# A Novel Proposed Expert System In Diagnosing Periodontal Disease

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## Abstract

This study objective's is to diagnose periodontal disease by designing the rule-based expert system. This research uses applied research and rule-based reasoning in diagnosing periodontal disease. This proposed system requires inputs such as cal values, bone loss, tooth loss, and age. The outputs are periodontitis stage and periodontitis grade. Tests are carried out on an expert system with medical record data to evaluate the rules that have been generated. The proposed rule-based expert system has an output accuracy of 86%. The Rule-based reasoning method is still reliable to be used as the basis for an expert system.

**Keywords:** Periodontal risk, Assessment, Expert System, Rule Based Reasoning
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## Introduction

Periodontal disease affects approximately 14% of the adult population globally, representing more than one billion cases worldwide. Periodontal disease or periodontal pathology is a disease that causes tooth loss due to inflammation from bacteria that results in progressive destruction of the supporting tissues of the teeth. Periodontal disease in society has a broad impact, namely disturbances in the quality of life, including limited dental function (difficulty chewing, food stuck, lousy breath, disturbed digestion), physical disability (inadequate diet, avoiding certain foods, unable to brush teeth properly, complaints of pain every time chewing food, aches, headaches, pain in the jaw), psychological discomfort (feeling low self-esteem, suffering a lot, worrying), and psychological disabilities (disturbed sleep, difficulty concentrating, feeling embarrassed)[1].

Periodontal disease is an inflammation of the supporting tissues of the teeth characterized by the destruction of connective tissue, periodontal ligament, and alveolar bone. Periodontal disease is divided into two, namely gingivitis and periodontitis. Inflammation confined to the

gingiva is termed gingivitis, and inflammation involving the destruction of connective tissue and alveolar bone is periodontitis [2].

The aetiology of periodontal disease is divided into local factors and systemic factors. Local factors are specific microorganisms or a collection of pathogenic periodontal microorganisms such as Porphyromonas gingivalis, Aggregatibacter actinomycetemcomitans, Prevotella intermedia, Fusobacterium nucleatum, Tannerella forsythia, and Treponema denticola.5. While systemic factors control the response of tissues to local factors so that the effects of local irritation can be exacerbated by systemic conditions, for example, hormonal influences (puberty), vitamin deficiency, and systemic disease effects.

Assessment of risk factors as a parameter in determining periodontal disease in the classification according to the American Academy of Periodontology (AAP) 2018 periodontitis is divided into stages and grades [3][4][5]. Stage indicates the severity and extent of disease and assesses case complexity while grade periodontitis to estimate the risk of future development of periodontitis and response to standard therapeutic principles and as a basis for determining the intensity of therapy and monitoring, estimating the potential health impact of periodontitis on systemic disease and otherwise, and to guide systemic monitoring and therapy with other medical peers

The risk factors that play a role are sociodemography, diabetes mellitus, smoking and stress. Although the initiator of periodontal disease is bacteria, risk factors also have a role in the severity of periodontitis.

The development of the world of information technology has undergone many rapid changes, along with the human need for information technology. This encourages experts to develop computers so that they can help humans work. One of computer science that can help develop computers to help human work is expert systems. One expert system that has been developed is an expert system that diagnoses periodontal disease. Many studies have researched expert systems to diagnose periodontal disease.



An expert system is a system on a computer that can solve problems that can only be solved by human expertise [6]. Expert systems are a branch of artificial intelligence. An expert system has a knowledge base with information from an expert. Rule-based reasoning is the basis of conventional expert systems. Several expert system functions are Interpretation, Prediction, Diagnosis, Design, Planning, Monitoring, Debugging, Repair, Instruction, and Control. The essential components of an expert system are illustrated in Figure 1. Knowledge acquisition is used to transfer knowledge from an expert to a machine so that it can be processed by a computer and produce a specific format to be entered into a knowledge base. The knowledge base contains the knowledge needed to understand, formulate and solve problems. An inference engine is a program that contains a methodology for reasoning based on the contents of a list of rules and specific algorithms for making decisions. The user interface is a medium that connects the system with the user. Users will input data or answers to questions posed by the expert system, and then the expert system will draw conclusions.



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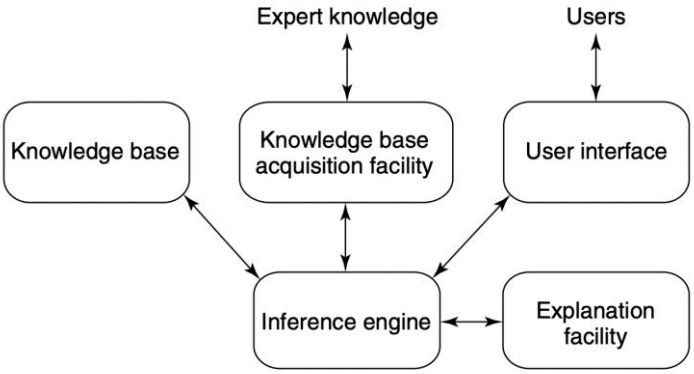


*Figure 1. Component of Expert System*

The contribution of this paper is to provide a brief description of the studies that have to develop an expert system diagnosing periodontal disease. This paper describes the input, method and output defined by each study. Then a novel expert system was proposed to diagnose periodontitis.

**Materials and methods**

This study proposes to design an expert system using rule-based reasoning to diagnose periodontitis based on stage and grade and a trial is conducted for rules using patient medical record data. The research was carried out by RSGMP UNHAS in the period of June-July 2022. The first step in this study is to determine the problems. The reviewed survey conducted focused on expert systems for diagnosing periodontal disease.

The survey review, extraction, and writing of a report from the results were carried out. Then we conducted interviews with experts who are specialist dentists. The interview contains what factors and rules are needed in diagnosing periodontitis disease. The next step is generating the rules. The results of this activity will serve as a knowledge base for the proposed expert system. The last step is to test the rules with . Our method can be seen in Figure 2.

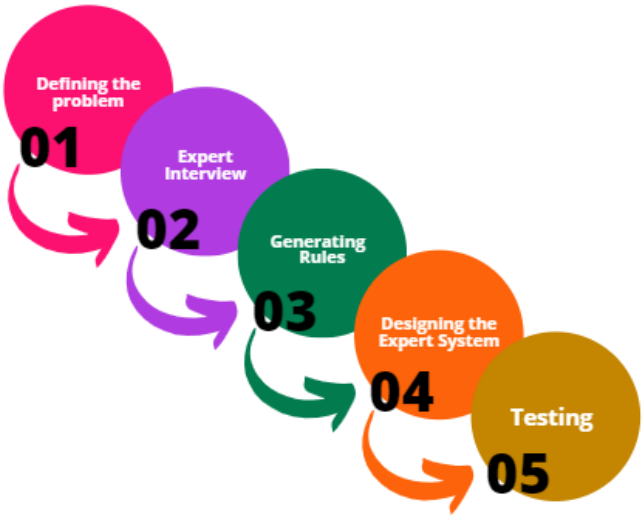


*Fig. 2. Methodology*



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**Results and discussion**

On the first step, we defining the conducted survey review. Several works have been done to develop an expert system for diagnosing periodontal diseases. Table 1 shows the results of our survey review. Each study is assigned an ID code, and then the method, the number of input variables, the type of output and the presence of treatment suggestions will be defined.



Table 1. Survei Review Result

| Paper ID | Method | Number of Input Variable | Output | Suggested Treatment |
|---|---|---|---|---|
| ID01 [7] | Fuzzy Logic, Rule Based System | 10 | Disease severity, Gingivitis grade, periodontitis grade and recommended treatment. | Yes |
| ID02 [8] | Certainty Factor | 15 | The name of the periodontal disease and the degree of certainty of the patient's disease | No |
| ID03 [9] | Semi-supervised fuzzy clustering, Graph-based clustering | 1 | Oral Disease Classification. | No |
| ID04 [10] | Deep Learning | 1 | Periodontal Disease Classification | No. |
| ID05 [11] | Fuzzy Logic, Rule Based System. | 3 | Gingivitis grade, periodontitis grade | No |
| ID06 [12] | Fuzzy Cognitive Maps (FCM) | 12 | Periodontal Disease severity | No |
| ID07 [13] | Certainty Factor | 5 | The degree of certainty of the patient's disease | No. |
| ID08 [14] | Dempster–Shafe | 26 | The degree of certainty of the patient's disease, Treatment Suggestion | Yes |

ID01 builds an expert system to diagnose periodontal disease using fuzzy logic. Fuzzy logic is used to map input variables. The input variables that will undergo defuzzification are Gingival Index, Alveolar Bone Loss, Probing Pocket Depth (PPD), Mobility, and Attachment Loss. In addition, there are 5 additional input variables in the form of age, PI, disease, drug and [15]. After the system maps the input, the expert system then uses 164 rules to make decisions and produces outputs in the form of disease severity, gingivitis level, periodontitis level and recommended treatment methods.

ID02. This study uses the certainty factor method to process data which are answers from users and experts. The input



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data are 15 symptoms of patients with periodontal disease, such as sensitive teeth, dry mouth, and gum colour. The output produced in the system under study is the name of the periodontal disease and the level of certainty of the user's disease.

ID03 Using a semi-supervised fuzzy clustering algorithm to create an expert system called the Dental Diagnosis System (DDS). The system in this study receives input from X-Ray images to diagnose patients' dental diseases.

ID04 uses deep learning technology with the CNN method to diagnose periodontal disease in patients. This study also received input from panoramic radiographs into the system to determine the severity of the periodontal disease.

ID05 Using Fuzzy Logic and rules in building an expert system to diagnose patients. The data input to the software is a factor that will affect the value of the level of dental and periodontal disease. The input data is divided into 3 linguistic variables, namely the gingival index (Gingival Index/GI), pocket depth (Probing Pocket Depth/PPD), and mobility (Mobility/MB). The GI linguistic variable has 3 linguistic values, namely L (Low), M (Middle) and H (High). The output of this system is Gingivitis grade and Periodontitis grade.

ID06 uses Fuzzy Cognitive Maps (FCM) in diagnosing periodontal disease. The input variables processed are 12 input variables such as oral hygiene, diabetes, pregnancy, economic and social status, and others. FCM is helpful for processing inputs used in expert systems. The output of this system is in the form of Periodontal Disease severity which is then compared with the results of decision-making from 3 experts to see the accuracy value.

ID07 uses Dempster – Shafer to get the highest percentage of the probability of periodontal disease based on the symptom information provided. The total input variables used in this system are 26. In addition to using the Dempster-Shafer method, the system built also uses 32 rules to support the production process of output values.

Rules are generated to get a decision or diagnosis result from the expert system. There are eight rules used to decide the stage and grade of periodontitis as shown in table 2.

Table 1 Rules

| No. | Rules |
|---|---|
| **1** | If the value of tooth loss = 0 and the value of CAL <= 2 then periodontitis Stage I |
| **2** | If the tooth loss value = 0 and the CAL value is between 3 - 4 then periodontitis Stage II |
| **3** | If the value of tooth loss = 0 and the CAL value is between 3-4 and there are pockets of 1-5 then Stage II periodontitis |
| **4** | If the value of tooth loss = 0 and the value of CAL = 0 and there are pockets 1-5, then periodontitis is Stage II |
| **5** | If the value of tooth loss is between 0-4 then Stage III periodontitis |
| **6** | If tooth loss = 0 and CAL >= 5 and there are pockets >= 6 then it is stage III |
| **7** | If tooth loss = 0 and CAL = 0 and there are pockets >= 6 then it is stage III |
| **8** | If the value of tooth loss > 5 then periodontitis Stage IV |



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The proposed expert system is expected to help dentists predict the level of a patient's periodontal risk. The input from this system is several variables from medical records such as cal value, bone loss, tooth loss, and age[16]. The Expert Decision Model used in this study was obtained from two factors: a literature study on periodontal risk and the results of interviews with specialist dentists. The inference engine will capture and convert the two outputs of expert decision factors into rule-based reasoning as the basis of the expert system. The application will process input and produce output in the form of Periodontitis Stage and Periodontitis Grade predictions. The proposed system can be seen in Figure 2.

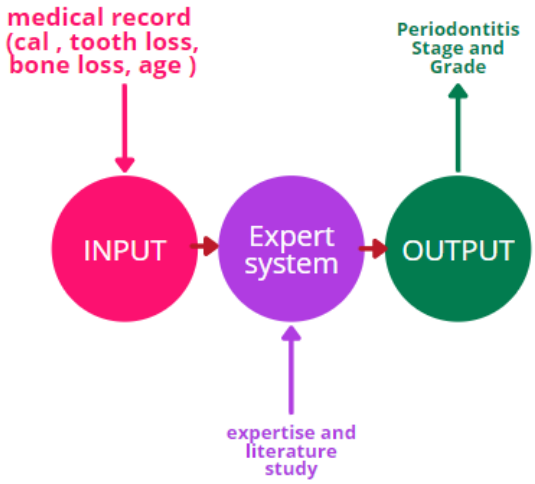


*Figure 2. Proposed Expert System*

Tests are carried out on an expert system with medical record data to evaluate the rules that have been generated. Medical record data is entered into the system to view the system output. Validation is then carried out by specialist doctors to see the system output and compared it with medical records. There are 23 medical record data used as test data in this study. The results of the system output can be seen in table 2. the value of the validation field will be true if the system output is the same as the value of the validation result by the doctor

Table 2 Accuracy Testing Result

| Testing ID | System Output (PERIODONTITIS) | | Validation |
|---|---|---|---|
| **1** | Stage III | A | **True** |
| **2** | Stage IV | B | **True** |
| **3** | Stage III | C | **True** |
| **4** | Stage III | C | **True** |
| **5** | Stage III | A | **True** |
| **6** | Stage IV | B | **True** |
| **7** | Stage III | A | **True** |
| **8** | Stage II | C | **True** |



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| | | | |
|---|---|---|---|
| **9** | Stage III | C | **False** |
| **10** | Stage III | B | **True** |
| **11** | Stage III | C | **True** |
| **12** | Stage III | A | **True** |
| **13** | Stage III | A | **True** |
| **14** | Stage III | A | **False** |
| **15** | Stage IV | A | **True** |
| **16** | Stage III | C | **False** |
| **17** | Stage IV | C | **True** |
| **18** | Stage III | B | **True** |
| **19** | Stage IV | C | **True** |
| **20** | Stage III | A | **True** |
| **21** | Stage III | B | **True** |
| **22** | Stage IV | A | **True** |
| **23** | Stage III | B | **True** |

The expert decision-making method in this proposed system is rule-based reasoning. In addition to these methods, there are other methods such as Fuzzy Logic and Machine Learning. Accuracy testing is then carried out with medical record data as test data. The proposed expert system produces output with 86% accuracy after validation test. This proves that the rule-based reasoning method, although conventional, is still reliable to be used as the basis for an expert system.

## Conclusions

The main objective of this paper is to design a new expert system that diagnoses periodontitis based on literature studies and interviews with experts. The proposed expert system requires inputs such as cal values, bone loss, tooth loss, and age. The proposed expert system outputs are periodontitis stage and periodontitis grade. The proposed rule-based expert system has an output accuracy of 86%. The Rule-based reasoning method is still reliable to be used as the basis for an expert system.

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