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Development User Interface Hospital Management Information System Based on a Heuristic Evaluation Approach in Surabaya Hospital Medical Services

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***Abstract*—Surabaya health service hospital uses the Medical Management System (M applications). However, the application is rarely evaluated. Inputs or feedback obtained from user cases, especially This study, is written to report the improvement of the SIMRS application model based on a heuristic assessment method. The method used in this study was to distribute questionnaires to the research objects that were evaluated, calculate the results of the heuristic assessment using the severity rating method, and then improve the model using the usability theory. This research consists of five usability components that demand improvement: visibility of system status, a match between the system and the real world, user control and freedom, error prevention, and recognition rather than recall. The conclusion is that five usability aspects have been fixed by following the concepts in the heuristic evaluation theory developed in designing a user interface model for the SIMRS application. This research employed a heuristic evaluation approach, which could determine the number of usability problems to be repaired. From the research, the level of problems in the SIMRS application user interface was minor problems. These problem solutions were given low priority in a SIMRS application model adapted to the usability principle.**

***Keywords*—Medical records; medical management system; heuristic evaluation; severity ratings; prototype.**

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I. INTRODUCTION

A decent application relies on the implementation and design of a user interface. The user interface is a part of the software that connects human and computer interaction [1]. The efficacy of an application is determined by the design and implementation of its user interface. It is, therefore, necessary to evaluate the user interface, and usability evaluation is one way to evaluate the application. Usability evaluation is the activity that can contribute experience user with an application [2]. An example of usability evaluation is heuristic usability evaluation [3].

Usability refers to a product's accessibility of use [4], users understanding in communicating with the system [5], and how much a system's viability is determined by its efficacy, efficiency, and satisfaction in particular situations. Additionally, a usability attribute specifies or measures how convenient an interface is to use [6]. Usability is one key factor for gaining users' satisfaction and confidence with the systems [7]. Users tend to use products that is easy to understand, work as usual, and can contribute well [8]. Additionally, there was a need for a usability evaluation, and the writer applied usability evaluation techniques to conduct an analytical and empirical analysis of the interaction. This evaluation provided heuristic, cognitive, and directional feedback due to the interaction [9].

Surabaya medical service hospital is one hospital that uses the Hospital Management Information System (SIMRS) application called the Medical Management System (MMS) that is running. However, SIMRS is a system that rarely earns significant attention from researchers, making this model rarely evaluated by users and developers. Evaluations are rarely conducted for all hospital service units that rely on this system. Unfortunately, this may affect the quality of Registration Counters, Outpatient Registration, Inpatient Registration, Pharmacy, Laboratory, Billing Systems, and Medical Records. Its users do not fully accept the information system. Frequent errors, an unattractive design, and difficulty in operation significantly impact how users view utilizing

information systems. Accordingly, the information system must be evaluated periodically to identify and fix user problems [10].

Consequently, developing a SIMRS application model based on a heuristic evaluation approach is necessary to enhance the effectiveness and efficacy of using the SIMRS application in Surabaya Medical Service Hospital. The number of usability problems that are discovered to all be fixed can be calculated using the heuristic evaluation approach. It will be developed into a SIMRS application model that has been adjusted to the usability principle based on the findings of these measurements. Heuristic evaluation studies bring an outcome on user acceptance of the application that the user uses and can improve the overall user experience [11]. The heuristic evaluation method can improve efficiency and identify usability problems before implementation to increase user satisfaction [12].

While formulating the problem solution, the writer used web coding to work on the prototype model for users. The interactive web was chosen as the medium of the pages to interact with the users while also providing ease of application usage. The model was built with executable codes in Web 2.0 [13]. Automated website usability evaluation tool[14] is another model that can be used, but then the writer chose interactive web for users to provide ease of application usage. Web accessibility is important from the point of view of human-computer interaction [15]. This research aims to develop a prototype of the user interface SIMRS model based on the heuristic evaluation method. We use Jacob Nielsen's 10 usability heuristics to develop a prototype SIMRS model.

II. Materials and Method

This research followed three phases. Phase I measured the problem's difficulty level in the user interface application with a heuristic evaluation approach. Phase II was recapitulation score result severity rating using heuristic evaluation. Phase III was redesigning the user interface application.

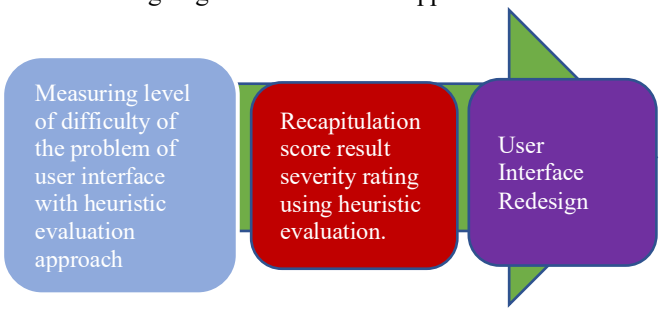

Fig. 1 Process of heuristic evaluation and redesign

A. Phase I. Measuring the Level of Difficulty of the Problem in the Application of User Interface with Heuristic Evaluation Approach

The ten usability heuristics for user interface design listed below are similar to a research by Mancilla et al. [16]. This research evaluated heuristics principles: (1) System status visibility; (2) System and real-world compatibility; (3) User control and freedom; (4) Consistency and standards; (5) Error prevention; (6) Recognition rather than recall; (7) Flexibility and efficiency of use; (8) Aesthetic and minimalist design; (9) Assist users in recognizing, diagnosing, and recovering from errors; (10) Support and documentation. Heuristic evaluation is a complete and detailed evaluation [17], and it is a fast and easy method to detect usability problems [18], [19]. According to Nielsen [20], user interface design has ten usability heuristics.

1) Visibility of System Status: The system should provide the user with information about what is happening by providing the appropriate feedback in real-time.

2) Match between the system and the real world: Instead of using language that could only be understood by the system, the system must adopt user language that includes words, phrases, and clear and acceptable concepts. Always keep up to date and distribute information normally and orderly.

3) User Control and Freedom: Users frequently choose the wrong buttons or functions when using the system, intentionally or accidentally. In these situations, they require a straightforward escape cue that they can use to leave the unwanted screen without pressing a button or reading a manual. Functions for undo (cancel) and redo (repeat) must be available.

4) Consistency and Standard: Users should not be perplexed if various words, situations, and actions have the same meaning. It is important to remember that all navigation systems must be reliable.

5) Error Prevention: Making a successful system design, which can predict problems in the early stages of the system, is preferable to showing error messages. Also, provide a confirmation option before the user proceeds with the action.

6) Assist users in identifying, diagnosing, and resolving problems with (Recognition rather than recall). Make objects, actions, and choices obvious so users do not have to remember information from one section to the next. Instructions for using the system should also be accessible whenever the user requires them.

7) Flexibility and Efficient of Use: Accelerators, which most novice users are unaware of and can speed up interactions for advanced users. The system should be capable of what must be considered is that the system must have functions that are understandable to both experienced and novice users.

8) Aesthetic and Minimalist Design: Dialogues should not include information that is irrelevant or is only used infrequently. The more specific information in a dialog should be adjusted based on the unit.

9) Help users recognize, dialogue, and recover from errors: Error messages should be written in plain language (not code) that identifies the error and suggests a solution.

10) Help and Documentation. That is preferred if the system can be operated without documentation, although it may need both. Each information item must be easy to locate, relevant to the user's task, provide specific instructions for the process, and not be excessively long.

Along with the design, the writer used heuristic evaluation to identify issues through testing and evaluating the application's development and usage. A usability test is a way to determine whether a product is usable and how users find using it [21]. Various usability evaluation techniques can

capture user perceptions about the user interface [22]. Usability is an important aspect of user experience [19].

B. Phase II. Recapitulation Score Result Severity Rating Using Heuristic Evaluation

The "usability" is used to seek the usability problems, which could be seen by analyzing the SIMRS MMS application of the hospital. Severity ratings were found from the problem, which could be grading how difficult it is to use the application. This could be achieved by seeing the problems using the program [23]. The severity rating can be used to assess the amount of usability issues that need to be corrected and an overview of what usability principles need to be introduced [23]. On a scale of 0 to 4, the severity of usability difficulties is calculated [23], and heuristic evaluation detects usability concerns that can be categorized by severity [4]. Table 1 below shows the usability problem scale.

TABLE I
USABILITY PROBLEMS SCALE

Scale	Description
0	There is no problem with the usability
1	Cosmetic problem category, the problem does not need to be fixed unless there is time remaining in project work.
2	Minor usability problem category. The problem is less urgent in troubleshooting.
3	Major usability problem category. The problem has high urgency in troubleshooting.
4	Catastrophe usability category. The problem needs to be fixed prior to product launch.

This study uses classifications of bad usability problems [24], and the participants were asked to categorize the usability problems they identified for each item in Nielsen's heuristics according to their severity. The participant took a questionnaire to identify the usability issues and categorize the problems as "no problem," "cosmetic problem," "minor problem," "serious problem," or "catastrophic problem." No problem will be chosen if the participant thinks there is no problem with the usability of SIMRS MMS, but the participant will choose a catastrophic problem if the person thinks the problem is the foulest. By employing heuristic evaluation, it is possible to acquire information related to the severity of the usability problems and solutions to the usability problems for even future users and developers [10].

Moreover, after the usability problems have been found, the writer uses heuristic evaluation to find the solution to the design flaws in the application. This evaluation is a way to find the problem in the design of a program and is a cheap way to find one than the other assessment tool to evaluate the design [15], [18], [25].

Furthermore, using the equation, generate a severity rating for each usability aspect:$Sv = \sum \frac{Hx}{n}$.

Sv: severity rating results in one usability aspect

Hx: Total rating scores of usability sub-aspects in each usability aspect (H1, H2, ……, H10)

n: The amount of sub-aspect usability in each usability aspect

The researchers conducted several steps while running this study. The steps are stated below:

- Problem's identification
- Literature study
- Arrangement and distribution of the questionnaire
- Data collection
- Usability measurement using the SIMRS MMS application heuristic application.
- Analyzing the heuristic evaluation result
- SIMRS Application prototype design for service unit
- Concluding and preparing for the final report

Furthermore, while conducting the research, the researcher utilized Research Conceptual Framework as the flow of the research. The framework is displayed below:

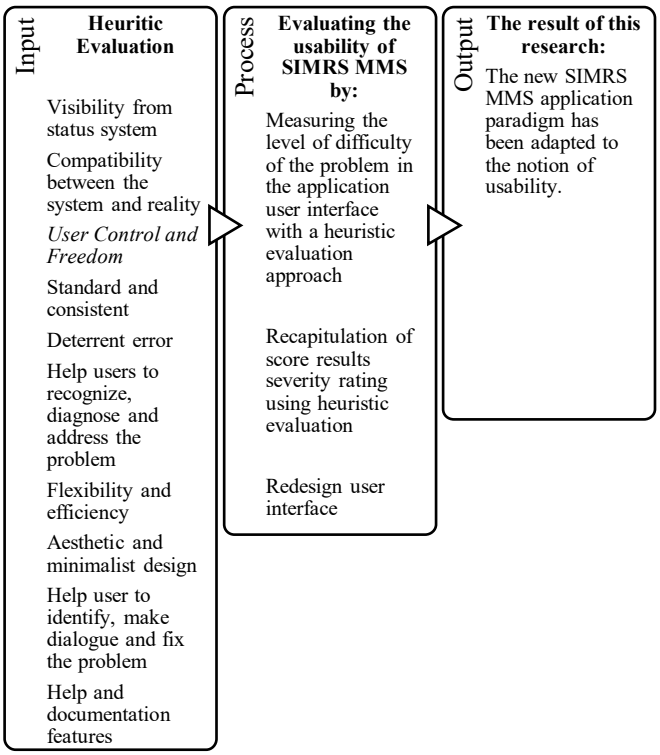

Fig. 2 Research Conceptual Framework

This research investigated the user's convenience in using the SIMRS MMS application using an inspection approach with a heuristic evaluation technique. This research used heuristic evaluation method in determining the level of difficulty of the problem in the program user interface. The new SIMRS MMS application development approach is based on usability. Heuristic evaluation inspection method used to evaluate the usability of the product interface [19], usability problems in the SIMRS MMS application could be identified. These problems were assessed according to the problem's difficulty level (Severity Ratings).

After performing the above calculations using the inspection method, the value of the difficulty level of the problem on the SIMRS MMS application user interface was obtained. Likewise, the application model was repaired and developed following the usability principle. Heuristic evaluation is a technique to analyze usability and find usability defects [26], and it is a method to modify the design of the systems [12].

The method used in this research was questionnaires to the research object being tested, calculating the heuristic evaluation results using the severity rating technique, and then

developing the model according to the usability principle. A prototype with mockup tools was used to develop the model. There were various tools to create mockups of different forms, precision, interactivity, and executability. Tools such as Balsamiq are capable of creating interactive mockups [27]. In this study, the research population was ten users of the SIMRS MMS application from the registration counter, medical records, outpatient registration, inpatient registration, pharmacy, laboratory, and billing system. The researchers used ten heuristic evaluation variables, which are:

TABLE II
EVALUATION HEURISTIC ASPECT

No	Usability Aspect	Code
1.	Visibility from the status system	H1
2.	Compatibility between the system and reality	H2
3.	User Control and Freedom	H3
4.	Standard and consistent	H4
5.	Deterrent error	H5
6.	Help users to recognize, diagnose and address the problem	H6
7.	Flexibility and efficiency	H7
8.	Aesthetic and minimalist design	H8
9.	Help users to identify, make dialogue and fix the problem	H9
10.	Help and documentation features	H10

C. *Phase III. Redesign User Interface*

After measuring the level of difficulty of the problem in the application of user interface with a heuristic evaluation approach and recapitulation score result severity rating using heuristic evaluation, then the SIMRS application prototype model was developed based on an assessment of the level of problems in the previous SIMRS application user interface. Like the research of Oulasvirta et al. [28], based on the usability objectives described in the preceding section, each application screen was examined for problems. To create an optimized visual design for the interface change, each element on the screen had its size, shape, and color adjusted.

In designing of GUI (graphical user interface), an application has extensive functionality to offer, GUIs are often organized hierarchically with two principles, visual containment, such as canvases, windows, and boxes can have other containers and elements within them, and Logical Compositionality such as a settings panel, a drawing canvas, and a dialog [28]. A new UI design prototype was developed as part of the user interface redesign phase to solve the usability problems encountered in the first phase. Each usability issue was addressed through a redesign process after the usability issues were sorted by severity level, working from the highest to the lowest severity level [29].

III. RESULT AND DISCUSSION

A. *Measuring the Level of Difficulty of the Problem in the Application of User Interface with Heuristic Evaluation Approach*

The methods employed in this study were distributing questionnaires. This research also calculated the outcomes of the heuristic evaluation using the severity rating technique. Also, this research developed the model under the usability principle. The number of usability issues discovered, and the average severity ratings were used to display the results. The following image depicts the SIMRS MMS application page display that was evaluated:

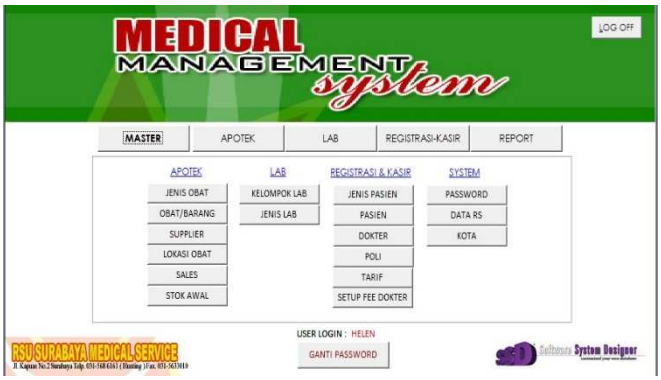

Fig. 3 Master Menu Interface Page Display

Figure 3 is the master menu form in the medical management system application. The researchers used ten variables in the heuristic evaluation, as shown in Table 3 below, where these ten variables are written in usability aspects. The usability sub-aspect is a development related to the usability dimension and encompasses items in the questionnaire.

TABLE III
USABILITY ASPECTS AND USABILITY SUB ASPECTS

Aspect and Sub Aspect Usability
Visibility from the status system
1. Each page has a title that describes the page's content. 2. Each page has a uniform symbol, icon, and design scheme. 3. When an object (button, choice button) is pressed or selected, a visual response distinguishes it. 4. The menus and pages have names that correspond to the content. 5. The difference between the currently selected menu and not can already be seen in the display menu.
Compatibility between the system and reality
1. A universal symbol that can be utilized by everyone. 2. The menu's name is written logically and is understandable to the user. 3. The form/image used is appropriate for the user's culture. 4. Users who are actively using the application can select a language.
Users' control and freedom
1. There is a help button when the system does not display the results of any process, for example, if an error occurs. 2. Users have the flexibility to search for data. 3. If the system has a multilevel menu, the user should be able to easily move to the previous page.
Standard and consistent
1. Each page is labeled with a title. 2. Each page follows a consistent standard of writing. 3. Each page's title is consistent regarding letters, sizes, and paragraphs. 4. The appearance of the form on the web for each page is the same and consistent. 5. There is a choice of language other than the language commonly used. 6. There is not only an image that can be displayed, but there is also standard access for users on each page, which is especially important for those with special needs (blind and deaf people).
Deterrent error
1. Text in instruction is clear and does not cause ambiguity. 2. All the information was grouped well. 3. There was guidance navigation for users on every page.
Help users to recognize, diagnose and address the problem.
1. There is an error message in failings when accessing the page. 2. There is a warning sign when the users make a mistake while making changes.

Aspect and Sub Aspect Usability	
Flexibility and efficiency	
1.	The contents of the application page are displayed in the language the user selects.
2.	Menus and other information are well-packaged.
3.	Group menus and other information are simple to recall.
4.	On each page, there is a navigation menu that can assist us.
5.	The navigation menu is in the proper location.
6.	The search menu is simple to locate and use
Aesthetic and minimalist design	
1.	There is a variety of foreign languages available for use by non-native speakers.
2.	The search menu is simple to remember and use, even for inexperienced users.
3.	The menu's layout is very familiar and easily accessible to the user.
4.	The system allows you to change the case of the characters.
5.	The system provides no option for selecting a color as an action code.
Help users to identify, make dialogue and fix the problem.	
1.	Each page's information is straightforward, allowing the user to make additional judgments.
2.	The use of appropriate font sizes and types on each page makes visitors feel at ease.
3.	The structure of each page is consistent and regular.
4.	The title of each page is clear and informative.
5.	There are no irrelevant characteristics.
Help and documentation features	
1.	A menu map is provided so users can easily see the available menus.
2.	There is a help menu that can assist users in navigating the site more effectively.
3.	There is contact information/correspondence information from the page's owner.

A questionnaire was distributed after determining the problem category by determining the usability aspects and sub-aspects using the heuristic evaluation method shown in Table 3 above. The following equation was used to calculate the value of the questionnaire evaluation results:
The calculation for the heuristic evaluation used the equation below:

$$\sum Hx = 0 * x + 1 * x + 2 * x + 3 * x + 4 * \text{x} \qquad (1)$$

$\sum Hx$ = the number of rating scores from the usability sub-aspect in each usability aspect (H1, H2……., H10)
x = usability point, contains one or null. Below is an example of the problem's difficulty level in the application of user interface with a heuristic evaluation approach.

TABLE IV
THE EXAMPLE OF THE LEVEL OF DIFFICULTY OF THE PROBLEM

Usability	Usability	SR					Total	Score
Aspect	Sub Aspect	0	1	2	3	4		
A	B	C	D	E	F	G	I	J
1	1	7	1	0	0	2	9	1.8
	2	7	2	0	0	1	6	1.2
	3	8	0	1	1	0	5	1
	4	7	2	0	1	0	5	1
	5	8	1	0	1	0	4	0.8
		37	6	1	3	3		5.8
		0	6	2	9	12	1	1.16

From Table 4 above, the table's value is the result of heuristic evaluation calculations. The list of severity rating values in columns C, D, E, F, and G is the value of the heuristic evaluation carried out. Column I is a column that contains the number of severity ratings obtained from the sum of the severity rating values.

According to equation (1) that,

I = (0*C1) +(1*D1) + (2*E1) + (3*F1) + (4*G1)

For example, sub aspect 1 in the table above that,

I = (0*7) + (1*1) + (2*0) + (3*0) + (4*2) = 9

The sub-aspects 2, 3, 4, and 5 calculations are the same.

Furthermore, column J is the severity rating value obtained, namely J = I/5, where 5 is the total questions on usability aspect 1 (Visibility from the status system).
For example, severity rating value sub aspect 1 that,

J = 9/5 = 1.8

The severity rating calculation of sub-aspects 2, 3, 4, and 5 are the same. Average value severity rating obtained from total SRscore in aspect usability 1/total questions in aspect usability 1. For example, the average value severity rating in aspect usability 1 (Visibility from the status system) obtained: 5.8 / 5 = 1.16.

B. Recapitulation Score Result Severity Rating Using Heuristic Evaluation

Furthermore, to produce a severity rating from each usability aspect using the equation:

$$Sv = \sum \frac{Hx}{n} \qquad (2)$$

Sv: severity rating results in one usability aspect
n: the amount of sub-usability aspects in each usability aspect

In the discussion about the results of calculating the questionnaire with a heuristic evaluation approach, this problem needs to be fixed before the product is launched, especially for assessing the level of problems in the SIMRS application user interface for the highest priority scale.

Here is the recapitulation score result severity rating using heuristic evaluation with usability aspect:

- Visibility from the status system with an average value severity rating of 1.16
- Compatibility between the system and reality with an average value severity rating of 1.69
- Users control and freedom with an average value severity rating of 4.33.
- Standard and consistent with an average value severity rating of 1.19.
- Deterrent error with an average value severity rating of 2.67.
- Help users recognize, diagnose, and address the problem with an average severity rating of 6.75.
- Flexibility and efficiency with an average value severity rating of 1.11.
- Aesthetic and minimalist design with an average value severity rating of 1.76.
- Help users to identify, make dialogue, and fix the problem with an average value severity rating of 1.
- Help and documentation features with an average value severity rating of 2.56.

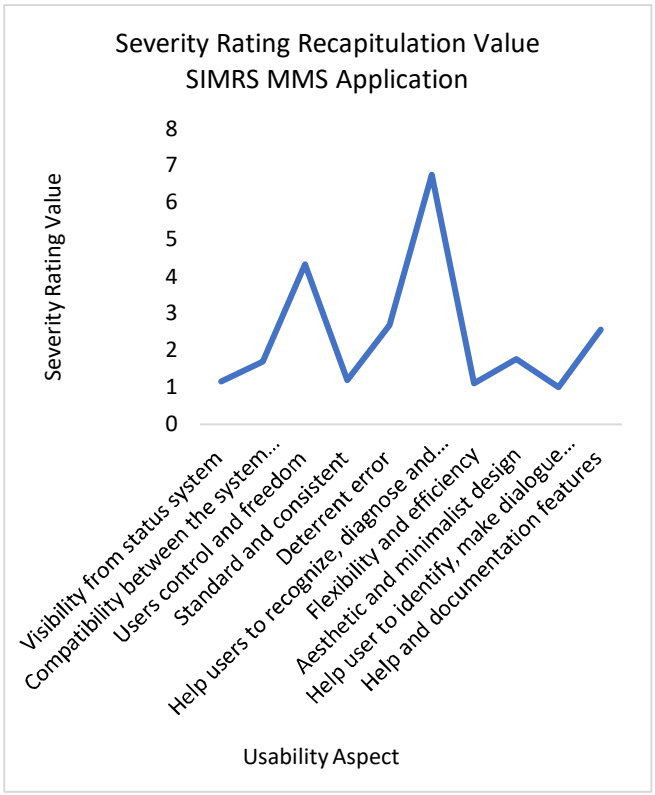

Fig. 4 Severity Rating Recapitulation Value SIMRS MMS Application from The Principles of Heuristic Evaluation

The SIMRS MMS application has usability problems, according to the average of the findings recapitulation of severity rating values using heuristic evaluations, with an average totals value of 2.42 or a scale of 2, meaning that the repair of this problem is accorded low priority. These details correspond to those in Table 1 above. The severity rating value demonstrates the extent of the SIMRS MMS application's usability problems.

C. Redesign User Interface

The SIMRS application prototype model was developed to evaluate the severity of the problems in the previous SIMRS application user interface. This evaluation involved measuring the difficulty of the problem in the application of the user interface using a heuristic evaluation approach and recapitulation score result severity rating using heuristic evaluation. The following are the results of using the heuristic evaluation method to calculate the usability aspect:

Figure 5 shows the calculation of usability aspects and usability sub-aspects, which shows the highest total severity rating in the visibility from the status system aspect was 9, especially in the usability sub-aspect. Each page has a title that describes the page's content. The writer fixes this, as seen in one of the modules for which we created a prototype model in web development, as shown below.

In Figure 5, the user interface showed that the user interface title was a pharmacy module page. The contents, of course, explain the transactions in the pharmacy unit. Beginning with both concocted and non-concocted drug service activities. This was similar to research by Zardari et al. [30] conveyed the visibility of system status which mentioned a page with a title that describes the page's content so users know on which level of the portal they were presently standing.

In other calculations on the level of the problem by using the heuristic evaluation on the deterrent error aspect that needs to be fixed is the usability sub-aspect on the text side in clear instructions and does not cause ambiguity that the highest total severity rating is 13. Another study by Jeddi et al. [10] is related to the deterrent error aspect that needs to be fixed. In those studies, the recommendations regarding the deterrent error principles are as follows: completion notification should be displayed once the data entry process is finished where there is no confirmation message after a process is completed.

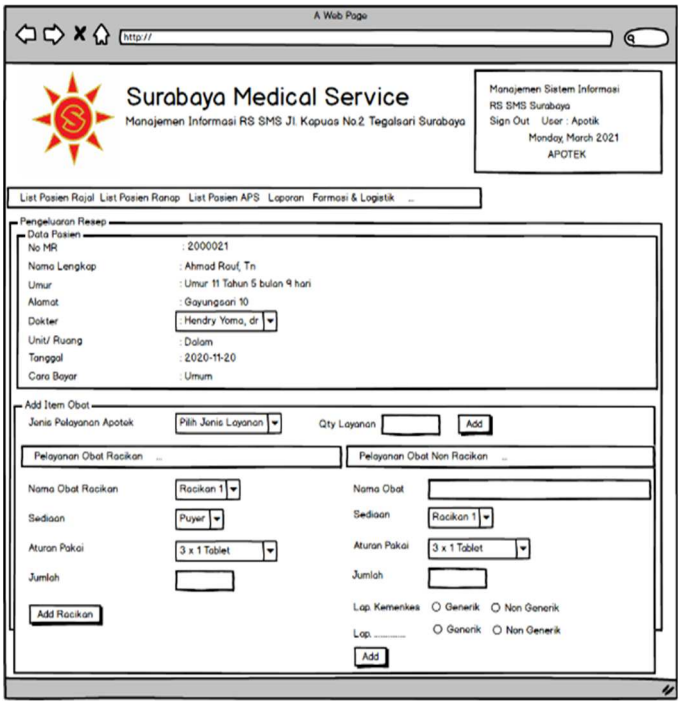

Fig. 5 Prototype Model for Pharmacy Module

IV. Conclusion

The usability test results for the SIMRS MMS application led to the following conclusions. The SIMRS MMS system's usability problems were under the heading of minor issues. It implies that fixing this problem is considered a low priority. The following five components of usability were required to be improved: visibility of system status, a match between the system and the real world, user control and freedom, error prevention, and recognition rather than recall. Following the principles of heuristic evaluation developed in the form of developing a user interface model for a hospital management information system (SIMRS) application, five usability aspects have been improved. Future studies can use other methods like think-aloud (TA) to identify usability problems of hospital management information systems (HIMS). So, this will be useful to support work on units that need it.

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