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Development of a User-Personalized Decision Support System for Contraception Method Selection

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***Abstract*—The number of unmet needs for contraception has not reached the target set by the Indonesian government, while the uneven distribution of health workers, the main source of information for contraception, is still an unresolved problem. The Internet serves as an alternative source of information for contraception selection. However, without personalization, it may lead to inappropriate choices. This study discussed the development of an information system for selecting contraceptives, incorporating a decision support system (DSS), enabling personalized recommendations based on user preferences to assist in determining the appropriate contraceptive method. The functionality of the information system was evaluated using black-box testing, conducted by reproductive health experts, while its usability was assessed based on ISO-9241-11:2018 standards with 25 respondents. The functional evaluation of the system showed that 14 functions successfully passed the testing procedures, while 2 functions failed. The usability evaluation yielded excellent results, with an overall score of 4.52. Based on these findings, the developed information system can serve as a medium for reducing the number of unmet needs for contraception by providing users with contraceptive information tailored to their preferences. Further research needs to enhance system information by integrating user medical reports and user location and evaluating the recommendation-to-selection conversion rate— the extent to which users follow the system's recommendations when choosing contraceptives.**

***Index Terms*—Contraception, decision support system, blackbox testing, usability evaluation.**

I. Introduction

Unmet need for contraceptives is one factor in fulfilling the Sustainable Development Goals (SDGs) [1]–[3]. The need for contraception aims to enable women to prevent pregnancy or maintain birth spacing [2]. Studies state that unmet need is related to the incidence of unwanted pregnancy [4], [5].

The unmet need for contraceptives in Indonesia is still far from the target. After successfully decreasing in 2020 (14.40%) compared to 2019 (13.40%), the unmet need rate rose again in 2021 (18.00%) [6]. A contributing factor to the unmet need target is the suboptimal provision of family planning counseling to the community by providers at health facilities. Family planning counseling is a process of information exchange and positive interaction between clients and counselor to help clients recognize contraceptive needs, understand benefits, side effects, and myths about contraception, choose the best solution, and make contraceptive decisions that will be used in accordance with the conditions being faced by couples of childbearing age [7], [8]. This process is expected to reduce couples' concerns about contraception usage [9].

Health workers are the most important source of information for family planning counseling [10]–[12], but equitable distribution of health workers remains a challenge [13]. In addition to health workers, the sources of information that have been accessed in searching for family planning are the community, mass media (electronic and conventional), and family [11]. The contribution of electronic media as sources of information for family planning in Indonesia is dominated by television, while the internet has a lower contribution [10], [11]. With the infrastructure currently available, the contribution of the internet as an alternative source of information in family planning should be increased considering that health-related information available on the Internet can provide education and empower users related to health problems, disease prevention, and other health services [14].

Nowadays, there is a lot of information on the Internet about contraception, both in Indonesian and foreign languages. Good quality health information on the internet can improve the knowledge, skills, and attitudes of its users, such as improved decision-making [14], including information about

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contraception. Meanwhile, poor quality information can lead user's mistake for contraceptive selection. Therefore, in addition to information about contraception, users need support in choosing contraception. This support is necessary to ensure that the contraception chosen is right for the user.

Several decision support information systems for selecting contraceptives have been developed. The decision support system that has been developed uses user's health condition as criteria to determine suitable contraceptives [15], [16]. However, it does not provide the freedom to choose a contraceptive with characteristics that suit the user's preferences yet. This research proposes the development of a decision support information system for selecting contraceptives that can be personalized by user's preferences. This information system gives users the freedom to determine the most important characteristics of a contraceptive that will affect user's contraceptive recommendation later.

II. Related Work

Unmet need for contraception is a global challenge, particularly in developing countries [17]. Lack of knowledge about contraception is one of the factors of unmet need for contraception [18]–[20]. Insufficient information can lead women to discontinue contraceptive use without considering alternative methods [18]. Similarly, limited access to information for men results in lower contraceptive literacy, preventing them from understanding proper usage [20].

Information system with Multi-Criteria Decision Making (MCDM) modeling used to provide contraceptive advice that matches the preferences of potential acceptors. MCDM is mathematical modeling for decision-making by evaluating and ranking several existing alternatives [21], and has been applied across various disciplines, including health [22]. In making a decision support system with MCDM, alternative, criteria, and weights are needed [23].

III. Research Method

This study uses the Research and Development (R&D) method consist of four stages. First, analyze the requirement by identifying alternative contraceptives and their criteria. Second, design an MCDM system for selecting contraceptives that can be personalized based on user preferences. Third, develop the application, and the last stage is evaluating the system. Fig 1 depicts the stage of this research.

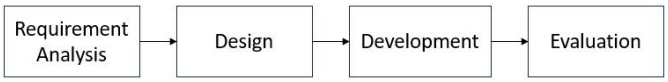

Fig. 1. Research Stages

A. Contraceptive Alternatives and Criteria Identification

Contraceptive tools/methods to be used as alternatives along with their characteristics identified from the Family Planning Decision Making Tool book available in the original version [24] and the Indonesian language adaptation version [25]. In addition, a literature review was conducted to obtain other characteristics. This literature review process involves reproductive health experts.

B. MCDM Design

The MCDM model used in this research is Weighted Product (WP). The weighted product method is a method of determining a decision by multiplication to be able to connect attribute values, where the attribute value must first be multiplied by the weight of the attribute concerned. This method is very suitable because prospective acceptors can determine the weight of each criterion's importance in each contraceptive. In addition, WP has a simple calculation process, consisting of 3 steps (normalization, S vector value calculation, and V vector value calculation). Simpler when compared to TOPSIS which has 5 steps [26], PROMETHEE (5) [27], and VIKOR (4) [28].

The following is the WP formula used in this research [29]: The first step is W_j normalization, where previously calculated in advance the total W_J=1. The value of W_j indicates the weight value of criteria i to the j.

$$\sum w_j = 1 \tag{1}$$

with

$$w_{ij} = \frac{w_i}{\sum w_j} \tag{2}$$

The second step is calculating each available alternative's S vector value.

$$S_i = \prod_{j=1}^{n} X_{ij}^{wj} \tag{3}$$

where i=1, 2, …, n; the value of n indicates the number of alternatives evaluated. X_{ij} is the value of the i-th alternative suitability rating against the j-th criterion, where w_j is a positive rank for the benefit criterion and negative for the cost criterion.

The third step is determining the available alternatives' V vector value. The largest V vector value is the most suitable alternative, followed by the second largest value, third, and so on.

$$V_i = \frac{S_i}{\sum_{i=1}^{m} S_i} \tag{4}$$

C. Application Development

Application development is carried out through the following stages: first designing a user flow diagram using Business Process Model and Notation (BPMN) 2.0 and prototyping a user interface. Second, developing application backend used to handle MCDM calculation based on the WP method, including database implementation for storing alternatives and criteria. Third, implementing application frontend to receive preference input from users.

D. System Evaluation

Evaluation of the user-personalization information system for selecting contraceptives is carried out through two types of evaluation, namely evaluation of application functions and evaluation of application usability. Function evaluation uses the black box testing method and usability evaluation uses a

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self-development questionnaire, based on mostly adapted guidance of usability, ISO 9241-11:2018 [30].

Blackbox testing, also called functional testing, is a functional testing technique that designs test cases based on the information from the specification [31]. With Black box testing, the software tester should not (or does not) have access to the internal source code itself [32]. Blackbox testing is not concerned with the internal mechanisms of a system; these are focused solely on the outputs generated in response to selected inputs and execution conditions [31], [33]. Three black box testing techniques are used for functional testing of this information system: Graph-based testing methods to test the pages in the applications, equivalence partitioning to test the input rank value on each contraceptive characteristic, and error guessing to test application's WP calculation.

Usability testing measures the ability of a system, product, or service used by users to achieve goals in an effective, efficient, and satisfactory manner in a particular context [34]. This test can help find undesirable conditions that occur from the users' perspective [35]. As mentioned, usability measurement is divided into three aspects, namely effectiveness, efficiency, and satisfaction. Effectiveness is the ability of the system to help user achieve goals accurately and completely, efficiency is the ability of the system to provide results according to the resources used by the user, and satisfaction is the user's responses to expectations and needs in the final results presented by the system, product, and service [34]. Usability evaluation was conducted using a closed questionnaire with a Likert scale of 1-5 developed by reproductive health experts. The respondent criteria for this usability evaluation are people of childbearing age.

IV. RESULT

A. Contraceptive Alternatives and Criteria

Several alternative contraceptives can be used in Indonesia. Contraceptives can be fitted to both male and female. Based on the book Aids for Family Planning Decision Making (ABPK-KB), there are two types of contraceptives that can be applied to males and seven types for females [25]. Contraceptives for male are vasectomy and condoms; while for females are intrauterine devices (IUDs), implants, tubectomy, pills, injections, condoms, and natural.

Each contraceptive device/method has characteristics that users can consider when choosing the right device/method. These characteristics will be used as criteria in system development. There are seven characteristics for each contraceptive, namely method [24], [25], [36]; effectiveness [24], [25], [36]; side effects [24], [25], [36], [37]; return of fertility [24], [25], [36], how to use [24], [25], [36], price [16], [37], and comfort during intercourse [38]–[42]. Alternatives and each criterion of the contraceptive device/method can be seen in Table 1.

Table 2.
Conversion Criteria Value to Number Scale

Criteria	Value	Scale	Type
Methods	Long-term	2	Advantages
	Needs repetition	1	
Effectiveness	Highly effective	3	Advantages
	Very effective with proper use	2	
	Effective with proper use	1	
Side effects	More	2	Disadvantages
	Fewer	1	
Fertility restoration	Immediately	3	Advantages
	Takes Time	2	
	Not possible	1	
Price	Expensive	3	Disadvantages
	Affordable	2	
	Free	1	
Installation/Usage	Surgery	3	Disadvantages
	By medical worker	2	
	Self-use	1	
Comfort	Disruptive	2	Disadvantages
	Non-disruptive	1	

Since the value of each criterion is not a number, it is necessary to convert it first to a number. After conversion, the criteria are classified into the advantage and disadvantage types (Table 2). For the advantage type, the best value of each criterion will get the highest scale number. So, the advantage type means the higher the value of the criteria, the more desirable, and this criterion will be multiplied by 1 at the normalization stage.

Table 1.
Criteria and Alternatives Used for Contraception Selection

Alternatives	Methods	Effectiveness	Side Effect	Return of fertility	Price	How to use	Comfort
IUDs	Long-term	Highly Effective	More	Immediately	Affordable	By medical worker	Disruptive
Implants	Long-term	Highly effective	More	Immediately	Affordable	By medical worker	Non-Disruptive
Tubectomy / Vasectomy	Long-term	Highly effective	Fewer	Not possible	Expensive	Surgery	Non-Disruptive
Pills	Needs repetition	Very effective with proper use	More	Takes time	Affordable	Self-use	Non-Disruptive
Injections	Needs repetition	Very effective with proper use	More	Takes time	Affordable	By medical worker	Non-Disruptive
Condoms	Needs repetition	Very effective with proper use	Fewer	Immediately	Affordable	Self-use	Disruptive
Natural	Needs repetition	Effective with proper use	Fewer	Immediately	Free	Self-use	Non-Disruptive

While the disadvantage type is the opposite condition, the worst value of each criterion will get the highest scale number, the lower value is more desirable and this criterion will be multiplied by -1 at the normalization stage. The conversion and classification done by an expert in the reproductive health sector.

B. MCDM Design

According to references that have been studied, contraceptive users consist of male and female. Some contraceptives can only be used by female like IUDs, Implants, Pills, and Injections, so the selection of alternative contraception for male and female is separated. The hierarchical structure of MCDM in Fig 2 and Fig. 3 depicts the difference between female and male contraceptives where the female has seven alternatives (A1-A7), and male has only two alternatives (A1-A2).

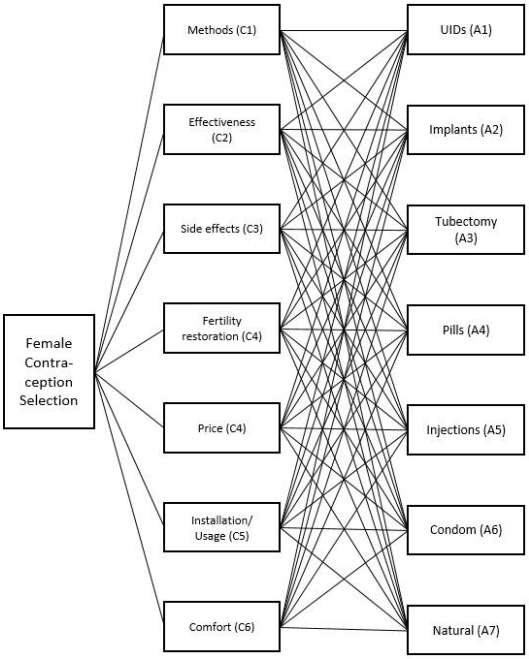

Fig. 2. Hierarchy selection of contraceptive for female.

C. Application Development

Application development begins with designing the application flow process using Bizagi Modeler and prototyping the user interface using Figma. Designed flow process contains four steps. The first step is choosing a gender so the system can determine the appropriate alternative contraceptive method. The second step is reading the provided information about the comparison of each characteristic of the contraceptive alternatives. The third step is personalizing the priority level of each contraceptive characteristic by assigning values from 7 (most significant) to 1 (least significant) according to user's preference. In the next step, the system will calculate according to input from the user and recommend three contraceptives with the highest V value, with their respective characteristics. If the user feels that the recommendation results are not suitable, the user can repeat by re-inputting the priority level of each contraceptive characteristic. Details of the process flow design process for the information system for selecting contraceptives

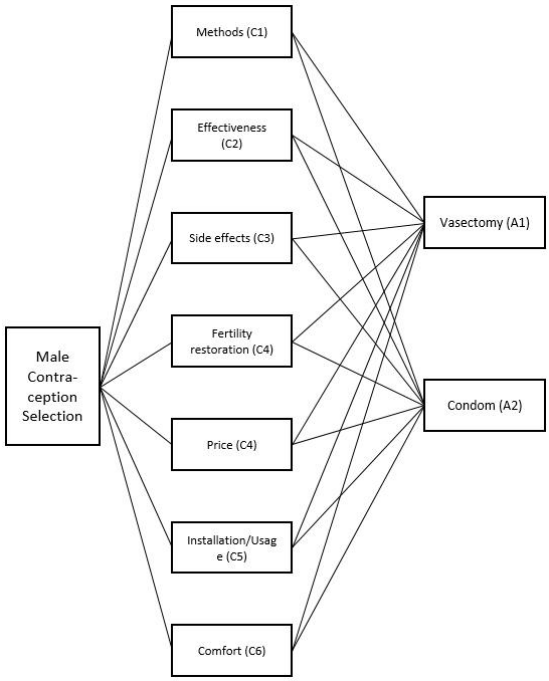

Fig. 3. Hierarchy selection of contraceptive for male.

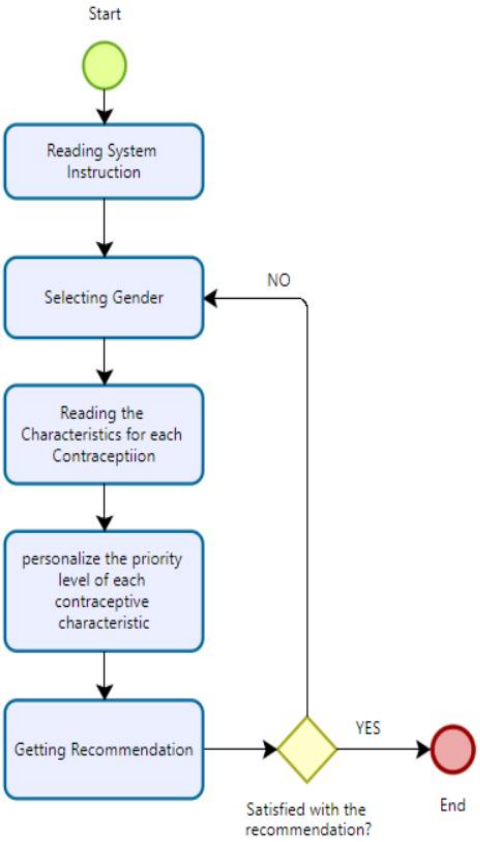

Fig. 4. Process flow design user-personalized contraceptive selection apps.

can be seen in Fig. 4. The flow process results are continued by creating a complete application prototype with connections between pages so that simulations can be carried out.

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The development process is continued with the implementation of the application backend and frontend. The application backend is built using the JavaScript programming language with the NodeJS runtime environment, while the database is created using MySQL. The application frontend is created using CSS and HTML based on the AdminLTE theme. This platform was selected for providing a responsive appearance, making it easier for user to access through their respective device browsers. Mobile phone and Laptop browser access results show perfect page views (Fig. 5 and Fig. 6).

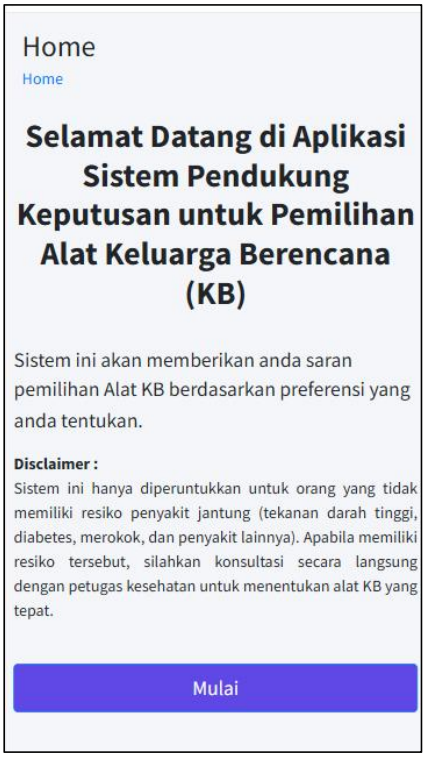

Fig. 5. Landing page of information system for selecting contraception in an android mobile phone browser.

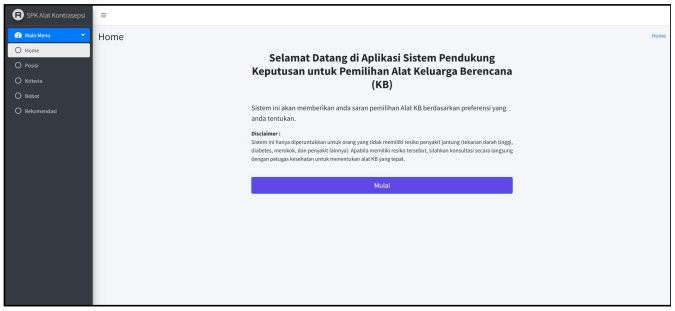

Fig. 6. Landing page of information system for selecting contraception in a windows laptop browser.

D. *System Evaluation*

The first evaluation is black box test with three different techniques. First black box testing technique is graph-based testing. The purpose of this test is to see if the system can display the pages properly and correctly. This test is carried out according to the process flow design in Fig 4. There are 10 test procedures detailed in Table 3.

Table 3.
Graph-Based Testing Procedures and Results

Test Description	Procedure	Expected Result	Result
Testing on start the application.	Select “Mulai’ button on main menu page.	Page switched to gender selection.	Pass
Testing on selecting male user.	Select “Pilih” button a Box “Suami” on gender selection page.	Page switched to list of contraception characteristic.	Pass
Testing on selecting female user.	Select “Pilih” button on Box “Istri” on gender selection page.	Page switched to list of contraception characteristic.	Pass
Testing on viewing the detailed of each contraception characteristics for male.	Select one of “Detail” button on list of contraception characteristic page, Test case: select detail of side effect.	Page switched to detailed side effect of each contraceptive for male.	Pass
Testing on viewing the detailed of each contraception characteristics for female.	Select one of “Detail” button on list of contraception characteristic page, Test case: select detail of Effectiveness.	Page switched to detailed effectiveness of each contraceptive for female.	Pass
Testing on returning to list of characteristics of contraception page.	Select “Kembali ke kriteria” button on detailed criteria of eacl contraception for male page.	Page switched to list of criteria of contraception.	Pass
Testing on return to list of characteristics of contraception page.	Select “Kembali ke kriteria” button on detailed criteria of eacl contraception for female page.	Page switched to list of criteria of contraception.	Pass
Testing on viewing priority level personalisation of each contraceptive characteristic page.	Select “Selanjutnya” button on list of characteristics of contraception page.	Page switched to characteristic priority level personalization page.	Pass
Testing on contraception recommendation.	Select “Cek Rekomendasi” button on characteristic priority level personalization page.	Page switched to list of recommended contraception based on user characteristic priority.	Pass
Repeating the process.	Select “Ulangi” button on list of recommende contraception.	Page switched to the main page.	Pass

Ten test procedures were performed with 100% Pass results. This indicates that the information system for selecting contraceptives successfully displays the correct information on the application page.

The second black box test uses equivalence partitioning technique. This test was conducted on the level priority personalization feature of each contraceptive characteristic, which requires value input from the user. The expected input values are numbers that limited are from 1 to 7. These numbers

are based on amount of characteristic for each contraceptive alternative. There are three test procedures detailed in Table 4.

Table 4.
Equivalence Partitioning Results

Test Description	Procedure	Expected Result	Result
Testing on input right value on the Methods, Effectiveness, Side Effect, Return of fertility, Price, How to use, and Comfort field.	Insert value according to the test case. Test case: insert number 1, 2, 3, 4, 5, 6, 7	Field shows the input value.	Pass
Testing on input out of range value on the Methods, Effectiveness, Side Effect, Return of fertility, Price, How to use, and Comfort field.	Insert value < than 1 and > than 7 according to the test case. Test case: insert number 0, 8, 9, 10	Field does not show the input value.	Fail
Testing on input anything other than number on the Methods, Effectiveness, Side Effect, Return of fertility, Price, How to use, and Comfort field.	Insert alphabet or special character according to the test case. Test case 1: insert aplhabet a, b Test case 2: insert special character %, &	Field does not show the input value.	Pass

The equivalent partitioning technique found one failure when conducting the procedure, namely the limitation of input values in determining the priority of each contraceptive characteristic. The information system for selecting contraceptives should limit the numbers that can be input to only numbers 1 to 7 according to the number of contraceptive characteristics. However, during testing, the system can be filled with larger or smaller numbers. This failure was caused by the system being developed only providing placeholder text, without any input validation. Input value limitation failure on this test can be tolerated because the WP method applies weight normalization (W_J =1) to the value of each characteristic entered by the user. The normalization ensures that numbers are converted to a comparable scale [43].

The last black box test is error guessing technique. This test was conducted to the calculation for recommending contraception alternatives. When the user has determined their priority criteria, the system will calculate using the WP method to recommend alternative contraceptives that have the highest value to the user. The recommendation results that appear by the system are expected to be in accordance with the calculations from WP. There are three types of test procedures detailed in Table 5.

The error guessing technique found one failure when conducting the procedure, namely the error handling when no value was inserted on the characteristic field. The information system for selecting contraceptives should return an error message and not continue the contraceptive calculation and recommendation process. Although there are clear instructions for users to fill in the value on each characteristic priority personalization field, the information system for selecting contraceptives must anticipate user errors that do not enter values into the field by implementing validation. Failure in error handling needs to be fixed because if there are no values inputted on the field on the priority page, the recommended contraceptive will not match the user's personalization.

The second evaluation is usability evaluation. This evaluation involves 25 respondents with the demographic characteristics presented in Table 6. All respondents were using their own devices to access the information system for selecting contraceptives. When conducting the usability test, the respondents were between 25 to 41 years old.

Table 5.
Error Guessing Results

Test Description	Procedure	Expected Result	Result
Testing on error handling.	No value inserted on the field, then press “Cek Rekomendasi” button.	System refuses to proceed to the next step.	Fail
Testing on Calculation male contraception personalized priority.	Insert priority rank value as follow: Methods: 4 Effectiveness: 5 Side Effect: 2 Return of fertility: 6 Price: 7 How to use: 2 Comfort field: 1 then press “Cek Rekomendasi” button.	System shows rank of the contraception alternative as follow: 1. Condom 2. Vasectomy	Pass
Testing on Calculation female contraception personalized priority.	Insert priority rank value as follow: Methods: 3 Effectiveness: 1 Side Effect: 2 Return of fertility: 6 Price: 7 How to use: 4 Comfort: 5 then press “Cek Rekomendasi” button	System shows top three rank of the contraception alternative as follow: 1. Natural 2. Implants 3. Condom	Pass

Table 6.
Respondents Socio-Demographic Characteristics

Demographic Characteristic	Item	Number of Respondent	Percentage
Last Education	Elementary School	3	12
	Junior High School	4	16
	Senior High School	12	48
	College	4	16
	Not stated	2	8
Generation	X	8	32
	Millennials	13	52
	Z	4	16

Respondents were asked to try the information system for selecting contraceptives independently. After getting the results of the contraceptive recommendations, respondents were asked to fill out the questionnaire. The usability results of each measurement aspect can be seen in Table 7.

Table 7.
Usability Results

Aspect	Score	Remark
Efficiency	4.38	Very Good
Effectiveness	4.72	Very Good
Satisfaction	4.59	Very Good
Overall Score	4.52	Very Good

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All aspects scored above 4.5, indicating that the usability level of the information system for selecting contraceptives is very good. In accordance with the demographics of the respondents, this system can be used very well by all educational backgrounds from elementary school to college, and all social generation backgrounds from Generation X to Generation Z. Slightly different from another study that state education and age may result in different level of usability [44].

The efficiency aspect scored 4.38. This means that the contraceptive recommendations for users were successfully obtained with the efforts and abilities of the users themselves, such as using a cell phone to access, an easy-to-understand interface, and ease of using the application. However, there is an item that scored low related to the system error, namely the inconsistency of the recommendations generated by the system. This score is in line with the results of the black box error guessing test that had been carried out previously.

The effectiveness aspect scored 4.72. This means that the system can provide information related to the characteristics of each contraceptive according to what is needed by the user and is able to present contraceptive recommendations according to user preferences very well.

The satisfaction aspect scored 4.59. This means that the expectations and needs of users to get contraceptive recommendations according to their preferences can be met very well by the system. Information about the characteristics of each contraceptive device presented by the application is also considered very satisfying by users.

V. Conclusion

The development of this information system is an effort to present alternative media that can provide information to users about contraceptives that have characteristics according to their preferences. The function of the information system was tested using a blackbox test with a high success rate (88%), confirming its readiness for use while highlighting areas for improvement. The usability of the information system was tested by measuring aspects of efficiency, effectiveness, and satisfaction with very good results (overall score of 4.52 out of 5). This shows that the usability of the information system is at a very good level and can be used by prospective users from various levels of education and generations.

This contraceptive selection information system can be used as an alternative source of information that is easily accessible through the device of prospective contraceptive users. This information system has the potential to be developed by integrating patient medical records and detecting user location so that contraceptive selection can be more accurate. Furthermore, support in various languages can be considered to reach prospective contraceptive users worldwide.

Although the results of the function and usability tests have shown very good results, further studies are needed to determine the rate of conversion of recommendations to the actual selection of contraceptives by users. Conversion rate measurement aims to measure the usefulness of the information system and to find other characteristics possessed by each contraceptive. In addition, further research can also be done by increasing the number of respondents and identifying other socio-demographic aspects.

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