoms can cause the disease and which treatment is suitable for the patient. Furthermore, the system also saves users time and information, and improves their knowledge. In this system have many symptoms of Kawasaki disease and the user can read also can avoid their children from this disease. The user can be always aware of this Kawasaki disease as it is very uncommon in Malaysia.

This paper contains six main sections. Section 1 describes the background of the project, while Section 2 provides the results of the literature review. Section 3 shows the research methodology and Section 4 explains the findings from the system analysis and design. Section 5 shows the development and testing of the system. The last section provides a conclusion.

2. Literature Review

Kawasaki disease was the main focus of this study. Kawasaki disease occurs with symptoms and signs in stages. Early symptoms, which can last up to two weeks, can include a high fever that lasts for five to six days, a rash on the abdomen and back, blood-stained eyes without collapsing, a heart attack and others. For the later symptoms begin within two weeks of the fever [5]. Children skin on hands and feet may begin to peel and come off into sheets. Some kids may develop temporary arthritis, or joint pain too. Other signs and symptoms are abdominal pain, vomiting, diarrhea, enlarged gallbladder and temporary hearing loss. Children who are younger than 1 or older than 5 are more likely to present incomplete symptoms. These children make up the 25 percent of Kawasaki disease cases that are at a heightened risk of experiencing heart disease complications [6].

As there is less information about this disease in Malaysia, it is important to provide a center that collects and disseminates information effectively. in addition, a self-testing tool to identify the disease based on the symptoms found will help the process of increasing awareness among the people.

Expert system is a piece of software designed using the techniques of Artificial Intelligence (AI). These systems use expert knowledge databases to provide guidance or to make decisions in fields such as medical diagnosis and trading in the stock exchange [7]. An expert system is a system that uses human knowledge which is captured on a computer to solve problems that usually require human knowledge. To make recommendations, the expert system finds and utilizes relevant information from the human users and from the available knowledge base. In the expert system, to solve a certain problem, the user will interact with a computer. This may occur because heuristic information can be processed by the expert system [8]. In general, a rule-based method is required to analyze and compute the knowledge base in order to develop an expert system [9]. It makes a lot of difference to an expert with an expert system.

Forward Chaining is a method of searching or tracking forward techniques that begins with the current knowledge and merging rule to produce a conclusion or goal [10]. It is also a search technique that begins with the known facts and then matches the IF part of the IF_THEN rules. If there is a truth, it matches the IF. In this project, expert system method with forward chaining reasoning will be employed.

Three existing systems are studied and analyzed to obtain more information which helps to develop the content and structure in Expert System of Kawasaki Disease Diagnosis. The existing system studied including An Expert System for Diagnosing Eye Diseases using Forward Chaining Method, Expert System Implementation for the Diagnosis of Skin Disease using Forward Chaining Method and An Expert System for Diagnosis of Human Disease. Table 1 gives the comparison summary.

Table 1: System's Comparison

Features/ System	Eye Diseases Diagnosis using Forward Chaining Method	Diagnosis of Skin Diseases using Forward Chaining Method	An Expert System for Diagnosis of Human Diseases	Expert System of Kawasaki Disease Diagnosis
Reasoning Technique	Forward Chaining	Forward Chaining	Forward Chaining	Forward Chaining
Database	MySQL	MySQL	Unknown	MySQL
Programming Language	PHP	C#	Unknown	PHP
System Type	Web-based	Web-based	Web-based	Web-based
User Login / Registration	Yes	Yes	No	No
Administration Login / Registration	Yes	Yes	Yes	Yes
Information Module	Yes	Yes	Yes	Yes
Diagnosis Module	Yes	Yes	Yes	Yes

3. Methodology

Expert System Development Life Cycle (ESDLC) has been utilized as methodology in this project. It has seven phases, which include problem identification and analysis, determining system specifications, selection of development tools, building a knowledge base, developing prototype systems, testing and validation, and final implementation [11]. Table 2 shows the system development flow and its deliverable.

Table 2: System Development Flow

Phase	Activity	Deliverable
Problem Identification & Analysis	Identify the stakeholder, Identify the problem and study what system feature should have in Kawasaki disease prognosis system	• The proposal of Kawasaki disease prognosis system • Project requirement
System Specification	Decide the software and hardware requirement, Determine the flow of the project, Determine the process that involves in the system, Determine the database design, Design user interface	• System Requirements • DFD • ERD • Flowchart • Expert system architecture • Database schema and data dictionary • System user interfaces
Development Tool Selection	Use the software to develop the system	• Selected tool
Knowledge Base	Gather the required knowledge from the expert	• A knowledge base covering the knowledge regarding Kawasaki disease symptoms
Prototype System	Communicate with the prototype through the prototype's user interface, Program code of the system	• Prototype and interfaces for the system
Testing & Validation	Demonstrate and validate the feature	• Workable system • Test report
Implementation	Develop the system based on the requirement of system.	• New usable feature

4. Analysis and System Design

This section explains the findings from analysis and design for this system. Figure 1 shows a context diagram that is drawn for an Expert System of Kawasaki Disease Diagnosis. It involves a process that represents the modelling system and shows the participants who will communicate with the system called external entities. In this context, the Administrator, Patient and Public Citizens are three entities that will interact with the system. In addition, there is also a data flow indicating the presence of an exchange of information between the entities and the system.

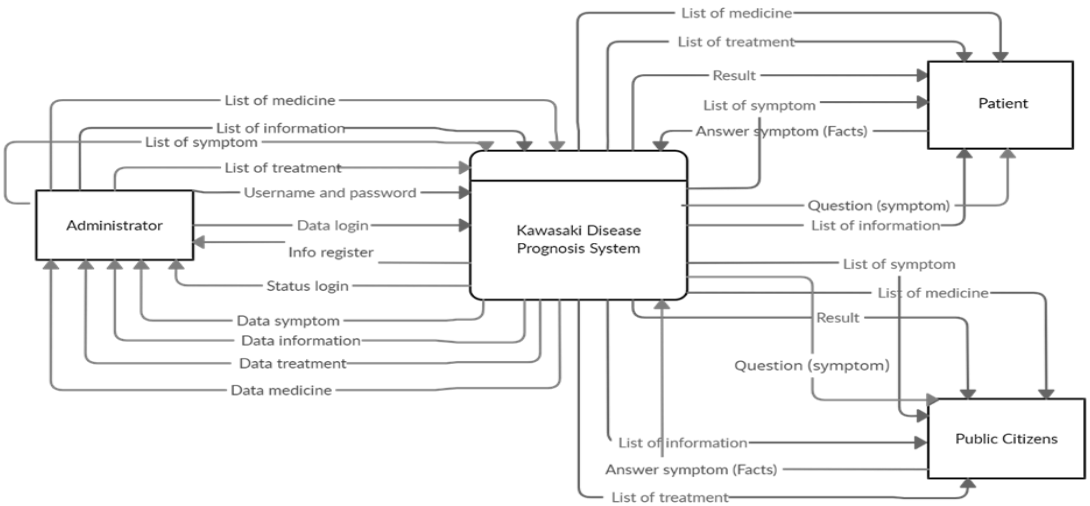


Figure 1: Context Diagram

Figure 2 shows the DFD level 0 which is the decomposition of the Expert System of Kawasaki Disease Diagnosis process shown in the context diagram. There are five processes, three external entities and five data stores in the Expert System of Kawasaki Disease Diagnosis Data Flow Diagram.

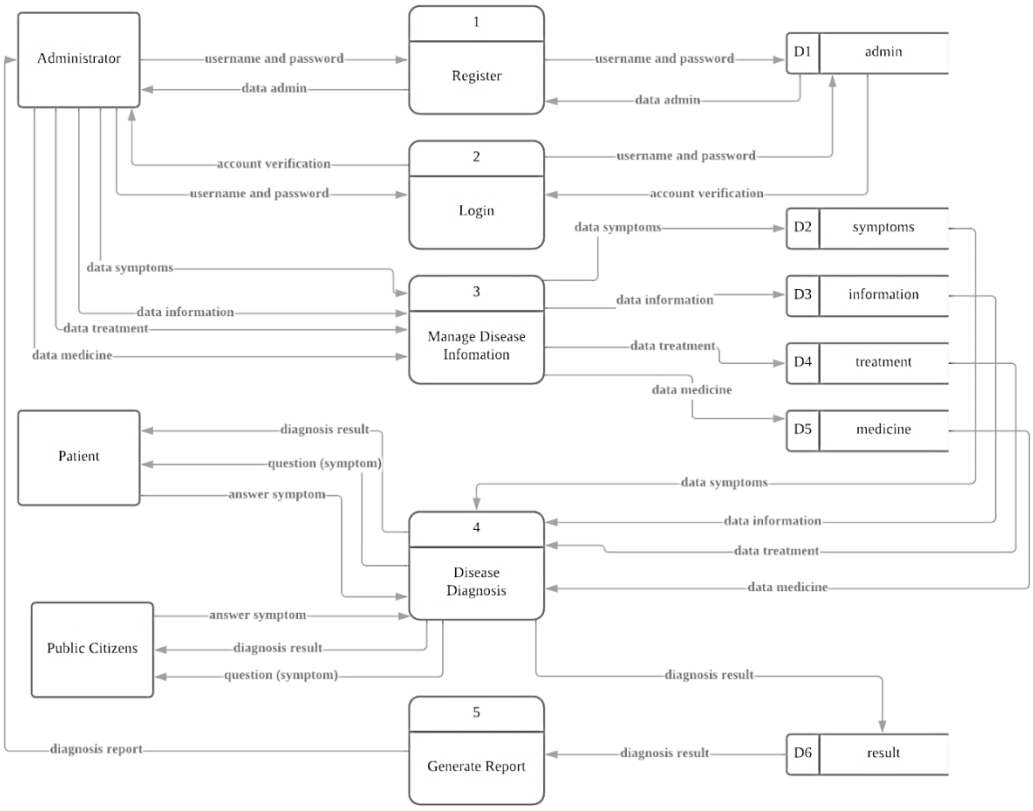


Figure 2: DFD Level 0

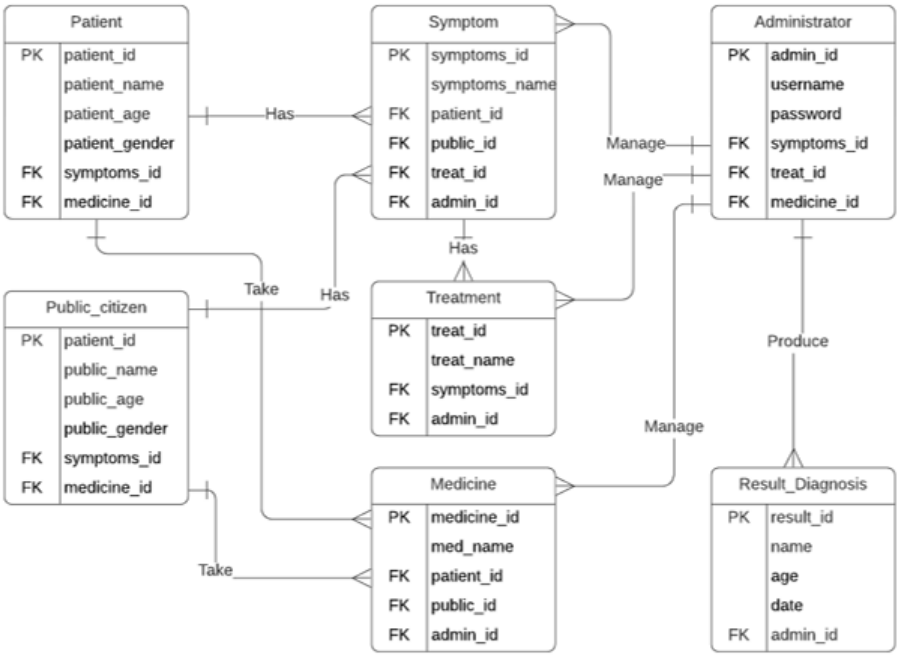


Figure 3: Entity Relationship Diagram (ERD)

The Entity Relationship Diagram (ERD) is one of the relational models used in the abstract system to organize data. ERD is an entity relationship model containing the entity set and relationship set components, each equipped attribute representing all the facts that will be checked in the real world and can be represented more systematically. The Entity Relationship Diagram (ERD) for Expert System of Kawasaki Disease Diagnosis can be seen in Figure 3.

Figure 4 shows the system architecture of the developed expert system. The expert system consists of three main sections which is the knowledge base, inference engine and the user interface.

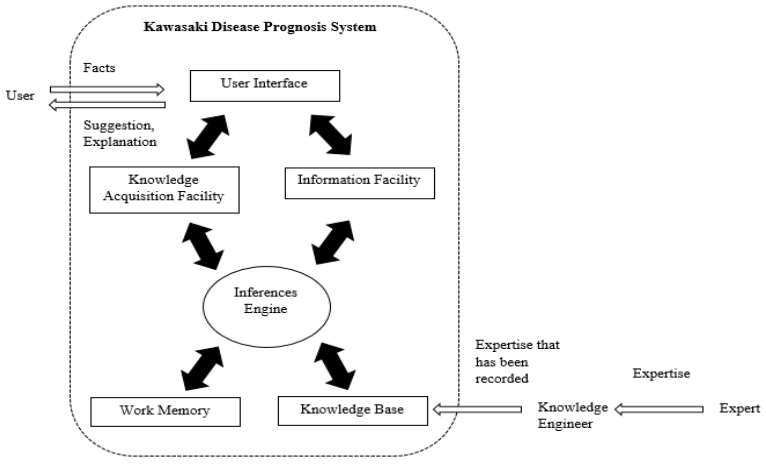


Figure 4: Expert System Architecture

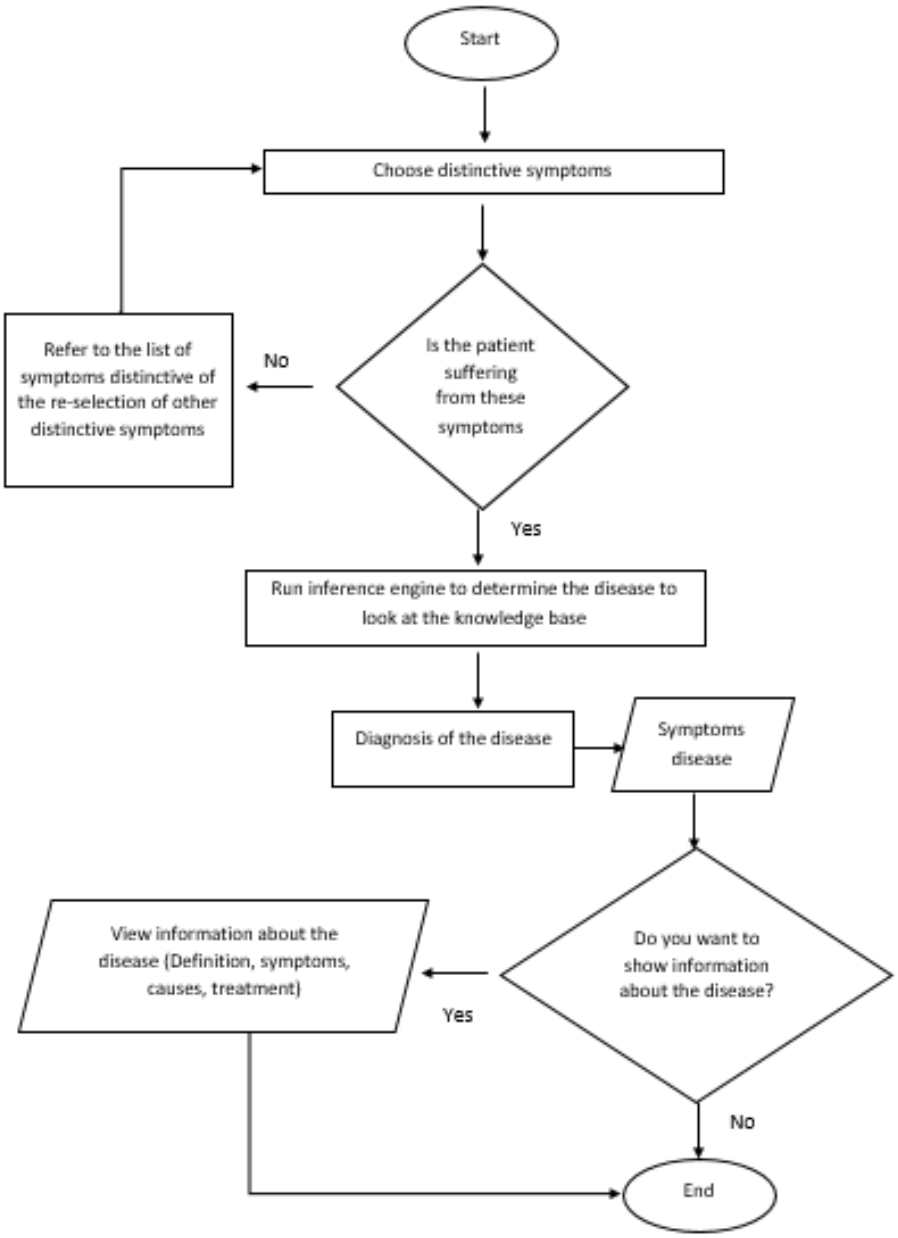


Figure 5: System Flowchart

Figure 5 shows the flowchart for the work of the proposed system. The patient will choose the particular symptoms they have in the system and the system will verify if the patient is suffering from the symptoms of the disease they face in this flowchart. After that the inference engine runs to evaluate the disease to lock in the knowledge base if yes. Then the disease will be detected, and the output of the disease will appear. Then, the machine will ask the patient if they want to see the disease information and if yes, they will show the disease information. The description, symptoms, causes and treatment were included in the details on the disease. If the patient does not want to access the data, they may simply exit the system.

A user interface that will be a medium that connects the user, the public with the inference engine, is involved in the design of this expert system. The network inference of the Expert System of Kawasaki Disease Diagnosis is shown in Figure 6.

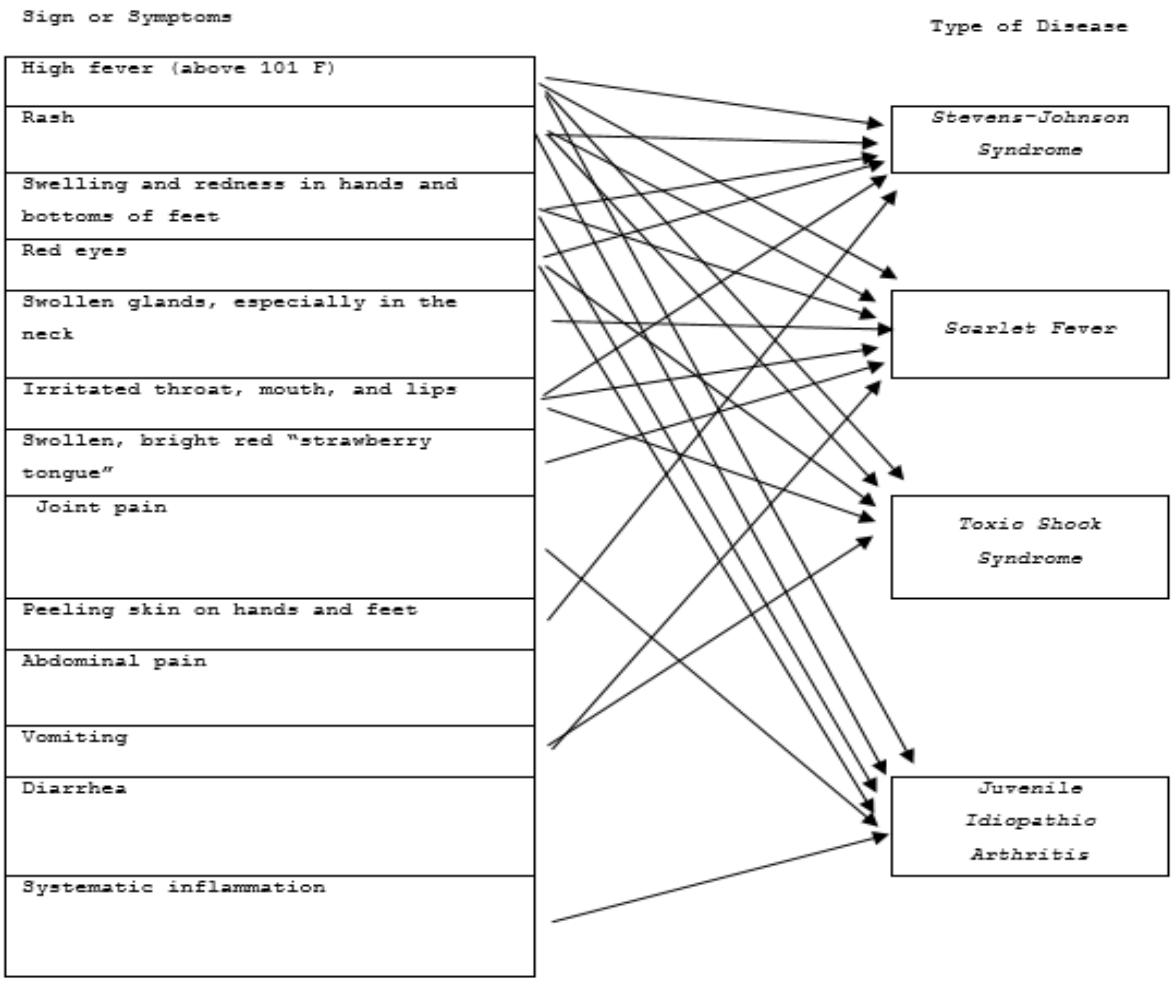


Figure 6: Network Inference Diagram

Part of rules in knowledge base are as follows:

```
IF High fever (above 101 F)
AND Rash
OR Swelling and redness in hands and bottoms of feet
AND Red eyes
OR Irritated throat, mouth, and lips
AND Peeling skin on hands and feet
THEN Stevens-Johnson Syndrome


IF High fever (above 101 F)
AND Rash
OR Swelling and redness in hands and bottoms of feet
```

```
AND Swollen glands, especially in the neck
AND Irritated throat, mouth, and lips
OR Swollen, bright red "strawberry tongue"
AND Vomiting
THEN Scarlet Fever
```

The process of designing the visual, metaphorical and practical aspects of a product or system. The interface design process begins with understanding users, the tasks they perform, and the goals they are trying to accomplish. Interface designers create the medium on the basis of this data to help users interact with products or systems so that they can achieve their objectives [12]. Part of user interface design are as shown in Figure 7 to 9. Figure 7 shows the question interface. For this process, the interface where the user (Patient and Public Citizens) conducts regarding the problems of experiencing or the problems that wants to ask.

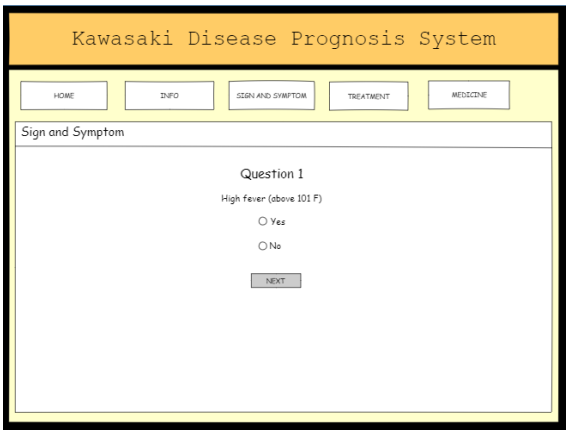


Figure 7: Question interface

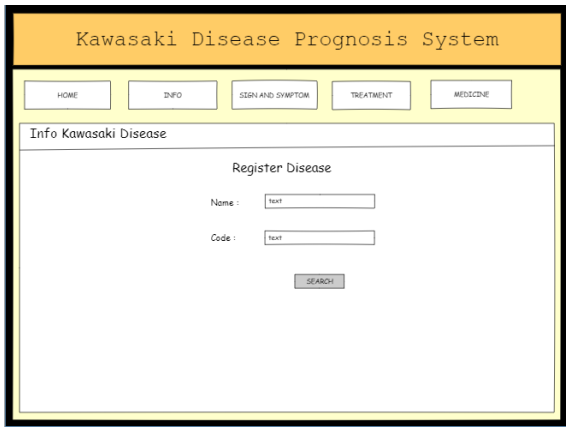


Figure 8: Info (Register Disease) interface

On the other hand, Figure 7 shows the page where Administrator can register the disease to the system. Figure 8 shows the Administrator add the data disease to the system.

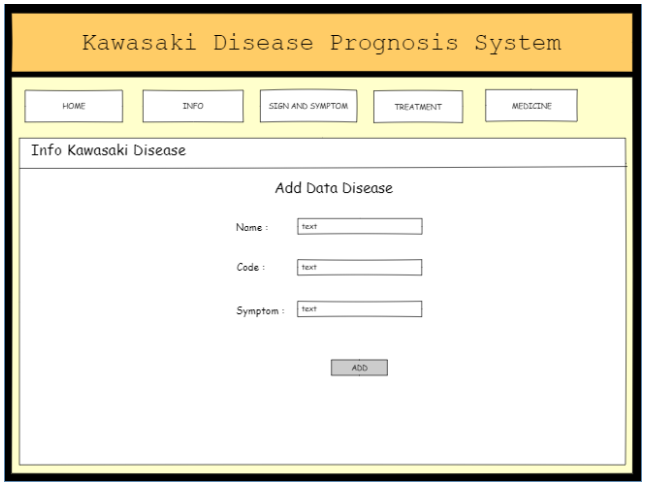


Figure 9: Info (Add Data Disease) interface

5. Implementation and Testing

This section summarizes the results of the implementation and testing phases. The first section demonstrates the implementation phase, which includes activities such as writing computer code, creating databases, and integrating systems. Figure 10 shows the source code of diagnosis page while for the interface of diagnosis shown in Figure 11 and Figure 12.

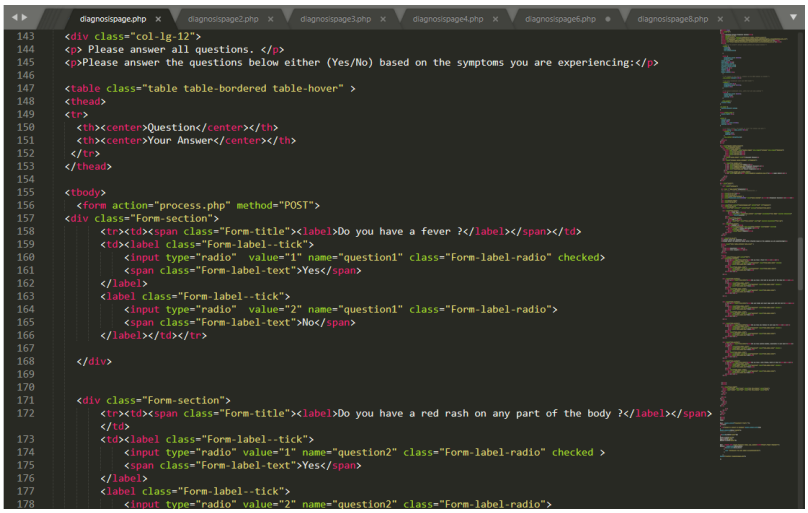


Figure 10: Diagnosis Source Code

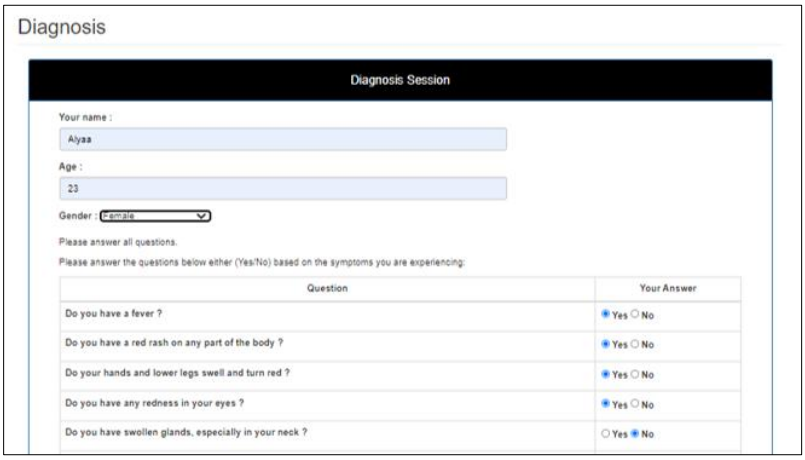


Figure 11: Diagnosis Page Interface Part 1

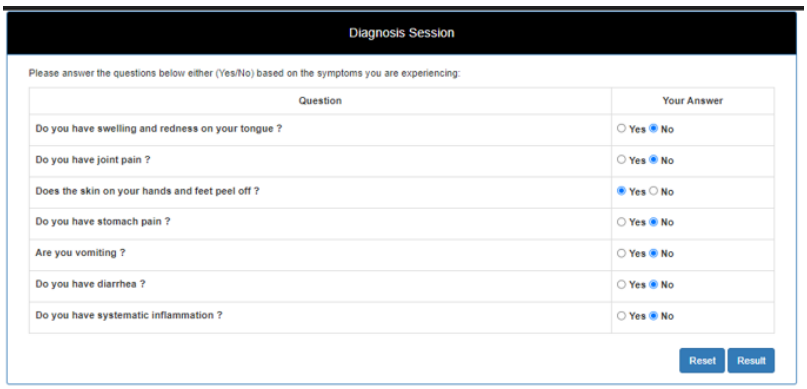
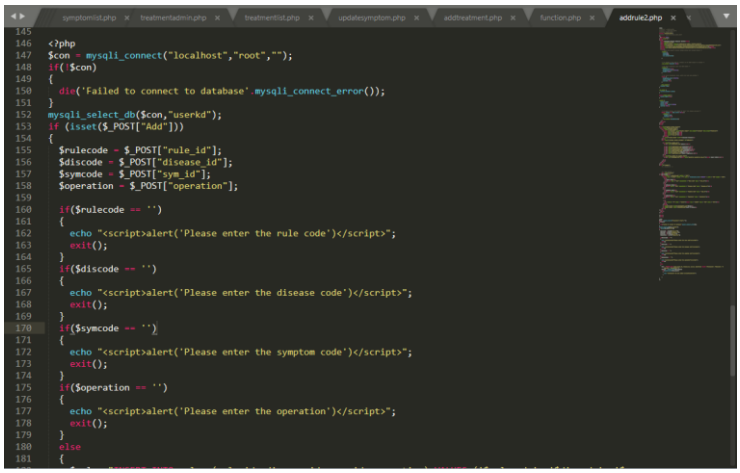


Figure 12: Diagnosis Page Interface Part 2

Further, for the rules page, the Administrator needs to add and update the rules based on the symptoms as well as the disease. Figure 13 shows the source code and Figure 14 shows the rules page interface. Lastly, patient users and citizens will answer questions and the results will be displayed. Administrators will manage user results. Figure 15 shows the source code of the result diagnosis page, while for the interface shown in Figure 16.



```php
<?php
$con = mysqli_connect("localhost","root","");
if(!$con)
{
  die('Failed to connect to database'.mysqli_connect_error());
}
mysqli_select_db($con,"userkd");
if (isset($_POST["Add"]))
{
  $rulecode = $_POST["rule_id"];
  $discode = $_POST["disease_id"];
  $symcode = $_POST["sym_id"];
  $operation = $_POST["operation"];

  if($rulecode == '')
  {
    echo "<script>alert('Please enter the rule code')</script>";
    exit();
  }
  if($discode == '')
  {
    echo "<script>alert('Please enter the disease code')</script>";
    exit();
  }
  if($symcode == '')
  {
    echo "<script>alert('Please enter the symptom code')</script>";
    exit();
  }
  if($operation == '')
  {
    echo "<script>alert('Please enter the operation')</script>";
    exit();
  }
  else
  {
```

Figure 13: Rules Source Code

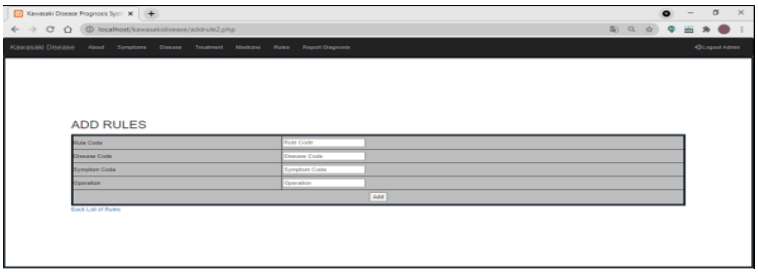
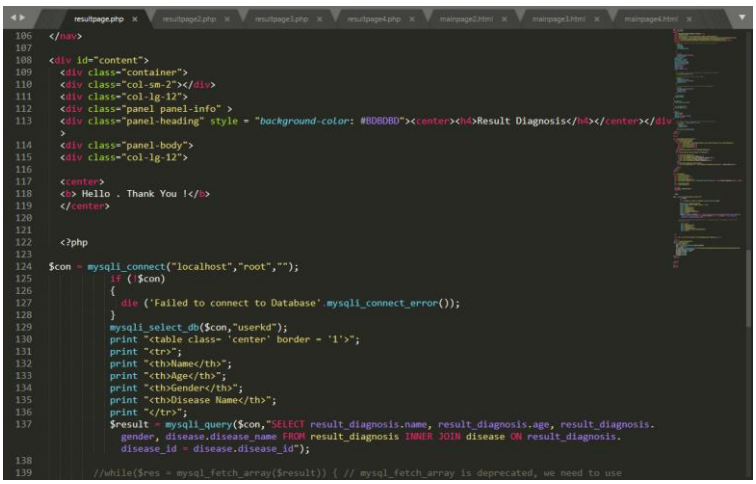


Figure 14: Rules Interface



```php
</nav>

<div id="content">
  <div class="container">
  <div class="col-sm-2"></div>
  <div class="col-lg-12">
  <div class="panel panel-info" >
  <div class="panel-heading" style = "background-color: #BDBDBD"><center><h3>Result Diagnosis</h3></center></div
  >
  <div class="panel-body">
  <div class="col-lg-12">

  <center>
  <b> Hello . Thank You !</b>
  </center>


  <?php

$con = mysqli_connect("localhost","root","");
        if (!$con)
        {
          die ('Failed to connect to Database'.mysqli_connect_error());
        }
        mysqli_select_db($con,"userkd");
        print "<table class= 'center' border = '1'>";
        print "<tr>";
        print "<th>Name</th>";
        print "<th>Age</th>";
        print "<th>Gender</th>";
        print "<th>Disease Name</th>";
        print "</tr>";
        $result = mysqli_query($con,"SELECT result_diagnosis.name, result_diagnosis.age, result_diagnosis.
          gender, disease.disease_name FROM result_diagnosis INNER JOIN disease ON result_diagnosis.
          disease_id = disease.disease_id");

      //while($res = mysql_fetch_array($result)) { // mysql_fetch_array is deprecated, we need to use
```

Figure 15: Result Diagnosis Source Code

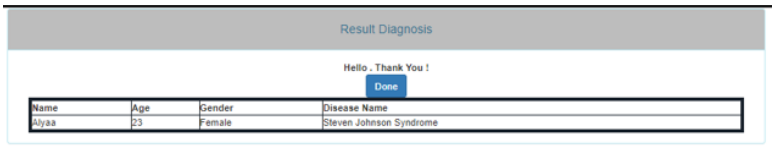


Figure 16: Result Diagnosis Interface

The testing phase is covered in the second part. The main purpose of this phase of testing is to identify system errors and accept the results of the evaluation. There are five functional module which are developed in this project such as administrator registration and login, Kawasaki disease information module, diagnosis module, data and knowledge management, and report module.

Table 3: System functional testing

Testing Modules	Testing	Expected Results	Actual Results
Administrator Registration and Login Module	• Input correct username and password	• Displays the main content of the system including Symptoms, Disease, Treatment, Medicine, Rules and Report Diagnosis	• Login successfully
Kawasaki Disease Information Module	• Administrator can update information about Kawasaki disease • Patient and public citizens can view the information of Kawasaki disease	• Display the information of Kawasaki Disease	• Successfully displayed the information
Diagnosis Module	• Administrator can add, delete, and edit the symptoms of the KD. • Administrator can add, delete, and edit the disease of the KD. • Administrator can add, delete, and edit the treatment of the KD. • Administrator can add, delete, and edit the medicine of KD. • Patient and public citizens can diagnose themselves by taking the KD test	• The symptoms list is displayed • The disease list is displayed • The treatment list is displayed • The medicine list is displayed • The result of diagnose are displayed	• Successfully add, delete, edit and view the symptoms, disease, treatment and medicine • Successfully to answer the test
Data and Knowledge Management	• Administrator can manage data including knowledge and rule used for expert system inferencing which is stored in the database	• Display the updated rules	• Successfully displayed the rules
Report Module	• Administrator can view the report of the patient and public citizens	• Display the patient and public citizens report	• Successfully generated and viewed the report

6. Conclusion

This developed expert system becomes an important pillar in the development of more flexible web applications for the dissemination of expert information and individual use in the future. Significant improvements in resource management can be obtained with the use of a physician system, so that it is expected to affect the future of health care in general practice and hospitals. This expert system is very useful and can facilitate professional work. In particular, whether the patient's condition is difficult or unusual or the person making the diagnosis is just a beginner, a specialist program can assist in the development of possible diagnoses based on patient details and understanding of system conditions contained in his or her knowledge base.

Acknowledgement

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