

Design of an Expert System for Early Diagnosis of Dental and Oral Diseases Using the Web-Based Forward Chaining Method

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Abstract: Teeth and mouth are important organs. Diseases that attack the teeth can cause bad effects, such as appearance and health problems. In general, people only undergo examinations at the dental clinic after serious problems with their teeth occur. This has an impact on the handling and treatment of patients. If the condition of tooth decay is already severe, usually extra treatment is carried out by a doctor, such as carrying out tooth extraction surgery. Expert systems are a branch of computer science that can be applied in the medical field, in this case dentistry. This research aims to produce a web-based expert system for early diagnosis of dental and oral diseases. This research has succeeded in creating an expert system for early diagnosis of dental and oral diseases, so that it can help the public to find out about the dental and oral diseases they are suffering from. The knowledge base of this expert system is made in the form of if-then rules. The inference method used is Forward Chaining. The results of the questionnaire show that the level of acceptance of the application among users is very good, namely 90.48%. Based on the results of these tests, it can be concluded that the expert system application that has been created can be recommended for use by the public as a tool for early diagnosis of dental and oral diseases.

Keywords: Expert System, Forward Chaining, Dental and Oral Disease, web, early diagnosis, oral diseases

1. Introduction

Teeth and mouth are important and very vital organs. Diseases that attack the teeth can cause bad effects, such as appearance and health problems. If serious dental problems occur, people generally have an examination at the Dental Polyclinic.

The results of basic health research show that the dental health condition of Indonesian people tends to be poor. From the results of a health survey involving 2,132 dentists, 57.6% of the Indonesian population admitted to experiencing dental and oral problems and only 10.2% received medical dental treatment. The problem that often arises is that most patients come to the dental clinic unaware of dental disease and how severe the tooth decay is. This has an impact on the handling and treatment of patients. If the condition of tooth decay is too severe, usually extra treatment is carried out by a doctor, such as carrying out tooth extraction surgery [1].

Expert systems, which are a branch of computer science, can also be applied in the medical field. Implementing an expert system can produce several benefits such as accuracy, speed, and can be accessed anytime, anywhere. Expert systems can ease the tasks of experts in their field,

in this case dentists [2]. The Forward Chaining method is one method that can be applied to a disease diagnosis expert system, in this case, to diagnose diseases of the teeth and mouth. Forward Chaining is a reasoning that starts from facts to obtain conclusions from those facts. Implementing the Forward Chaining method in diagnosing dental and oral diseases, namely, by collecting facts regarding the symptoms that often occur in dental and oral diseases. Searching for facts about the symptoms of dental and oral disease can be done by interviewing sources, namely dentists, to obtain rules whose premise is suitable for the type of dental and oral disease. Once the type of dental and oral disease is known, then the best solution or treatment can be given to treat the dental and oral disease [3].

With the existence of a web-based expert system for early diagnosis of dental and oral diseases using the Forward Chaining method, which can be accessed online (using the internet and device). The public will be able to carry out the diagnosis process anytime and anywhere by adopting the expertise of dentists and obtaining information about health and solutions to dental and oral diseases [4]. Dentists can also be helped to diagnose dental and oral diseases in patients more quickly and accurately and provide the best treatment solutions to patients.

Therefore, in this research, an expert system for early diagnosis of dental and oral diseases will be created which aims to provide information to the public or patients regarding health and solutions to dental and oral problems. In their work, dentists can also be helped by expert systems that have high speed and accuracy [5].

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Expert systems can also provide disease diagnosis results and disease treatment solutions that should be given to patients [6].

2. Literature Review

"Expert systems are a branch of AI (Artificial Intelligent) that makes extensive use of specialized knowledge of expert human-level problem solving ". An expert system consists of several concepts that it must have. The basic concept of an expert system, according to, is:

1. Expertise

Is a special knowledge obtained from practice, study, and knowledge. Knowledge can be facts, theories, rules, global strategies for solving problems.

2. Expert

Involves activities of recognizing and formulating problems, solving problems quickly and accurately, explaining the solution, learning from experience, restructuring knowledge, solving rules and determining relevance.

3. Transferring Expertise

Is the process of transferring expertise from an expert into a computer so that it can be used by other people who are not experts. This knowledge is placed into a component called a knowledge base.

4. Inferencing Rules

It is a computer capability that has been programmed. This inference is carried out by an inference engine which includes procedures for solving problems.

5. Rules

This is necessary because the majority of expert systems are rule-based systems, which means knowledge is stored in the form of rules.

6. Explanation Capability

It is a characteristic of an expert system that it has the ability to explain or provide advice on why certain actions are recommended or not recommended.

3. Method

The structure of an expert system can be described as follows, according to, namely:

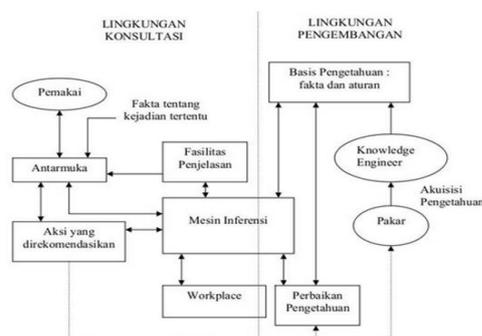


Fig 1. Expert System Structure

There are several components in an expert system, namely:

1. User interface

Mechanisms to provide opportunities for users and expert systems to communicate. The interface receives information from the user and converts it into a form that can be accepted by the system. In addition, the interface receives information from the system and presents it in a form that can be understood by the user [7].

2. Knowledge Base

The knowledge base contains knowledge for understanding, formulating, and solving problems. Expert system Knowledge Base components are composed of two basic elements, namely facts and rules. Facts are information about objects in a particular problem area, while rules are information about how to obtain new facts from facts that are already known. In the expert system structure above, the knowledge base is here to store knowledge from experts in the form of rules (if <condition> then <action> or condition-action rules can also be created).

3. Knowledge Acquisition Facility

Includes the process of collecting, transferring and converting an expert's problem-solving abilities or documented knowledge sources into computer programs, with the aim of improving or expanding the knowledge base [8].

4. Inference Engine

The inference engine is the brain of an expert system and is also known as a control structure or rule interpreter (in rule-based expert systems). This component contains the reasoning mindset mechanism used by experts in solving a problem. The inference engine here is a processor in an expert system that matches the condition part of the rule stored in the knowledge base with the facts stored in working memory.

5. Working Memory

Useful for storing facts produced by the inference engine by adding parameters in the form of degrees of confidence or it can also be said to be a global database of facts used by existing rules [9].

6. Explanation Facility

Providing the correctness of the resulting solution to the user (reasoning chain).

7. Knowledge Improvement

Experts have the ability to analyze and improve their performance as well as the ability to learn from their performance. This ability is important in computerized learning, so that the program will be able to analyze the causes of success and failure experienced and also evaluate whether existing knowledge is still suitable for use in the future [10].

“Inference is a procedure (program) that has the ability to carry out reasoning. Inference is displayed in a component called an inference engine which includes procedures regarding problem solving. The task of the inference engine is to draw conclusions based on the knowledge base it has”.

Forward chaining means using a set of condition-action rules. In this method, data is used to determine which rules to run, then those rules are executed. Maybe the process adds data to working memory [11]. The process is repeated until a result is found.

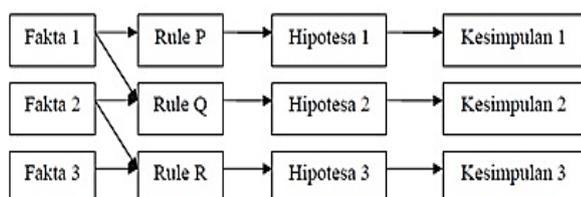


Fig 2. Forward Chaining Method

4. Results and Discussion

“The medical diagnosis process is the first step taken to treat an illness [12]. The diagnosis process is a process carried out by a health expert to determine the type of disease suffered by the patient, then determine the diagnosis of the disease so that he can provide appropriate treatment for the type of disease (etiology) and its symptoms (symptomatic).”

The expert objects are experts who have been selected to be interviewed regarding dental disease, namely:

Name: Drg. Endang Setiowati

Position: Dentist at Djanti Medika clinic

There are several symptoms that arise from types of dental and oral diseases described by Drg [13]. Endang Setiowati is as follows:

1. Periodontal Abscess

Periodontal abscess is a localized inflammation where one of the manifestations is in the form of pus in the tissue supporting the teeth.

Symptoms experienced:

- 1). Bad breath
- 2). Body temperature feels feverish
- 3). Swollen gums
- 4). Smooth shiny gums
- 5). Gums look pink
- 6). Gums bleed easily
- 7). The base of the gums is festering
- 8). Pain when chewing
- 9). There is swelling of the lymph nodes
- 10). Gum recession or receding gums occur
- 11). Pockets form between the teeth and gums
- 12). There are plaque deposits on the teeth

13). There is tartar on the teeth

Treatment: Perform scaling, root planing, curettage or flap surgery according to the severity.

2. Bad breath

Bad breath is an unpleasant odor in the oral cavity.

Symptoms experienced:

1). Bad breath

Treatment: Eliminating etiological factors can also use mouthwash (mouth cleanser).

3. Cheilitis

Cheilitis is inflammation that occurs on the lips, generally at the corners of the lips.

Symptoms experienced:

- 1). Reddish lips
- 2). Dry lips
- 3). Lips feel dry and hard
- 4). You can see a reddish color at the corners of the mouth
- 5). The corners of the mouth feel sore
- 6). The corners of the mouth are scaly
- 7). There are ulcers or sores at the corners of the mouth

Treatment: Give moisturizer to the lips, increase vitamin intake, given antibiotics/minosep, increase water intake.

4. Erythema Multiforme

Erythema Multiformis is a limited disease of the skin and mucous membranes. Generally occurs in young adult men but can also occur in children. The cause is a reaction to microorganisms or substances in the drug.

Symptoms experienced:

- 1). There are horizontal brownish spots on the lips
- 2). Reddish lips
- 3). Dry lips
- 4). Lips feel dry and hard
- 5). Lips feel hot as if they are burning
- 6). Body temperature feels feverish

Treatment: Administration of immunomodulating drugs, low dose systemic corticosteroids and/or gargling with atropine, and topical palliation.

5. Gingivitis

Gingivitis is inflammation of the teeth.

Symptoms experienced:

- 1). Swollen gums
- 2). Gums smooth and shiny
- 3). Gums look pink
- 4). Gums bleed easily
- 5). There are plaque deposits on the teeth
- 6). There are ulcers or wounds on the oral mucosa

Treatment: Scaling and increasing DHE (Dental Health Education).

6. Herpes Simplex (Primary herpetic Gingivostomatitis)

Herpes Simplex (Primary herpetic Gingivostomatitis) is a blister-like bubble which is an HSV virus infection (Herpes Simplex Virus) in the corners of the mouth or lips.

Symptoms experienced:

- 1). Body temperature feels feverish
 - 2). Swollen gums
 - 3). Gums bleed easily
 - 4). There is swelling of the lymph nodes
 - 5). Feels sore when eating and drinking
 - 6). There are ulcers or wounds on the oral mucosa
 - 7). Redness appears in the mouth area
 - 8). There are vesicles or bubbles on the oral mucosa
- Treatment: Giving antivirals, improving body nutrition, and giving anti-pain medication, getting enough rest.

7. Calculus

Calculus is tartar on teeth.

Symptoms experienced:

- 1). Bad breath
- 2). Gums bleed easily
- 3). There are plaque deposits on the teeth
- 4). There is tartar on the teeth

Treatment: Scaling, root planing, curettage or flap surgery according to the severity, drinking lots of water during and after eating can also help minimize plaque formation[14].

8. Candidiasis

Candidiasis is a fungal infection (*Candida Albicans*) in the oral cavity caused by an imbalance in the normal flora (microorganisms) in the mouth.

Symptoms experienced:

- 1). Bad breath
- 2). There are white spots on the tongue
- 3). There are white spots in the oral cavity
- 4). Feels sore when eating and drinking
- 5). There are ulcers or wounds on the oral mucosa

Treatment: Cleaning the fungus in the affected area [15], administering anti-fungal medication, and increasing DHE (Dental Health Education).

9. Cancer

Cancer is uncontrolled and malignant cell growth.

Symptoms experienced:

- 1). There are white bumps on the inside of the lips
- 2). There are horizontal brownish spots on the lips
- 3). There are white, slimy patches in the mouth
- 4). Dry lips
- 5). Wounds bleed easily
- 6). Open sores on the tongue
- 7). Redness appears in the mouth area
- 8). The disease progresses quickly within a month
- 9). Wounds or lumps that appear continue to occur repeatedly

Treatment: Administration of anti-cancer drugs or chemotherapy, or radiotherapy, increasing DHE (Dental Health Education).

10. Media Caries

Media caries is a condition where new cavities affect the dentin layer [16].

Symptoms experienced:

- 1). The dentin layer is visible
 - 2). Cavity
 - 3). Tooth pain when exposed to hot or cold substances
- Treatment: Dental restoration (tooth filling), cleaning teeth, applying fluoride to teeth.

11. Deep Caries

Deep caries is a condition of cavities that have affected the pulp tissue.

Symptoms experienced:

- 1). The dentin layer is visible
- 2). Cavity
- 3). Tooth pain when exposed to hot or cold substances
- 4). The pulp tissue is infected
- 5). Throbbing pain in the gums without any stimulation by hot or cold substances

Treatment: Tooth restoration (tooth filling), cleaning and sterilizing the root canal, tooth extraction if it is very serious.

12. Superficial Caries

Superficial caries is a condition of cavities that only reach the outer layer or enamel.

Symptoms experienced:

- 1). White spots can be seen on the teeth
 - 2). Cavity
- Treatment: Tooth restoration (tooth filling), teeth cleaning.

13. Temporomandibular joint disorders

Temporomandibular joint disorders are disorders of the muscles or joints around the temporomandibular joint (the joint that attaches to the skull bone) or (cranium) [17].

Symptoms experienced:

- 1). Accompanied by headaches
 - 2). Pain in the TMJ joint (Tempura Mandibular Joint)
 - 3). Pain in the chewing muscles
- Treatment: Repair of Dental Occlusion, surgery if severe.

14. Linken Planus

Linken planus is an itchy disease that often recurs, namely, starting as a rash of small bumps that spread and then merge to form scaly, rough plaques.

Symptoms experienced:

- 1). Red scaly spots can be seen in the mouth area
- 2). Accompanied by itching
- 3). The open wound is whitish blue in color
- 4). There is a purple lump with angular edges in the mouth area
- 5). Wounds or lumps that appear continue to occur repeatedly

Treatment: Administration of betamethasone valerate 0.1% cream or ointment, treated with steroids and topical or systemic immunosuppressants.

15. Salivary gland problems

Salivary gland problems are swelling of the salivary gland ducts [18].

Symptoms experienced:

- 1). Infection of the salivary glands
- 2). Pain in the salivary glands
- 3). Swelling of the salivary glands

Treatment: Giving antibiotics or antivirals according to the cause, salivary gland duct surgery.

16. Pulp Necrosis

Pulp necrosis is the death of pulp tissue due to inflammation of the pulp tissue which progresses to a chronic condition.

Symptoms experienced:

- 1). Cavity
- 2). Very large hole in the tooth
- 3). There is decay in the teeth
- 4). The pulp tissue is numb
- 5). The pulp tissue space is open

Treatment: Root canal treatment (PSA/Endodontic treatment) or tooth extraction.

17. Periodontitis

Periodontitis is inflammation of the gums that has spread to the area supporting the teeth [19].

Symptoms experienced:

- 1). Bad breath
- 2). Swollen gums
- 3). Gums smooth and shiny
- 4). Gums look pink
- 5). Gums bleed easily
- 6). Gum recession or receding gums occur
- 7). Pockets form between the teeth and gums
- 8). There are plaque deposits on the teeth
- 9). There is tartar on the teeth

Treatment: Scaling, root planing, curettage or flap surgery according to the severity, as well as giving antibiotics if it is severe.

18. Acute pulpitis

Acute pulpitis is inflammation of the pulp tissue that is not severe, if the cause of the inflammation has been removed the pulp will recover as before [20].

Symptoms experienced:

- 1). Cavity
- 2). Teeth bleed
- 3). Tooth pain when exposed to hot or cold substances
- 4). Very large hole in the tooth
- 5). Pain when lying down
- 6). The pulp tissue is infected
- 7). Throbbing pain in the gums without any stimulation by hot or cold substances

Treatment: Dipulpotomy (pulp cutting), dental restoration (tooth filling), cleaning and sterilization of root canals and administration of pain relievers [21].

19. Chronic Pulpitis

Chronic pulpitis is a severe inflammation of the pulp tissue that will not recover even if the cause is removed, gradually leading to tissue death.

Symptoms experienced:

- 1). Teeth bleed
- 2). Very large hole in the tooth
- 3). A reddish lump appears in the tooth cavity
- 4). Pain when lying down
- 5). Pain when teeth are pressed against food
- 6). Pain when chewing
- 7). The pulp tissue is infected
- 8). The pulp tissue space is open

Treatment: Dipulpotomy (pulp cutting), dental restoration (tooth filling) and administration of painkillers, devitalization (nerves are turned off) and root canal treatment (PSA/endodontic treatment).

20. Thrush

Thrush is inflammation of the oral mucosal tissue.

Symptoms experienced:

- 1). Reddish lips
- 2). Body temperature feels feverish
- 3). Accompanied by itching
- 4). Wounds bleed easily
- 5). Open sores on the tongue
- 6). Feels sore when eating and drinking
- 7). There are ulcers or wounds on the oral mucosa

Treatment: Increasing nutritional intake, vitamins and water, giving minosep, minimizing factors that trigger canker sores such as eating and drinking at temperatures that are too hot (predisposition) [22].

The actors involved in designing an expert system for early diagnosis of dental and oral diseases using the web-based Forward Chaining method are as follows:

- a. Patients: Can access all user menus consisting of the home menu, website profile menu, health consultation menu, health articles menu, suggestion box menu, login sub menu and patient list sub menu.

Input: The input that will be provided is patient data and advice data.

- b. Doctor: Can access all user menus and administrator menus which consist of login menu, home menu, article menu, symptom menu, disease type and solution menu, diagnosis rule menu, suggestion menu, patient data menu, doctor admin menu and report menu.

Input: The input that will be provided is admin data, article data, symptom data, disease and solution data and diagnosis rule data.

Output: The output provided is medical record report data.

The class diagram design created is as follows:

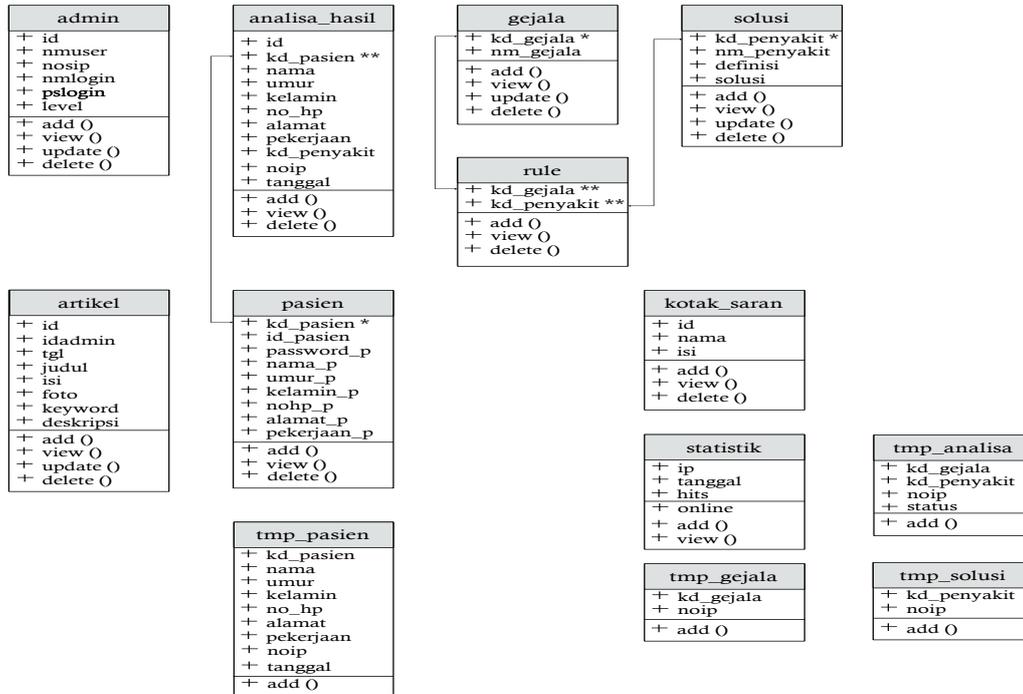


Fig 3. Expert System Class Diagram

The doctor admin homepage is the main page display for the Oral and Disease Diagnosis Expert System admin. The following is an explanation of the main menu display:

- a) **Articles** function for doctor admins to input, update and delete as well as display article data.
- b) **Symptoms** function for doctor admins to input, update and delete as well as display data on symptoms of dental disease.
- c) **Types of disease and solutions** function for admin doctors to input, update and delete as well as display dental disease data, definitions and treatment solutions for dental disease.
- d) **Diagnosis rules** function for doctor admins to input and delete as well as display rule data for symptoms according to the type of disease.
- e) **Suggestions** function for doctor admins to display all data on suggestions given from patients to improve the quality of service.
- f) **Patient data** functions for doctor admins to display all patient data who have registered.
- g) **Doctor admin** functions for doctor admins to input, update and delete as well as display doctor admin data.
- h) **The report** functions for doctor admins to display patient diagnosis data as well as print and export patient diagnosis data into print-out and excel.

Menu types of disease and solutions function for admin doctors to input, update and delete as well as display dental disease data, definitions and treatment solutions for dental disease.

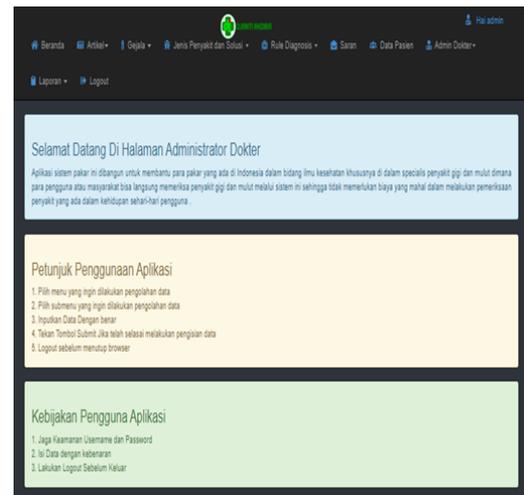


Fig 4. Doctor Admin Home Menu

No	Kode Penyakit	Penyakit	Definisi	Solusi atau Pengobatan	Opsi
1	PD01	Abses Pericoronal	Abses Pericoronal adalah radang yang terlokalisasi dimana abses atau absesitasnya dalam bentuk nanah pada jenggot pendukung gigi.	Melakukan Scaling, root planing, curettage atau basin flap yang disusutkan dengan insang kearahannya.	CR
2	PD02	Bau mulut	Bau mulut adalah bau yang tidak sedap pada rongga mulut.	Menggunakan pasta gigi yang mengandung mouthwash.	CR
3	PD03	Cheilitis	Cheilitis adalah peradangan yang terjadi pada bibir, umumnya ada pada sudut-sudut bibir.	Memberikan perembat pada bibir, menambah asupan vitamin, membatasi diet antibiotik/medas, meningkatkan asupan air.	CR
4	PD04	Eritema Multiforme	Eritema Multiforme adalah suatu penyakit kulit dan memunculkan mukosa yang terlokalisasi. Umumnya terjadi pada gigi dimana mulut tapi juga pada ekstremitas. Penyebabnya berupa reaksi terhadap misoprogesterone atau zat pada obat.	Pemberian obat-obat immunomoderas, kortikosteroid sistemik dosis rendah dan atau kortikosteroid dengan obat steroid, dan melakukan pantiif fokal.	CR
5	PD05	Gingivitis	Gingivitis adalah peradangan pada gigi.	Melakukan scaling dan mengkilapnkan GHE (Dental Health Education).	CR
6	PD06	Lesas Simpleks atau Primary Herpes Gingivostomatitis	Lesas Simpleks (Primary Herpes Gingivostomatitis) adalah pelembing seperti mekapit yang merupakan infeksi virus Herpes Simpleks (Virus) pada bagian sudut mulut atau bibir.	Pemberian antivirus, perawatan mulut bersih, dan pemberian obat anti nyeri, larutan yang cukup.	CR
7	PD07	Kalkulus	Kalkulus adalah karang pada gigi.	Melakukan scaling, root planing, curettage atau basin flap yang disusutkan dengan insang kearahannya, minum banyak air selama dan setelah makan juga dapat membantu.	CR

Fig 5. The type of disease

The report functions for doctor admins to display patient diagnosis data as well as print and export patient diagnosis data into print-out and excel.

No	Kode Pasien	Nama Pasien	Ura	Jenis Kelamin	No. Handphone/WA	Alamat	Pekerjaan	Tanggal Diagnosis	Penyakit	Status	Operasi
1	PSN-000002	Mina Marlinda Khasani	7 Tahun	Wanita	2147483847	Jalan Raya Kawing Arta Kencana 2 No E 10 R1 004 R4012	siswa	2020-01-12 08:15:17	Kandilaka		Operasi
2	PSN-000002	Mina Marlinda Khasani	7 Tahun	Wanita	2147483847	Jalan Raya Kawing Arta Kencana 2 No E 10 R1 004 R4012	siswa	2020-01-12 16:27:16	Bau mulut		Operasi
3	PSN-000007	ese	7 Tahun	Wanita	2147483847	Jalan Raya Kawing Arta Kencana 2 No E 10 R1 004 R4012	siswa	2020-01-11 17:44:49	Bau mulut		Operasi
4	PSN-000004	ese	7 Tahun	Pria	2147483847	Jalan Raya Kawing Arta Kencana 2 No E 10 R1 004 R4012	siswa	2020-01-11 21:48:27	Bau mulut		Operasi
5	PSN-000007	ese	7 Tahun	Wanita	2147483847	Jalan Raya Kawing Arta Kencana 2 No E 10 R1 004 R4012	siswa	2018-10-29 03:14:28	Kanker		Operasi

Fig 6. Report Menu

5. Conclusion

Based on the results of the research that has been carried out, several conclusions can be drawn as follows:

This expert system application for early diagnosis of dental and oral diseases can be accessed online anytime and anywhere without having to go to a dentist's clinic using a smartphone or laptop (device) and internet network and web browser. The application of this expert system for initial diagnosis of dental and oral diseases can help the public in the initial diagnosis of dental and oral diseases. The accuracy value of the system output diagnosis is high. This expert system application for early diagnosis of dental and oral diseases uses Forward Chaining as its inference method and can make it easier for users to carry out the diagnosis process.

Author contributions

Yohanes Bowo Widodo: Conceptualization, Methodology, Software, Field study, Visualization, Investigation **Fikri Yusuf Al Ihsan:** Data curation, Writing-Original draft preparation, Software, Validation., Field study, Writing-Reviewing and Editing.

Conflicts of Interest

The author declare that there is no Conflicts of Interests.

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