Dental Disease Detection Using Hybrid Fuzzy Logic and Evolution Strategies

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Abstract**—Dental disease detection is needed because majority of Indonesian have ever experienced dental disease. There are three areas affected by dental disease: South Sulawesi, West Sulawesi, and South Kalimantan according to Basic Health Research 2013. Obtaining accurate detection is difficult because it requires expert observations and interviews in order to improve their perception. Accurate dental disease detection is required by dentists as a tool to make it easier to improve patient interaction and time effeciency. Good and accurate detection requires an approach to obtain a model capable of processing observation data. This research proposes a method as solution utilizing hybrid approach employed both fuzzy logic and evolution algorithm. Evolution Strategies is used for optimization that get results better accuracy than simply using FIS Tsukamoto. Optimization focuses on the function of the degree of membership. This can be utilized to categorize the following dental disease. Variance: pulpitis, gingivitis, periodontitis and advacend periodontitis using formula Root Mean Square Error (RMSE) obtain with RMSE 0.82.**

Index Terms**—FIS; Detection; Hybrid; Evolution Strategies.**

I. INTRODUCTION

Dental disease is a disease that is often perceived by people regardless of age as one of the most prevalent diseases in Indonesia [1]. Currently, several types of dental diseases emerge along with technology growth in medical sciences. New medication and treatment make their appearance from time to time in accordance with the needs and work time allocation efficiency.

Dental disease based on symptoms [2] generally can be categorized, including the type of disease such as pulpitis, gingvitis, periodontitis and advanced periodontitis. These diseases possess similar symptoms such as plaque, inflamed gums, pain, red gums, swollen gums, bleeding gum, breath odor, wobbly teeth. But the difference among these diseases is the severity of each symptom which is known as parameter.

Pulpitis is inflammatory diseases involving dental pulp caused by a bacterial infection in dental caries, dental fracture or other circumstances that resulted in pulp exposure against bacterial invasion. Thermic factor, hyperemia changes, and other factors. Gingivitis gum inflammation accompanied by bone changes that lead to periodontitis. It is also reffered as oulitis or ulitis. Periodontitis is tissue inflammatory reaction surrounding the teeth, usually caused by gingivitis keperiodontium expansion inflammation and advanced periodontitis severity resulting in severe inflammation and wobbly teeth [3].

An accurate approach is to get a model that matches with the expert knowledge and information. They are subsequently processed into the system as a tool for dentist. In this research, the researchers propose a hybrid approach method. Tsukamoto Fuzzy inference system possess advantage in classification process, therefore dental diseases can be classified based on disease symptoms types [4]. Evolution strategies method are very effective to produce a better solution [5] and has been shown in several studies using hybrid approach [6]. with a population-based algorithm that is suitable for complex problems difficult to solve the mathematical model-based analysis approach [7].

II. REVIEW OF LITERATURE

In previous studies, researchers utilized fuzzy infenrence system (FIS), which is part of the fuzzy logic, also known as an inference engine because it is easy to process knowledge into rules form as was conducted in the study [8][9]. However, in examination process that uses only Fuzzy Inference system requires long time in the process because the testing process is still done manually. Comparing expert and system results to get a better fuzzy inference system (FIS) result can be combined with other methods such as Artificial Neural Network (ANN), which is used in the previous study [10] [11]. FIS can also be combined with K-Means [12] [13] and evolutionary algorithms methods which used in previous study [14] [15] [16]. FIS can also be combined with direct method, one of them is Tsukamoto method [17] [18] [19].

FIS is considered superior as it is can be used in selection, detection, prediction, ranking process. It is capable of calculating accuracy level by utilizing Root Mean Square Error (RMSE). Tsukamoto FIS methods successfully applied in a variety of classification problems. This research utilize Tsukamoto FIS system in order to detect dental disease through several phases. The general stages starts from inputs, fuzzi-fication, inference system, defuzzy-fication, and the final result output. For defuzzyfication process there are several methods used to easily examine obtained results in accordance with the needs of the case which is as follows:

1. Centroid method
2. Height method
3. First (or last) of maxima
4. Mean-max method
5. Weight average

III. Fuzzy Logic

Lothfi A. Zadeh (1962) introduced fuzzy logic, which refers to the principles of human reasoning [20]. Fuzzy logic possess important role in decision making which could be utilized in various fields such as disease detection system (medical field) [21]. Classic logic states that everything is binary, which means there are only two possibilities, "right or wrong", "yes or no", and so on. These possess affiliation value of 0 or 1. Fuzzy logic is set theory logic used to address uncertainty without having to use complicated mathematical equations.

Fuzzy logic possess the following general work steps [22]:

1. Determine linguistic variables / numerical.
2. Establish affiliation function.
3. Establish a rule base.
4. Change the crisp data into fuzzy using the affiliation function.
5. Evaluate the rule in the rule base.
6. Combining the results obtained on each rule.
7. Change the output data into the crips.

IV. Hybrid FIS – Evolution Strategies

This study combines two methods which are expected to obtain optimal results compared to previous research. Fuzzy inference system (FIS) is known as an inference engine that possess advantage on information or knowledge processing in the rules form. Method of evolution strategies (ES) is part of evolution algorithm method relying on mutation as well as performing population manipulation. It is consisting of several chromosomes, therefore chromosomes illustrates possible solution coding of problems to be resolved.

Hybrid FIS - ES is a process of resolving a problem which utilize fuzzy into the process of Evolution Strategy algorithms. Hybrid FIS – ES general work steps is exhibited as follows [23]:

1. Initialize population at random.
2. Calculate fitness value of each chromosome by applying parameter values in fuzzy process.
3. Performing recombination process ($\mu + \lambda$) in each iteration
4. Each parent gene carried out recombination process.
5. Update parent gene chromosome by means recombination process.
6. Evaluate fitness value of each chromosome.
7. Update sigma value based on fitness value of children chromosome.
8. Select next generation by way of selection
9. Repeat steps 3 through 8 until criterias cease to be fulfilled.

V. Methodology

Problems on dental disease detection was examined through observations and interviews with experts. It is based on disease symptomps which becomes input variables criterion affecting output parameters.

This study used 100 patients data and their symptoms as (see appendict). The criteria used are disease symptoms as indicators affecting output variables. This study utilized 8 input variables as criteria used in previous studies [4]. Based on expert interviews, disease symptoms that becomes input criteria are as follows:

1. Plaque
2. Inflamed gums
3. Pain
4. Red gums
5. Swollen gums
6. Easily bleeding gums
7. Breath odor
8. Wobbly teeth

A. Fuzzification

Fuzzification is a process which changes crisp value input (the certain value). Value that has been set at the time of inputting, subsequently converted into fuzzy sets in the form of linguistic value. Uncetainty of ambiguity value in input variables do not possess clear value. As such, these values can be presented into affiliation functions. Fuzzfication process' output is fuzzy value. Fuzzy value taken as the inference engine mechanism afterwards.

Fuzzy sets (linguistic variables) used in this study are as follows:

1. Plaque : {low, moderate, severe}
2. Inflamed gums : {low, moderate, severe}
3. Pain : {low, moderate, severe}
4. Red gums : {low, moderate, severe}
5. Swollen gums : {low, moderate, severe}
6. Easily bleeding gums : {low, moderate, severe}
7. Breath odor : {low, moderate, severe}
8. Wobbly teeth : {low, moderate, severe}

Value to each range variable is the qualitative criteria value which initially requires transformation into value scale as shown in Table 2.

Table 2
Scale Value Of Criteria Variable

Criteria	Range
Low	0 - 40
Moderate	30 - 70
Severe	60 - 90

Fuzzy set with three degree of membership are formed into a function as shown in Figure 1. Each input variable used consists of 8 input variables.

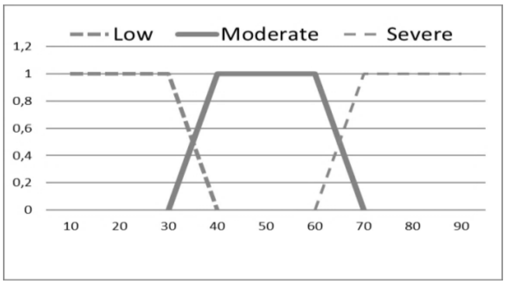

Figure 1: Input membership function simptom

Variable input Equations (1), (2) and (3) generate degree of effectiveness, efficiency, satisfaction, and ease of use as follows:

$$\mu_{Low}(x) = \begin{cases} 0, & x \geq 40 \\ \dfrac{40-x}{40-30}, & 30 < x < 40 \\ 1, & x \leq 30 \end{cases} \quad (1)$$

$$\mu_{Moderate}(x)=\begin{cases}0; & x\le 30\, atau \quad x\ge 70\\ \dfrac{x-30}{40-30}, & 30\le x<40\\ \dfrac{70-x}{70-60}, & 60\le x<70\\ 1; & 40\le x\le 60\end{cases} \tag{2}$$

$$\mu_{Severe}(x)=\begin{cases}1; & x\ge 70\\ \dfrac{x-60}{70-60}, & 60<x<70\\ 0; & x\le 60\end{cases} \tag{3}$$

Output Degree of membership Function category of dental disease can be shown in Figure 2.

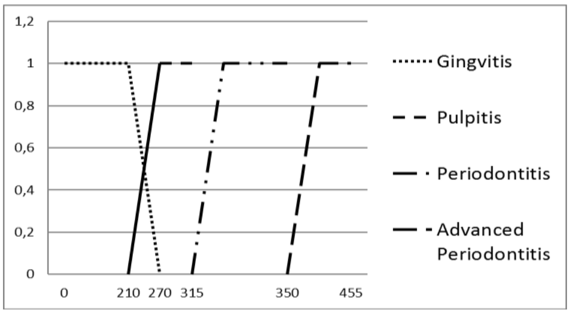

Figure 2: Output degree of membership function category on dental disease

Note:
(A) Pulpitis (C) Periodontitis
(B) Gingivitis (D) Advanced Periodontitis

The definition on degree of membership functions to variable ouput are shown in Equations (4), (5), (6), and (7).

$$\mu_A(x)=\begin{cases}0, & x\ge 270\\ \dfrac{270-x}{270-210}, & 210<x<270\\ 1, & x\le 210\end{cases} \tag{4}$$

$$\mu_B(x)=\begin{cases}0, & x\le 210, \quad x\ge 315\\ \dfrac{x-210}{270-210}, & 210<x<270\\ 1, & 270\le x<315\end{cases} \tag{5}$$

$$\mu_C(x)=\begin{cases}0, & x\le 315\\ \dfrac{x-315}{350-315}, & 315<x<350\\ 1, & x\ge 350\end{cases} \tag{6}$$

$$\mu_D(x)=\begin{cases}0, & x\le 350\\ \dfrac{x-350}{455-350}, & 350<x<455\\ 1, & x\ge 455\end{cases} \tag{7}$$

B. Rule

FIS rules stages as calculation basis used in fuzzy inference system tsukamoto is exhibited on Table.3. These rules were used in this research.

The fourth row in Table 3 exhibits symptoms of mild plaque, mild Inflamed gums, severe pain, moderate red gums, mildly swollen gums, mild gums bleeds easily, mild bad breath, mild wobbly teeth. Dental disease symptomps are categorized as pulpitis.

Table 3
Rules of Dental Disease

If	Symptom							Then
P	GR	N	GM	GB	GMB	BM	GG	
L	L	L	L	L	L	L	L	A
L	L	M	L	L	L	L	L	A
L	L	M	M	L	L	L	L	A
L	L	S	M	L	L	L	L	A
L	L	S	S	L	L	L	L	A
L	M	L	L	L	L	L	L	B
L	M	M	L	L	L	L	L	B
L	M	M	M	L	L	L	L	B
M	M	M	M	M	L	L	L	B
M	S	M	M	M	M	M	L	C
M	S	M	M	M	M	M	L	C
M	S	S	M	M	M	M	S	C
S	M	M	M	M	M	M	L	C
S	S	M	M	M	M	M	L	D
S	S	S	M	M	M	M	M	D
S	S	S	S	S	L	L	L	D
S	S	S	S	S	M	M	M	D
S	S	S	S	S	S	M	M	D

Note:
Linguistic variable category
L : Low
M : Moderate
S : Severe

Note:
Dental disease category
A : Pulpitis
B : Gingivitis
C : Periodontitis
D : Advanced periondontitis

C. Inference Engine

Processing inference engine performed utilized Tsukamoto approach. Input variables application was conducted to determine dental disease detection category based on values on each disease symptomps criterion. Examples of the values of patients disease symptomps are as follows :

1. Plaque : 10
2. Inflamed gums : 15
3. Pain : 75
4. Red gums : 55
5. Swollen gums : 15
6. Easy bleeding gums : 25
7. Breath odor : 25
8. Wobbly teeth : 0

The set of languages that can be formed into linguistic values based on the values of input variables the following criteria :

1. Plaque : {low}
2. Inflamed gums : {low}
3. Pain : {severe}
4. Red gums : {modere}
5. Swollen gums : {low}
6. Easy bleeding gums : {low}
7. Breath odor : {low}
8. Wobbly teeth : {low}

The value of membership from criterion variable input is calculated based on the patient's symptoms values input. The results are exhibitted in Table 4.

In the first row in Table exhibits count function results of the degree of membership to dental disease symptoms criteria. This criteria consists of eight symptoms based on Equation (1) which is used to obtain value µ_Low, Equation (2) to get value µ_moderate and Equation (3) to get value µ-_severe.

The next step is to determine rules set in accordance with the linguistic variable set (low, moderate, severe) based on calculated degree of membership. Utilized rules are as follows:

- Rule 4 → Plaque: LOW, inflamed gums: SEVERE, pain: SEVERE, red gums: MODERATE, swollen gums: LOW, Gum bleeds easily: LOW, bread odor: LOW, wobbly teeth: LOW. Including the category of pulpitis disease.
- Rule 6 → Plaque: LOW, inflamed gums: MODERATE, pain: MODERATE, red gums: LOW, swollen gums: LOW, Gum bleeds easily: LOW, bread odor: LOW, wobbly teeth:LOW. Including the category of gingivitis disease.

Table 4
Value of Fuzzy Set (Value of Linguistic)

Criteria	Value of Set
Plaque	μ_{Low} (10) = 1
	$\mu_{Moderate}$ (10) = 0
	μ_{Severe} (10) = 0
Inflamed gums	μ_{Low} (15) = 1
	$\mu_{Moderate}$ (15) = 1
	μ_{Severe} (15) = 0
Pain	μ_{Low} (75) = 0
	$\mu_{Moderate}$ (75) = 0
	μ_{Severe} (75) = 1
Red gums	μ_{Low} (55) = 0
	$\mu_{Moderate}$ (55) = 0
	μ_{Severe} (55) = 1
Swollen gums	μ_{Low} (25) = 1
	$\mu_{Moderate}$ (25) = 0
	μ_{Severe} (25) = 0
Gum bleeds easily	μ_{Low} (25) = 1
	$\mu_{Moderate}$ (25) = 0
	μ_{Severe} (25) = 0
Breath odor	μ_{Low} (25) = 1
	$\mu_{Moderate}$ (25) = 0
	μ_{Severe} (25) = 0
Wobbly teeth	μ_{Low} (0) = 1
	$\mu_{Moderate}$ (0) = 0
	μ_{Severe} (0) = 0

Based on utilized rules, degree of membership function's minimum value have been determined and calculated. The results are exhibitted as in Table 5.

Table 5
Degree of Membership Minimum Value

Rule	Variable	Value
4	Plaque	1.0
	Inflamed gums	1.0
	Pain	1.0
	Red gums	**0.0**
	Swollen gums	**0.0**
	Gum bleeds easily	1.0
	Breath odor	1.0
	Wobbly teeth	1.0
	μ4	1.0
6	Plaque	1.0
	Inflamed gums	1.0
	Pain	**0.0**
	Red gums	**0.0**
	Swollen gums	**0.0**
	Gum bleeds easily	1.0
	Breath odor	1.0
	Wobbly teeth	1.0
	μ6	0.0

D. Defuzzyfication

The last step in FIS process is defuzzyfication. It is a process which calculates Z value for any rules that would be used with the following formula :

$$Z = \frac{\sum\left(\alpha_{p_i} * z_i\right)}{\sum \alpha_{p_i}} \quad (8)$$

where:
Z : Average defuzzyfication centralized
α_p : Alpha predicate value (minimum value of the degree of membership)
Zi : Crisp values obtained from inference result
i : Number of fuzzy rules

E. System Accuracy

In order to obtain Tsukamoto FIS accuracy, Equation 9 formula was utilized. Furthermore, accuracy result is used as fitness value of each chromosome contained in FIS-ES hybrid process.

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(Yi' - Yi)^2} \quad (9)$$

where :
RMSE : Root Mean Squares Error
Y' : Data from detection
Y : Actual data
n : Number of data

F. Hybrid FIS – Evolution Strategies

Hybrid fuzzy logic–evolution strategies is process of solving problems using evolution strategies. There are stages of processing by using Tsukamoto FIS. The execution was preceded by using Evolution Strategies on any given iteration period. For example, at each iteration researcher examine one parent with two children as chromosomes. Tsukamoto FIS accuracy was added to each chromosome as fitness value and then be selected back in chromosomes. It means chromosome possessing fitness value better than another on each chromosome in ES stages. One parent of 2 children to be used for the next iteration to get optimal results. Chromosomes randomly formed on the parameters of each chromosome.

VI. RESULT AND ANALYSIS

This study exhibits 82% accuracy to hybrid method compared to merely utilizing Tsukamoto FIS method resulting in 70% accuracy, Boundary problem on used 100 Data which involved symptoms of patients, 8 variable input as symptoms of dental disease to dental disease detection and 4 variable output: pulpitis, gingivitis, periodontitis, and advanced periodontitis as dental disease detection category . Tsukamoto FIS result is exhibited in Table 6. Hybrid testing process method used lambda 20 maximum with 100 iterations and 500 chromosomes to obtain optimal accuracy results. Test result is exhibited in the following Tables 7, 8, and 9.

Table 6
Result Utilizing Tsukamoto FIS

Parent	Actual	Detection	Result
1	Pulpitis	Pulpitis	1
2	Pulpitis	Pulpitis	1
3	Pulpitis	-	0
4	Pulpitis	Pulpitis	1
8	Advanced Periodontitis	Periodontitis	0
9	Advanced Periodontitis	Advanced Periodontitis	1
	Pulpitis	Pulpitis	1
10	Pulpitis	Pulpitis	1
11	Gingvitis	Periodontitis	0
...	Pulpitis	Pulpitis	1
100	Pulpitis	Pulpitis	1

Table 7
Result Utilizing Hybid FIS-ES

Iteration	Cromosome= 10, Lamda (λ)= 2					Average
	1	2	3	4	5	
25	0.7	0.7	0.7	0.7	0.7	0.7
50	0.7	0.7	0.7	0.7	0.7	0.7
75	0.7	0.7	0.7	0.7	0.7	0.7
100	0.7	0.7	0.7	0.7	0.7	0.7
…	0.7	0.7	0.7	0.7	0.7	0.7
475	0.7	0.7	0.7	0.7	0.7	0.7
500	0.7	0.7	0.7	0.7	0.7	0.7

Table 8
Result Utilizing Hybid FIS-ES

Cromosome	Iteration= 100, Lamda (λ)= 2					Average
	1	2	3	4	5	
25	0.7	0.7	0.7	0.7	0.7	0.7
50	0.7	0.7	0.7	0.7	0.7	0.7
75	0.7	0.7	0.7	0.7	0.7	0.7
100	0.7	0.7	0.7	0.7	0.7	0.7
…	0.7	0.7	0.7	0.7	0.7	0.7
475	0.72	0.72	0.72	0.72	0.7	0.716
500	0.72	0.72	0.72	0.72	0.72	0.72

Table 9
Result Utilizing Hybid FIS-ES

Lamda (λ)	Iteration= 100, Cromosome=500					Average
	1	2	3	4	5	
1	0.72	0.72	0.72	0.72	0.72	0.72
2	0.72	0.72	0.72	0.72	0.72	0.72
3	0.72	0.72	0.72	0.72	0.72	0.72
4	0.72	0.72	0.72	0.72	0.72	0.72
…	0.72	0.72	0.72	0.72	0.72	0.72
19	0.82	0.82	0.82	0.82	0.8	0.816
20	0.82	0.82	0.82	0.82	0.82	**0.82**

VII. CONCLUSION AND FUTURE STUDY

This research proves that hybrid fuzzy logic using evolution strategies can be utilized to detect 4 category of dental disease. The forementioned disease are pulpitis, gingivitis, periodontitis and advanced periodontitis. These were obtained using accurate detection of dental disease with RMSE (root mean squared error) formula with 82% accuracy result compared to Tsukamoto FIS (70%).

This study could be improved in degree of membership functions to obtain fewer errors on detection result. The boundary of membership functions can be adjusted using meta-heuristic algorithm such as genetic algorithm and variable neighborhood search [24].

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APPENDIX

Patient Data and Disease Symptoms

Patient	Plaque	Inflamed Gums	Pain	Red Gums	Swollen Gums	Easy Bleeding Gums	Breath Door	Wobbly Teeth	Category of Dental Disease
1	20	10	10	25	15	15	25	0	Pulpitis
2	20	30	30	50	20	20	20	0	Pulpitis
3	20	70	70	70	10	10	10	0	Pulpitis
4	25	75	75	70	25	25	25	0	Pulpitis
5	15	75	75	65	20	20	20	0	Pulpitis
6	45	45	45	45	50	55	10	10	Gingvitis
7	50	50	50	50	50	55	55	25	Periodontitis
8	75	45	45	40	45	40	40	40	Periodontitis
9	75	65	65	55	50	55	40	35	Periodontitis
10	45	45	45	45	45	45	45	35	Periodontitis
11	65	70	70	70	45	45	35	35	Advanced Periodontitis
12	65	50	50	40	45	45	40	0	Advanced Periodontitis
13	20	80	80	70	25	25	25	0	Pulpitis
14	55	55	55	50	50	50	50	40	Periodontitis
15	70	60	60	55	50	40	40	35	Advanced Periodontitis
16	0	75	75	75	0	0	0	0	Pulpitis
17	30	25	25	25	20	20	10	10	Pulpitis
18	45	45	45	45	45	45	0	0	Gingvitis
19	75	70	70	60	50	50	35	35	Advanced Periodontitis
20	80	75	75	70	60	55	45	45	Advanced Periodontitis
21	0	20	20	0	0	0	0	0	Pulpitis
22	0	35	35	30	20	10	0	0	Pulpitis
23	45	40	40	40	45	40	10	0	Gingvitis
24	45	40	40	40	45	30	0	0	Gingvitis
25	45	40	40	40	45	20	0	0	Gingvitis
26	10	30	30	30	0	0	0	0	Pulpitis
27	40	40	40	40	40	30	0	0	Gingvitis
28	35	40	40	40	40	20	0	0	Gingvitis
29	25	70	70	70	20	20	0	0	Pulpitis
30	55	40	40	40	50	50	30	0	Gingvitis
31	30	75	75	60	30	30	30	0	Pulpitis
32	30	60	60	60	30	30	10	0	Pulpitis
33	25	25	25	25	0	10	0	0	Pulpitis
34	0	45	45	30	0	20	0	0	Pulpitis
35	35	55	55	45	45	30	10	0	Gingvitis
36	60	60	60	55	50	50	35	0	Periodontitis
37	30	30	30	20	10	20	0	0	Pulpitis
38	30	30	30	30	20	20	0	0	Pulpitis
39	55	55	55	25	25	20	15	0	Pulpitis
40	25	55	55	50	15	15	10	0	Pulpitis
41	20	50	50	25	25	10	10	0	Pulpitis
42	35	40	40	40	45	40	20	0	Gingvitis
43	60	60	60	40	45	40	30	0	Gingvitis
44	30	45	45	40	20	20	30	0	Pulpitis
45	45	50	50	40	40	35	35	0	Periodontitis
46	25	10	10	25	15	15	25	0	Pulpitis
47	20	30	30	50	25	25	25	20	Pulpitis
48	25	75	75	75	10	10	10	15	Pulpitis
49	25	75	75	70	25	30	25	0	Pulpitis
50	15	75	75	65	20	20	10	0	Pulpitis
51	40	45	45	45	40	40	10	10	Gingvitis
52	0	20	20	0	0	0	0	0	Pulpitis
53	0	35	35	30	20	10	0	0	Pulpitis
54	40	40	40	40	45	40	10	0	Gingvitis
55	40	40	40	40	45	30	10	0	Gingvitis
56	40	40	40	40	45	20	10	0	Gingvitis
57	10	30	30	30	0	0	0	0	Pulpitis
58	45	45	45	40	40	30	0	0	Gingvitis
59	35	40	40	40	40	20	0	0	Gingvitis
60	20	70	70	70	20	20	0	0	Pulpitis
61	55	45	45	40	40	40	30	0	Gingvitis
62	30	75	75	60	30	30	30	0	Pulpitis
63	30	60	60	60	30	30	10	0	Pulpitis
64	25	25	25	25	0	10	0	0	Pulpitis
65	0	45	45	30	0	20	0	0	Pulpitis
66	35	55	55	45	45	30	10	0	Gingvitis
67	60	60	60	55	50	50	35	0	Periodontitis
68	30	30	30	20	10	20	0	0	Pulpitis
69	30	30	30	30	20	20	0	0	Pulpitis
70	55	55	55	25	25	20	15	0	Pulpitis
71	25	55	55	50	15	15	10	0	Pulpitis
72	20	50	50	25	25	10	10	0	Pulpitis
73	35	40	40	40	45	40	20	0	Gingvitis

Patient	Plaque	Inflamed Gums	Pain	Red Gums	Swollen Gums	Easy Bleeding Gums	Breath Door	Wobbly Teeth	Category of Dental Disease
74	60	60	60	40	45	40	30	0	Gingvitis
75	30	45	45	40	20	20	30	0	Pulpitis
76	45	50	50	40	40	35	35	0	Periodontitis
77	60	55	55	55	50	55	55	0	Periodontitis
78	70	40	40	40	45	40	40	40	Periodontitis
79	75	65	65	55	50	55	40	0	Periodontitis
80	45	45	45	45	45	45	45	0	Periodontitis
81	65	70	70	70	45	45	35	35	Advanced Periodontitis
82	65	50	50	40	45	45	40	0	Advanced Periodontitis
83	20	80	80	70	25	25	25	0	Pulpitis
84	55	55	55	50	50	50	50	40	Periodontitis
85	70	60	60	55	50	40	40	35	Advanced Periodontitis
86	20	80	80	70	25	25	25	0	Pulpitis
87	50	55	55	50	50	50	50	35	Periodontitis
88	70	60	60	55	50	40	40	35	Advanced Periodontitis
89	0	75	75	75	0	0	0	0	Pulpitis
90	30	25	25	25	20	20	0	0	Pulpitis
91	45	45	45	45	45	45	0	0	Gingvitis
92	70	70	70	60	50	50	35	35	Advanced Periodontitis
93	80	70	70	70	60	55	40	40	Advanced Periodontitis
94	0	75	75	75	0	0	0	0	Pulpitis
95	30	25	25	25	20	20	10	10	Pulpitis
96	45	45	45	45	45	45	0	0	Gingvitis
97	75	70	70	60	50	50	35	35	Advanced Periodontitis
98	80	75	75	70	60	55	45	45	Advanced Periodontitis
99	60	75	75	60	40	45	40	40	Advanced Periodontitis
100	70	45	45	45	40	40	35	0	Advanced Periodontitis