

**DEVELOPMENT OF COLOR BLINDNESS TEST APPLICATION USING
ISHIHARA TEMPLATE AT RUMBAI PUBLIC HEALTH CENTER**

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ABSTRACT

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This research addresses the problem of color blindness testing at Puskesmas Rumbai which serves color blindness checks using printed books. The colors in the book became less clear as time went on. Therefore, this research makes a digital color blindness examination as part of the application for obtaining a certificate of health. The resulting application is named SIP SEHAT which stands for Aplikasi Pelayanan Surat Keterangan Kesehatan. This application was developed using prototyping method approach. There are 3 categories of users of this application, namely the registration section, doctor or nurse, and administration section. The registration section inputs the identity of the patient who will perform the examination. Meanwhile, doctors or nurses carry out examinations and medical examinations of patients who come. Color blindness test is one of the features found in doctors or nurses. Patients independently answer 24 Ishihara templates that appear on the application. Based on the answers from the patient, the application will display the color blindness test results, whether including total color blindness, partial color blindness, or not color blindness. The administration section prints a certificate of a patient who has performed an examination and gets a recapitulation of health examination reports per month. The application has been tested with 3 types of testing, namely accuracy testing, correctness testing, and usability testing. Based on these three tests, it can be concluded that this application is ready for use by the Puskesmas Rumbai to serve the processing of certificates of health. Based on service process analysis, this application makes the process of managing a health certificate making more efficient by 42.86%.

Keywords: *Color blindness test, Ishihara test, Certificate of health, SIP SEHAT, Puskesmas*

I. INTRODUCTION

Color blindness must be detected early. Some job positions or institutions require the applicants to be free from color-blind due to the job requirements that demand the worker to be able to distinguish colors such as to tell the colors of wires apart in electrical-related jobs. To determine whether one is color-blind is usually through a consultation with a doctor. The doctor conducts a test using a test book. This test is known as the Ishihara test. An Ishihara test book consists of plates or sheets filled with dots in different colors and sizes that form particular patterns.

The images printed in the Ishihara test book will change color as the book ages. The colors in the image will fade as stored for a long time. The fading color will affect the originality of the plate for the test equipment, which will affect the accuracy of the test results [1]. Moreover, the Ishihara test has a limitation. It can only be conducted in a white lit room with sufficient lighting intensity [2].

Other than the problems of the color blindness tests, some problems were also found regarding the process of obtaining the certificate. Based on the results of observations and interviews with the research objects, to obtain a free from colorblind certificate, people in Pekanbaru, especially in the Rumbai Pesisir district were examined at the Rumbai Health Center. In this public health center, the free-from colorblind certificate is part of the health certificate. To get a health certificate, patients who sign up are also examined medically other than a colorblindness test. The medical examination includes body temperature, blood pressure, and other tests.

Figure 1 is the flow diagram of the health certificate service at the Rumbai Health Center. There are three sections that patients have to go through to get a health certificate, namely the registration section (green), clinic/doctor (red), and the administration section (orange).

Patients must first register at the registration section to get a queue number. Then, patients queue up at the polyclinic. After the patient is called, the doctor will complete the patient's medical data, including body temperature, blood pressure, and blood type. The doctor also conducts simple observations to see the patient's health condition. After that, the doctor does a color blindness examination on

the patient. The doctor shows the Ishihara book to the patient and the patient is supposed to answer each plate they see. Then, the patient takes the note given by the doctor to the administration. The administration staff then fills in the data from the doctor's note into the provided template. Then the administration staff prints the letter and the patient makes payment to get the health certificate.

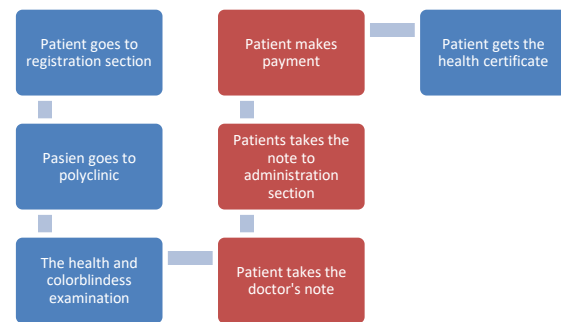


Figure 1. Flow Diagram of the making health certificate service at the Rumbai Health Center.

The problem found in this process is many interactions between staff who are not involved in health checks with patients. In this case, the registration and administration section. Both of these sections interact directly with the patient. During an outbreak of infectious diseases, this increases the risk of transmission to the staff. On the other hand, too much interaction with staff also increases the risk of disease transmission to healthy patients that come to the health center only to obtain a health certificate for a need.

Based on these two problems, the problems related to color blindness examination and the procedure of obtaining a health certificate that increase the risk of disease transmission, this study develops a digital color blindness test application that is integrated with the application to obtain a health certificate.

Several studies have developed a computer-based application to test the type of color blindness a person has to solve this problem [3], [4]. A study conducted by [3] developed a desktop application for colorblindness test. This application also implements the Ishihara 24 plate test. The application is used by the Police as one of the police admission tests. This desktop-based application is not suitable for the test to get the

health certificate if the test is carried out using PCs separated by rooms.

To solve the research conducted by [3], the research of [4] developed a web-based colorblindness test application that is accessible using an internet connection. This application aims to make it easier for people to do color blindness tests online with the Ishihara card to get information on whether the person is color-blind or not through the website. In this online color blindness test, the user enters data and determines the color then writes what they see on the Ishihara card. However, the application is not intended for a specific institution. This application is not integrated, thus it can print a health certificate from the Puskesmas (Public Health Service) or clinic.

Likewise, the Android-based application was developed by [1], [5]–[11]. This mobile-based application is not integrated with health certificate services. There is also a weakness of using a smartphone, users can memorize the answers if the questions are not randomized which will cause inaccuracy of the test results in reflecting the actual results.

Based on the description of the previous research, the problem discussed in this study is how to integrate an application to detect color blindness into a health certificate service application. From this research, the efficiency of health certificate services at the case study site, Rumbai Health Center, will be measured after using the developed application is the novelty of this research.

II. METHODOLOGY

Generally, the methodology used in this research includes literature study, problem analysis, solution design, and implementation and testing.

2.1 Literature Review

Literature studies of this research are related to color blindness, the Ishihara test, and several other things related to the colorblindness test.

2.1.1 Color Blindness

William F. Ganong (2003) in [3] defined color blindness as a condition in which a person cannot distinguish certain colors that can be distinguished by people with normal eyes. Color blindness can occur due to heredity or abnormalities in the retina that is not sensitive

to color. Color blindness can also be caused due to impairment in the optic nerves or disorders of the brain. In addition, color blindness can also occur due to heredity.

According to [10], color-blind is classified into 3 types, namely:

- 1) Impaired vision due to changes in the sensitivity of one or more types of cone cells (trichromatic). The disorder causes the sufferer to have difficulty distinguishing one of the basic colors, namely red, green, or blue.
- 2) Partial color vision disorder in which a person can only distinguish two color components (dichromate) or one color component (monochromate). This occurs because one or two of the cone cells in the retina are missing.
- 3) Total color vision disorder in which a person cannot recognize color at all (achromatopia). This happens because the three cone cells to distinguish colors on the retina are absent.

2.1.2 Ishihara Test

The Ishihara color blindness test was developed by Dr. Shinobu Ishihara in 1917 in Japan. The Ishihara test is the most common test for color blindness. The Ishihara test consists of dots of various colors. It contains a collection of arranged picture cards and colored dots. Each card has an assortment of images and a background of various colors. The Ishihara test is usually used to diagnose partial color blindness for red and green colors [12].

In general, the Ishihara test contains 38 plates consisting of numbers, shapes, or lines composed of different colored dots from the basic color dots that are difficult to distinguish for people who suffer from color blindness. However, currently many are using only 24 plates.

Ishihara plate is divided into 5 types [2]:

- 1) Introduction. It is a readable sample plate by partially color-blind people and people with normal color vision. This type includes plate number 1. Figure 2 is an example of an introduction-type plate. Patients with partial color-blind and normal vision can see the number 12, while patients with total color-blind cannot see the numbers on the plate.
- 2) Transformation. It is a plate on which partially color-blind people see different numbers from what people with normal

color vision see. Included in this type are plate numbers 2-9. Figure 3 is an example of this type of plate.

On the plate, patients with partial color blindness read different numbers than patients with normal vision. Usually, the number read by partially colorblind patients is 4.



Figure 2. Introduction type plate

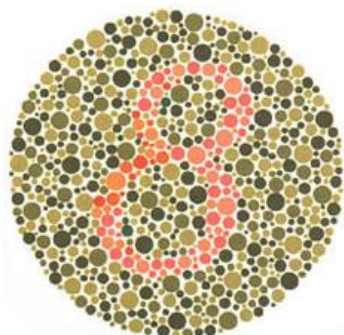


Figure 3. Transformation type plate

- 3) Vanishing. It is a plate that is only readable to patients with normal color vision. Included in this plate are plate numbers 10-17. Figure 3 is an example of a vanishing plate.

Patients with partial color blindness cannot see the numbers on the plate.

- 4) Hidden numbers, namely plates that can only be seen by partially color-blind patients. Included in this plate are plate numbers 18-21. Figure 5 is an example of this type of plate.

On the plate, patients with partial color blindness see that there are hidden numbers in the plate. Patients with normal vision do not see the numbers on the plate.

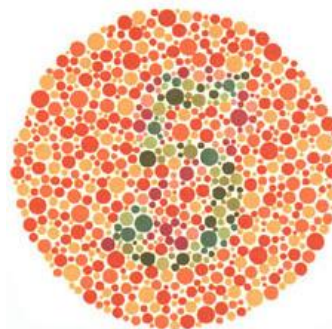


Figure 4. Vanishing plate

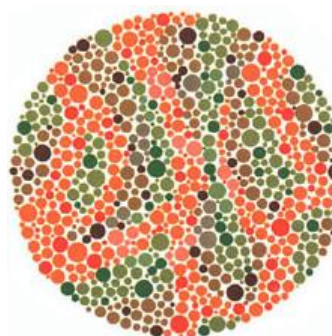


Figure 5. Hidden numbers plate

- 5) Protan or deutan classification. It is a plate consisting of two-digit numbers to distinguish the type of partial color blindness experienced by the patient, whether red or green color blindness. Plate numbers 22-25 are included. Figure 6 is an example of this type of plate.

On the plate, patients with partial color blindness of one color, red or green, can only see one number. This plate is to determine the type of partial color blindness of the patient.



Figure 6. Protan and deutan classification type plate

The results of the color blindness test are based on whether or not a person can read the numbers from each page shown. This test is also equipped with specific guidelines for assessment.

2.2 Problem Analysis

Problem analysis was carried out with direct interviews at the research case study site, Rumbai Health Center (Puskesmas). Interviews were conducted with the head of the Puskesmas, the administrative division, and the doctor who carried out the examination.

2.3 Solution Design

Based on the problems, it is concluded that the right solution is to create a web-based application. Then, the application is designed and developed using a prototyping software development methodology.

At the initial stage, a prototype application for the service to make a health certificate was designed. Then, the design is reviewed and evaluated by the parties who use it, in this case, the doctor and the administrative section. The results of the review and evaluation are then revised to get the desired application interface prototype. The prototype display interface is obtained after going through 3 iterations.

After that, the program code is made for each interface display. After the program has been coded, a review and evaluation of the final results of the application are carried out through focus group discussion (FGD) activities involving the head of the Puskesmas, the head of administration, administrative staff, and the doctor. From the results of the FGD, there are still some features that need improvements. Then the improvement process is carried out and reviewed again to get the expected results. This evaluation process is done in 2 iterations.

The prototyping methodology used is an illustrative method [13], which is the output of the development process is an example of a report and a screen display. However, in technical implementation, the application development process is modified according to a more acceptable process to users. An overview of the implemented prototyping method is in Figure 7.

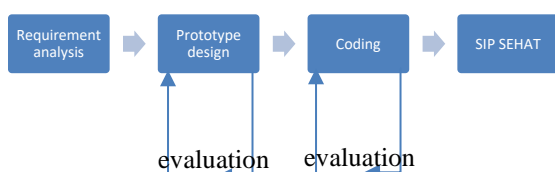


Figure 7. Flow Diagram of Prototyping Method

III. RESULTS AND DISCUSSION

The developed application is named SIP SEHAT which stands for Aplikasi Pelayanan Surat Keterangan Kesehatan (Health Certificate Service Application). This web-based application is intended for health workers who serve the management of health certificates to the public. This SIP SEHAT could be used at Puskesmas or clinics that serve the making of health certificates. This application has several main features, namely patient registration, medical examination, color blindness test, health certificates print, and report.

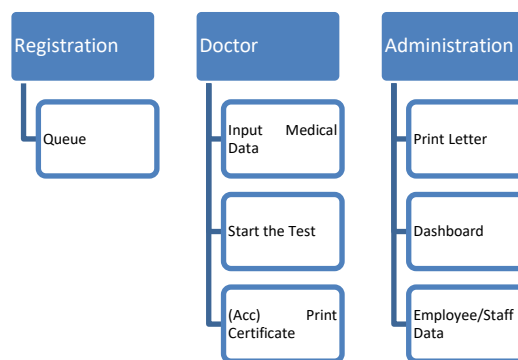


Figure 8. SIP SEHAT site map

The sitemap for the SIP SEHAT application is shown in Figure 8. There are 3 user categories of this application, namely: registration, doctors, and administration. The registration section's role is to enter the identity data of the patient who registers.

Then, the doctor examines the patient according to the queue given and enters the medical data from the examination. A doctor is the one that has the authority to declare whether a patient is healthy or not. After that, the patient takes the color blindness test. The results of the color blindness test will be saved in the patient's biodata. If the medical data and color blindness test have been completed, the doctor will send approval to the administration section to print the certificate.

The administration section prints the health certificate of the patient who gets the doctor's approval. The administrative section can also view reports on the patient visits who request the certificate, which is displayed in the form of line graphs and tabulations. The administrative division also manages the staff if there is an addition of doctors or other staff on duty at the health service place.

The following explains some of the main features found in the SIP SEHAT application.

3.1 Registration section

The registration section only has 1 feature, which is to add to the queue of patients who register for a health certificate.

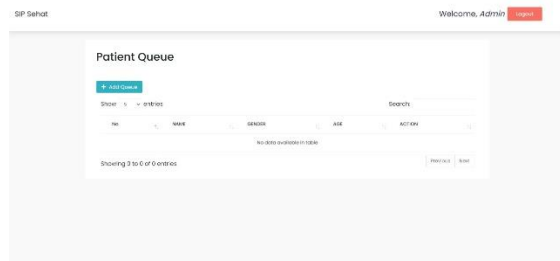


Figure 9. Register form

The registration section can add registering patients to fill in the patient's identity data. The registration section also adds what the patient needs the health certificate for. There are 4 options provided, namely applying for a job, continuing education, requirements for obtaining a driver's license, and others.

3.2 Doctor

Doctors can view patient queue data inputted by the registration section on the Queue menu. The doctor calls the patient for a medical examination, including blood pressure, blood type, weight, height, and body temperature. The doctor can also add information if there are things that need to be noted in the medical examination.

After a medical examination, the doctor gives the color blindness test on the patient. The patient is asked to answer 24 templates that have been provided. After all the questions are answered, the doctor could immediately see the test results. There are three test results, namely total color blind, partial color blind, and non-color blind. Conclusions are made based on the Ishihara test plate type and analysis of the probability that the patient's answers. Based on the explanation in the previous section, the conclusion making rules is shown in Table 1 and also refer to the research conducted by [3]. This rule has also been confirmed by the examining doctor at the Rumbai Health Center.

Table 1. Color blindness conclusion making rule

Result	Condition
Totally Color Blind	1. If plate 1 is wrong and answers on the other plate are ignored
Partially color blind	1. If plate 1 is correct, plate 2-16 are wrong more than 3, or 2. If plate 1 is correct, plate 22-24 answers are only correct on one plate, or 3. If plate 1 is correct, if the patient sees the number on plate 18-21
Not color blind	1. If plate 1 to 17 are correct or plate 1 must be correct and more than 13 plates are answered correctly 2. Plate 22 to 24 are correct or 2 plates are correct

After that, the doctor can approve or disapprove to print a health certificate.

3.3 Administration Section

The administrative division prints the health certificate after the doctor approves. The administration section adds the certificate number after printing the letter. The administration also received a report of the examination result that has been done at the Rumbai Health Center. The examination data recapitulation is required as a report to the Pekanbaru City Health Office. The data is reported in the form of numbers and graphs as shown in Figure 10.

In addition, the administration section also acts as an administrator who manages users on the application.

3.4 Accuracy Testing

The accuracy test is performed towards the output of the color blindness test. The test is carried out by validating the result of the color blindness test from the application to the doctor, in this case, Dr. Fanny. There are 18 test cases used in the test. These test cases are designed to produce the expected output that is in line with the theory obtained in the reference. All test cases were then tested on the SIP SEHAT application and the result is 1 test case is total color blind, 11 test cases are partial color blindness, and 6 test cases are not color blind.

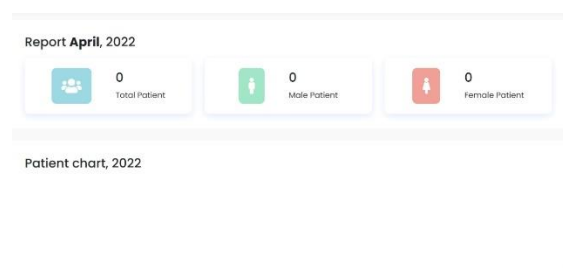


Figure 10. Interface of health certificate management reports

The outcomes of the 18 test cases were then validated by doctors who are experienced in color blindness tests at the Rumbai Health Center. Based on the validation that has been done, the doctor stated that the results of the application to the 18 test cases were valid and resulting expected outcomes. Based on the doctor's validation, the conclusion is the color blindness test in the SIP SEHAT application has accurate results.

Tabel 2. Accuracy Testing Result

No	Test Case	Exp. Output	System Output
1	1	Total	Total
2	2,3,7,12	Partial	Partial
3	4,6,12,16	Partial	Partial
4	2,5,9,16	Partial	Partial
5	2,6,8,9,12,16	Partial	Partial
6	2,4,6,...,16	Partial	Partial
7	2-16	Partial	Partial
8	22,23	Partial	Partial
9	23,24	Partial	Partial
10	22,24	Partial	Partial
11	22,23,24	Partial	Partial
12	18	Normal	Normal
13	19	Normal	Normal
14	20	Normal	Normal
15	21	Normal	Normal
16	19,21	Normal	Normal
17	18,19,21	Normal	Normal
18	18,21,22,23	Partial	Partial

Table 2 is the result of accuracy testing. In the table, the test case column contains the plate number that was incorrectly answered and the Exp Output column indicates the expected output, and the system Output, which shows the output of the application, is the type of disorder that is not colorblindness. Total means total color blindness, Partial means partial color blindness, and Normal is not color blind.

3.5 Correctness Testing

Testing the completeness and suitability of features in the application with the user's

expectations has been conducted once on July 6, 2020. The test is done by demonstrating the application to the head of the Rumbai Health Center, the head of administration, four administrative staff, and a doctor at the Rumbai Health Center.

Based on the demo, Rumbai Health Center asked for improvements to some application features. Among the improvements requested, 2 parts are considered major improvements, namely: (1) the format and content of the certificate is and additional information to state that the examination does not include the Covid-19 examination, (2) feature to add users for the registration section. The second improvement is the addition of the requirements that were not discussed in the previous requirement elicitation.

Revision requests were then handled immediately and have been successfully carried out. The revisions were then confirmed and validated by the administrative staff through the web address that has been hosted. Based on the validation process, the administrative staff stated that the features in the application were as expected.

3.6 Usability Testing

Usability testing focused on testing the ease of use of the application. 30 people participated in the test. They were people who need to obtain a health certificate from the Puskesmas in general. To find out whether the system fulfilled the expected benefits, a measurement was used in the form of a questionnaire. Here is a list of questions asked to see the level of convenience of the application.

- 1) The menu on this color-blind test system is easy to use and understand.
- 2) The interface of color blindness test application is appealing.
- 3) The application works fine
- 4) It doesn't take long to run the application and get information about color blindness
- 5) You have no difficulty in using this application
- 6) This application could accurately inform the results of the color-blind test
- 7) Did not find errors when using this application

Table 3 displays the questionnaire result of each question.

Table 3. Usability Testing Questionnaire Result

Question	Index (%)	Remark
1	96	Very Good
2	93,3	Very Good
3	94	Very Good
4	95,3	Very Good
5	82,6	Good
6	90,6	Very Good
7	90,6	Very Good

Based on the results of tests carried out using a Likert scale calculation (5 scales), the seven statements on the questionnaire produced a percentage value above 75% and the average of those seven statements yielded a percentage value of 91.8%. Therefore, the SIP SEHAT application is concluded to be in the good criteria.

3.7 Analysis of Service Process Efficiency

Figure 11 below shows the process taken to process a Health certificate at the Rumbai Health Center after using SIP SEHAT. Compared to the process that occurred before using SIP SEHAT in Figure 1, the process is more efficient, namely in the patient's activities to obtain a health certificate after being examined by a doctor, marked with a red box in Figure 1. These three processes are patient interactions with medical personnel in the medical worker in the Administration.

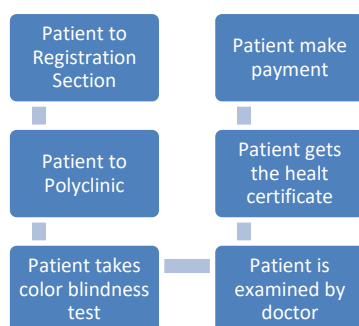


Figure 11. Process to Obtain Health Certificate using SIP SEHAT

It will reduce the risk of the TU section interacting with many patients who potentially transmit diseases, such as COVID-19. Based on this, the service process for obtaining a health certificate at the Rumbai Health Center is more efficient as much as:

$$efficiency = \frac{3}{7} \times 100\% = 42.86\% \quad (1)$$

IV. CONCLUSION

Based on the testing and analysis carried out in this study, the conclusion is that the SIP SEHAT application is ready to be used by the Rumbai Health Center, especially for making and obtaining health certificates. This application makes the process of managing a health certificate making more efficient by 42.86%.

As for the Ishihara color blindness test, the list of questions that the patients need to answer could be further optimized with artificial intelligence techniques. It will speed up the process of providing health certificate services.

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