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Innovation of Detector Score Plaque Sensor Based to Improve the Effectiveness and Afficiency of Dental Health Services

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Abstract: One of the main causes of oral diseases is plaque. Dental plaque that is not cleaned can increase the risk of oral diseases such as caries and periodontitis. Plaque measurement with conventional methods such as the use of disclosing solutions has limitations, both in terms of effectiveness, patient comfort, and potential chemical risks. To increase the effectiveness and efficiency of measurement, a Smart Detector Score Plaque was developed that utilizes a camera, Ultraviolet (UV) sensor and supporting applications to calculate plaque scores. This research uses the Research and Development (R&D) method with a post test only design with control group design. Sampling using purposive sampling technique, 30 patient respondents and 30 oral health worker respondents were obtained according to the inclusion criteria. The independent variable is the plaque score detector "Smart Detector Score Plaque" and the dependent variable is plaque score and quality of service. Feasibility test analysis using ICC and Wilcoxon statistical test to assess the effectiveness of the developed tool. The expert validation test of the "Smart Detector Score Plaque" tool obtained an average value of 91 very feasible categories with a p-value of 0.001. The results showed that there was no significant difference between the results of plaque measurement using disclosing and the "Smart Detector Score Plaque" tool seen from the p-value = 0.563. The quality of service has significantly improved (p-value = 0.000) with the use of the Smart Detector Score Plaque tool. The "Smart Detector Score Plaque" tool is feasible and effective to use to identify and calculate the plaque score index in order to improve the quality of oral health services.

Keywords: *Smart Detector Score Plaque, Ultraviolet, Quality of Service.*

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I. INTRODUCTION

Oral health is an important aspect of overall health that requires comprehensive attention and treatment[1]. Dental health in Indonesia is still an interesting problem because the prevalence of caries and periodontal disease reaches 80% of the population. According to the 2018 Basic Health Research report (Riskesdas), 57.6% of the population in Indonesia suffered from oral diseases[2]. Meanwhile, according to the results of the Indonesian Health Survey (SKI) in 2023, it is known that the proportion of dental and oral problems in Indonesia is 56.9%[3]. Efforts to overcome this problem have not been seen clearly when measured by public dental health indicators, for example, the prevalence of dental caries and periodontal disease is still very higt[4]. Oral hygiene assessment aims to assess the condition of an individual's dental hygiene. This hygiene can be measured using certain criteria known as indices to monitor the development or decline of individual dental hygiene[5]. Oral hygiene reflects a condition in which a person's oral cavity does not contain impurities, such as plaque and calculus. The oral environment that is always moist, dark, and wet is very supportive of the growth and development of bacteria that cause plaque formation[6].

Basically, thin plaque has a color that is almost similar to the color of the teeth, making it difficult to see with the naked eye unless it is given a dye. In an effort to overcome this problem, the dental field has developed a technique for staining plaque bacterial cells, known as disclosing solution. This technique is used to detect the presence of bacteria and help improve the effectiveness of the treatment to be carried out[7].

Disclosing solution is a dye used to change the color of dental plaque so that it contrasts with the white color of the tooth surface. This staining process assists the operator in calculating the plaque index and serves as an educational tool

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to educate and motivate people to be more diligent in maintaining dental hygiene[8]. So far, conventional methods commonly used to detect plaque include visual Measurement by dental hygienists and the use of plaque staining solutions. Although these methods have been widely used, there are various limitations that reduce their effectiveness. Visual Measurement relies heavily on the skill and accuracy of the examiner, which can lead to inconsistencies in detection results. Meanwhile, the use of plaque staining solutions is often considered impractical because the application process takes time, and can cause discomfort and aesthetic disturbances for patients, such as temporary discoloration of teeth and oral soft tissues[9] In addition, conventional methods have not fully addressed the need for efficiency in modern dental health services that demand speed, accuracy, and convenience. This limitation is a challenge in the implementation of routine Measurement s, both in health facilities and in promotive and preventive activities in the communityt[9].

Faisal & Zulfikri, (2023) also explained that this disclosing material is difficult to find in the market, especially in small towns, because disclosing solutions are only available in dental equipment stores in big cities. Disclosing solution is made of chemicals that are less preferred because of their unpleasant taste. In addition, the aniline dye contained in disclosing has been shown to have cariogenic potential. The erythrosine dye content in disclosing is a triiodine derivative of fluorescein with a high concentration of iodine, which can cause thyroid cancer if ingested.

Seeing these various weaknesses, an innovative approach is needed that is more practical, efficient, and can provide more objective results in detecting dental plaque. Along with the development of increasingly sophisticated technology, the development of tools for health has also increased significantly. One of the technologies developed in oral health is fluorescent imaging technology used in biomedical detection. Endogenous fluorophores are irradiated with ultraviolet light and emit visible light [10]. stated that since it was first reported in the 1920s that dental plaque can emit fluorescence with ultraviolet light irradiation. Based on several studies, it is suggested that plaque bacteria contain porphyrin components, especially protoporphyrin - IX, which has fluorescent properties. Therefore, when bacteria containing these components are exposed to the presence of UV light, the components emit color, so that they can detect the presence of dental plaque. [11].

Along with technological advances in the development of plaque detection products that innovate in the health sector, especially in the field of oral health in increasing the use of dental and oral Measurement tools that continue to develop in order to obtain tools with sophisticated quality and better quality, researchers are interested in developing Measurement tools to detect plaque in the form of an optical sensor-based plaque score Smart detector.

II. RESEARCH METHODS AND SAMPLE

This research uses the Research and Development (R&D) method, which aims to develop a plaque score detector tool (Smart Detctor Score Plaque) to detect and calculate the plaque score index in improving the quality of health services. This method aims to test, develop, and create specific products. In this study, the goal is to produce a plaque score detector development tool (Smart Detctor Score Plaque), test its effectiveness, and assess the feasibility of its development. This product is innovatively designed to detect and calculate plaque scores and improve the quality of dental health services. Data collection for the research used a descriptive method, involving interviews and literature reviews, while the effectiveness of the product was tested using an analytical method. The R&D procedure consists of five main stages: 1) Information gathering, 2) Product design, 3) Expert validation and revision, 4) product trials, and 5) Product results[12]

The initial stage of information gathering was conducted to identify problems in the field that would form the basis for the development of medical devices. Data was obtained through observation, interviews, and systematic literature reviews to reinforce existing empirical findings.

Researchers designed a sensor-based Smart Detector Plaque Score to automatically detect dental plaque. The Measurement is performed with UV light to highlight the plaque, which is then recorded using a camera. The recorded images are analyzed with computer software to identify plaque and calculate the plaque index score. The results are images of the teeth with the detected plaque areas and plaque scores that can be used for objective evaluation of dental health.

Expert validation is an active process designed to evaluate the effectiveness of the design of a product to be created. This validity test is carried out by three experts, namely an Information technology expert, an electromedical expert, and a dentist. Providing a questionnaire using David Garvin's Eight Dimensions of Quality[13]. Validation analysis was conducted using the Intraclass Correlation Coefficient (ICC).

After validation, This study conducted a trial using a posttest only with control group design, which was carried out twice on the same people. The sample used in the trial to develop the Smart Detector Plaque Score tool consisted of dental and oral health workers and patients who met the inclusion and exclusion criteria and were selected using purposive sampling. The sample consisted of 60 participants, with 30 patients and 30 dental and oral health professionals from the Barru District Health Center. The trial procedure includes :

- Explains the purpose and objectives of the trial to dental therapists and dentists, as evidenced by the completion and signing of informed consent forms.
- Provides training on the use of the “Smart Detector Score Plaque” tool.
- Conducts Measurement s and measures plaque index using the “Smart Detector Score Plaque” tool.

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- Providing an explanation regarding plaque index measurement using disclosing solution.
- Conducting Measurement s and measuring plaque index using disclosing solution.
- Recording the results of plaque index Measurements.
- Collecting final data on the quality of healthcare services related to the effectiveness and efficiency of the device.
- Collecting data on the quality of healthcare services related to the effectiveness and efficiency of the "Smart Detector Plaque Score Sensor-Based Device"
- Collecting data on the quality of healthcare services related to the effectiveness and efficiency of the disclosing solution

The data analysis used in this study includes descriptive statistical analysis to describe the results of data collection, as well as Intraclass Correlation Coefficient(ICC).

Descriptive analysis was used in the information collection stage because the data obtained was quantitative, derived from interviews and observations. Validation tests by experts were conducted using ICC reliability tests to assess the consistency of scores when assessments were performed by different experts.

In the product testing stage, data analysis also used descriptive statistics to describe the percentage of data collection results. Before analysis, the data obtained is first checked for completeness, then coded to facilitate the processing. The data is then tabulated into predefined tables before analysis is conducted. Since the data is not normally distributed, a nonparametric test, specifically the Wilcoxon test, is used.

III. RESULTS

A. Information Collection Result

Based on the results of information gathering, it is known that dental clinic services have included various programs such as screening, Measurement, education, and mass toothbrushing, but their implementation is still not optimal due to limited facilities, especially in the Measurement of dental plaque, which is not yet comprehensive due to the lack of disclosing agents. These agents are not routinely available, are less popular because they leave a color in the mouth, and require more time to use. Therefore, there is growing support for the development of a simple, comfortable, portable plaque detection tool that is connected to a digital application to facilitate visual and informative monitoring of results.

B. Smart Detector Score Plaque Design

The design of the *Smart Detector Score Plaque* a tool utilizing ultraviolet (UV) lighting on teeth, aimed at clearly highlighting areas with plaque presence. Subsequently, the illuminated teeth are recorded using a camera, producing images containing visual information regarding the distribution and intensity of plaque. The images are then analyzed through processing using a specialized computer program designed to automatically detect plaque and measure plaque index scores.

The final result is an image of the teeth with accurately identified plaque areas and plaque index scores that can be used for objective evaluation of oral health.

C. Expert Validation

The feasibility test of the smart detector score plaque was carried out by 3 expert validators, namely, information technology expert, an electromedical expert, and a dentist is. The validation process uses a questionnaire instrument consisting of 16 statements. The results of the data were analyzed using the Intraclass Correlation Coefficient (ICC), which can be seen in the following table:

➢ *Validity Test*

Tabel 1 Expert Validation

Variable	Avarage	Score	*p-value*	Category
ICC	91%	0.724	0.001	High realiability

Based on table 1, it shows that he average feasibility value is 91% with a very feasible category. The results of expert validation show that the p-value = 0.001, which means that the tool is declared feasible for testing. Based on the results of Average measures from the Interclass Corelation Coefisient test, the result is 0.724 with a high reliability category.

D. Product Result

Table 2 Frequency Distribution of Gender Characteristics of Respondents

Characteristics	N	F%
Male	6	20%
Female	24	80%

Table 2 shows the frequency distribution of characteristics of the 30 dental and oral health worker respondents who participated in this study, the majority were female, as many as 24 respondents (80%). Meanwhile, there were 6 male respondents (20%).

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Table 3 Frequency Distribution of Dental Health Workers

Characteristics	N	%
Dentist	12	40%
Dental And Oral Therapist	18	60%

Table 3 frequency distribution, out of a total of 30 health workers who became respondents, 12 people (40%) were dentists, while 18 people (60%) were dental and oral therapists.shows

Table 4 Effectiveness Test Results of the Smart Detector Score Plaque Tool on Plaque Measurement

Variabel	Mean ±SD Control	Mean ±SD Intervensi	Delta Δ±SD	p-Value
Plaque Score	2,106±1,016	2,116±0.966	0,01±0,11	0,563

Table 4 the average plaque measurement result in the control group was 2.106, while in the intervention group it was 2.116. The test results above show that the p-value of the difference in plaque measurement results using disclosing and smart plaque score detector is 0.563 (p>0.05), indicating that there is no significant difference between the results of plaque measurement using disclosing and smart plaque score detector. Since both measurement methods have relatively comparable results in measuring plaque, this means that the development of plaque score detectors is effective and feasible to use in plaque measurement.

Table 5 Effectiveness Test Results of the Smart Plaque Score Detector Tool for Improving the Quality of Dental Health Services

Variabel	Mean ±SD Control	Mean ±SD Intervensi	Delta Δ±SD	p-Value
Quality of service	52,30±3,75	90,63±9,31	38,30±9,15	0,000

Table 5 that the results of the service quality effectiveness test with p-values of 0.000 (p <0.05), which means that the "Smart Detector Score Plaque" tool is effective for improving the quality of oral health services. There was an increase in quality between the use of disclosing and smart plaque score detectors, where when using disclosing in the control group the average value of service quality was 52.30 which was included in the "good" category and when using a smart plaque score detector as an intervention group it increased to 90.63 which was included in the "very good" category. The difference between the initial data (control group) and the final data (intervention group) of service quality is 38.30.

IV. DISCUSSION

- *Detector Score Plaque Information Collection*

Information was collected through observation, interviews, and systematic literature review. Observations were conducted in the working area of the Barru District Health Center, South Sulawesi, while interviews involved health workers such as health center heads, dentists, and dental therapists. From observations and interviews, it was found that one of the important Measurement s to monitor dental health is plaque Measurement . However, in reality, plaque Measurement s in health care facilities show that this procedure is rarely or never performed. One of the main causes is the limited materials provided at the service.

The use of disclosing agents reveals the limitations of disclosing agents, which are considered impractical for use in healthcare settings that require effective and efficient services. Disclosing agents also have an unpleasant taste and can leave staining on the mucosa, which can cause discomfort for patients and slow down the diagnosis process. Therefore, an innovative solution is needed that allows plaque measurement to be performed more easily, comfortably, and efficiently.

Efforts that can be made include the development of plaque detection innovations utilizing technological advancements that can facilitate Measurement s conducted by healthcare professionals. This is supported by previous research journals indicating that the proper utilization of technology, such as sensors, can help provide solutions tailored to the Measurement needs of healthcare professionals.

With the introduction of the smart plaque detector, plaque measurements are expected to be carried out more frequently and become part of routine checkups in healthcare services. This device is expected to assist healthcare professionals in monitoring dental hygiene, particularly dental plaque, which can potentially cause various dental and oral health problems. This device can also improve the effectiveness and efficiency of healthcare professionals in providing services to patients.

- *Smart Detector Score Plaque Design and Expert Validation*

The use of inadequate medical equipment can cause various problems, both for healthcare workers and patients. With the industry entering the Society 5.0 era, the healthcare equipment sector in Indonesia has shown significant growth. Rapid technological advances have enabled the creation of more sophisticated and efficient medical devices. These innovations not only make it easier for medical personnel to diagnose and treat patients, but also improve the quality of real-time patient monitoring. Thus, the use of technology in

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the health sector has great potential to support a more effective and efficient healthcare system[14]·[15].

The plaque detection device developed in this study utilizes an ultraviolet (UV) sensor and supporting applications to calculate the plaque score index. Its feasibility was proven through statistical calculations using the Interclass Correlation Coefficient test, which showed a p-value of 0.001. This means that the "Smart Detector Score Plque" device is feasible as a health Measurement tool with a reliability value that falls into the high category.

Fig 1. Smart Detector Plaque Score Device

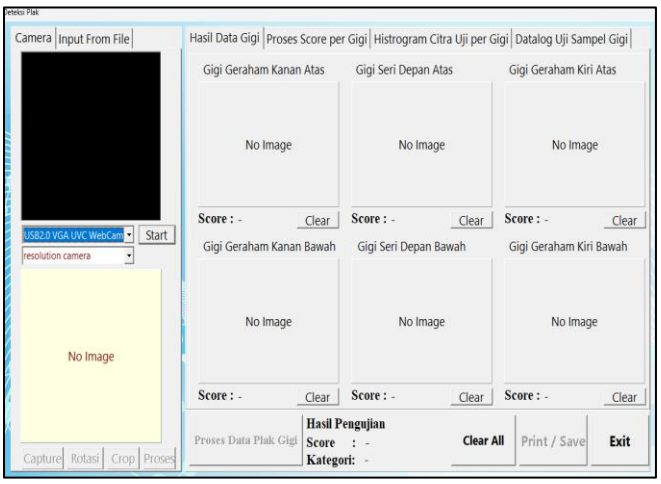

Fig 2. Smart Detector Plaque Score application

➢ *Product Result Test*

After passing the development stage, the next stage is to test the product on a wider scale. A trial of the smart detector plaque score product was conducted as an effort to improve the quality of dental and oral health services using two groups of subjects, with measurements taken in the intervention group and the control group. This study was conducted at nine health services within the working area of Barru Regency, South Sulawesi Province. This study involved 30 dental health workers who worked at dental clinics in each community health center. The health workers involved consisted of 12 dentists and 18 dental and oral therapists.

- *Test of the Effectiveness of Smart Detector Score Plaque Tool on Plaque Measurent*

To test the effectiveness of Smart Detector Score Plaque, control and intervention groups were involved where the control group used disclosing and the intervention group used the Smart Detector Score Plaque tool. The Wilcoxon test results showed a p-value of 0.563 ($p > 0.05$), which means there is no significant difference between the conventional method using disclosing and the Smart Detector Score Plaque tool in plaque measurement, with an average score of 2.106 for the control group and 2.11 for the intervention group. The average difference was only 0.01, indicating that although the results of the intervention group were slightly higher, the difference was not significant, so the Smart Plaque Score Detector tool was declared effective and feasible to use as an alternative to plaque measurement.

Plaque measurement using disclosing and smart detector score plaque has a similar principle, which is to detect the layer on the teeth that contains plaque bacteria. Disclosing uses a dye that contains chemicals that can provide coloration when applied to the teeth. Chemicals that are sensitive to layers consisting of bacteria will give a different color so that plaque areas on the teeth are visible. Meanwhile, the smart detector score plaque utilizes ultraviolet (UV) light because there are profirin bacteria found around the plaque area. The content of this porphyrin will cause fluorescence coloring when irradiated with UV so that plaque can be identified[11]. This similarity in working principle makes the measurement results of the two methods tend to be close, especially under the same environmental conditions. The small differences in measurement results from these two tools can occur due to several factors.

The difference in data obtained can be caused by several things, one of which is the use of two different types of tools or instruments. Different tools can give different results, even though they are used to measure similar things. In addition, the process of using the tool by each operator (dental and oral health worker) can also affect the results. This is in line with research conducted by Magdarina et al (2013) cited in Arzaqi et al (2024) explaining that differences in results can occur when the examination is carried out using two different instruments or due to differences in interpretation from each operator. Each health worker may have a slightly different way or technique of using the tool, which is influenced by their experience, training, and work habits. These differences can ultimately lead to variations or inconsistencies in the data obtained[16].

In addition, other factors that can affect the variation in examination results between disclosing and smart plaque score detectors are the influence of environmental light and uv light reflected from the device. Examination using disclosing is not affected by environmental light while examination using the tool is affected by light. This is supported by research conducted by Agustini et al (2017) where the research compared uv light wavelengths. The results showed that anterior teeth exposed to violet (420nm) and blue (450nm) LED colors did not show fluorescence. Whereas teeth exposed to UV LED light with a wavelength of 400 nm emit a reddish-orange fluorescence color[11].

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Therefore, environmental light and reflected uv light can affect the inspection results causing variations in the data obtained.

- *Test of the Effectiveness of Smart Detector Score Plaque Tool for Improving the Quality of Dental Health Services*

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One important aspect in improving the quality of health services is the provision of quality medical devices[17]. The Smart Detector Score Plaque innovation is one form of effort to improve the quality of dental health services through the provision of more accurate and efficient examination tools. Mahardiana et al. (2022) mentioned that good medical devices have characteristics such as high accuracy, proper use, and safety for users. These qualities can be maintained through periodic calibration, routine maintenance, and result testing. Well-functioning medical devices, including electromedical equipment, are an important factor in supporting health services in various facilities, including health centers[18].

The Wilcoxon test results showed a p-value of 0.000 ($p<0.005$), which indicated that there was a significant difference between the control group using disclosing and the intervention group using the Smart Detector Plaque Score innovation in improving the quality of dental health services. The average quality measurement results in the control group were 52.30, while in the intervention group it reached 90.63, with a difference of 38.30.

Based on the test results, Smart Detector Score Plaque is proven to be effective and efficient in improving the quality of dental health services by providing fast, accurate, and consistent examination results, facilitating early detection of dental and oral problems, and accelerating the service process. This tool also functions as an interactive educational media through visual displays and an easy-to-understand plaque scoring system, thus encouraging patients to care more about their oral health. In addition to reducing the workload of health care providers through an automated system and minimizing errors in manual data recording, its long-term use is also more economical compared to consumables-based methods. However, regular calibration is still required to maintain the accuracy and performance of this tool

Several studies have also indicated that recent advances in light sensor technology for medical diagnostic purposes have shown significant progress in improving diagnostic accuracy and the quality of patient care. Optical-based detection approaches using these sensors allow for easier and faster detection processes. Moreover, light sensors are considered effective in detecting the presence and severity of dental plaque, particularly in field applications that require speed and practicality. Research shows that the integration of intraoral cameras and application-based image processing technology can result in a rapid and efficient plaque detection system[19], [20].

V. CONCLUSION

The innovation of developing a smart plaque detector tool can be used as a tool to detect dental plaque and improve the quality of dental health services in terms of the effectiveness and efficiency of the tool. This feasibility is proven through expert testing using the Interclass Correlation Coefficient (ICC) test, which shows a high level of reliability. The smart plaque detector tool is effective for detecting and calculating plaque score indices to improve the quality of dental healthcare services. This tool has the advantage of a supporting application for calculating plaque score indices, thereby enhancing the effectiveness and efficiency of plaque examinations. Additionally, the use of this tool does not involve the use of chemicals during examinations. This makes the smart plaque detector tool a more practical, innovative, and relevant tool for supporting dental healthcare facilities and infrastructure.

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