Iraqi Journal of Science, 2025, Vol. 66, No. 9, pp: 3969-3980
DOI: 10.24996/ijs.2025.66.9.35

ISSN: 0067-2904

Enhanced Intelligent System Model for Managing Anxiety in In-Vitro Fertilization (IVF) Patients

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Received: 27/9/2024 Accepted: 14/7/2024 Published: 30/9/2025

Abstract

In vitro fertilization (IVF) program patients have elevated anxiety levels. Therefore, they immediately contact fertility doctors through existing communication media to get treatment. However, fertility doctors cannot respond quickly due to high workloads. The intelligent health system that implements the Case-Based Reasoning (CBR) model is widely used to assist doctors in handling patient complaints. However, the system provides opportunities for modification so that the performance of the CBR model increases and further assists fertility doctors in handling IVF patient anxiety. This study modified the CBR model by integrating several previous research results (CCBR similarity formula, combination of CBR with Rule-Based Reasoning, the role of patient feedback, and the application of a minimum standard value of 80%). Measurement of the coefficient matrix to assess system performance using the Chris Case-Based Reasoning (CCBR) similarity formula produced an accuracy value of 52.58%, and the performance of the combination of the CBR model with the Rule-Based Reasoning model increased the accuracy value by 47.42%, so it can be stated that the CCBR model is a better intelligent system model for handling IVF patient anxiety.

Keywords: CBR, CCBR, Feedback, Intelligent System, IVF Patient.

1. Introduction

The majority of women participating in IVF programs have elevated anxiety levels [1–4], reaching 80% [5]. If the patient feels something different from usual after in-vitro fertilization (IVF), they immediately contact the fertility doctor through communication media [6–9]. The length of time spent receiving treatment affects the anxiety level of IVF patients, and the level of anxiety is a factor that influences the success of the IVF program [3,4]. Currently, fertility doctors have a high workload, which is a factor that affects the length of time involved in IVF patient anxiety [6–9].

Intelligent health systems are widely used to assist doctors in handling patient anxiety [10–13] the Case-Based Reasoning (CBR) model is the model that is commonly used in intelligent health systems [14–16], but the CBR model has several weaknesses [14–21], such as: (1) the accuracy value is low compared to the accuracy value of the CBR mode modification, (2) it does not yet have a standard value to determine the quality of recommendations produced by an intelligent system.

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This research combined the results of the previous three researchers: (1) first research [6,7] which provides evidence that IVF patient feedback as a user of the system has a significant influence on the intelligent system, (2) second research [8,22] which proved that the modification of the CBR similarity formula called the Chris Case-Based Reasoning (CCBR) similarity formula produced good system performance, (3) third research [9,23] proves that combining the CCBR similarity formula with Rule-Based Model Reasoning (RBR) can help doctors improve system recommendations that have a similarity value below the set standard value. The purpose of this study is to improve the performance of the CBR model through several modifications, and the results of the modifications are called the CCBR model. The CCBR model certainly has better performance than the CBR model for intelligent systems in handling IVF patient anxiety.

This paper is structured as follows: Section 1 presents an introduction explaining the background of the research, Section 2 presents the materials and methods used to complete the research, Section 3 explains the research results and presents their discussion, and the conclusions are presented in Section 4.

2. Materials and Methods

The following explains the materials used in the research and the stages to complete it.

2.1 Materials: Previous Research Results

This research uses previously published results to be integrated into a new model. The modified basic model is the result of research from another research team, which is then modified using some of the research results from this research team to create a new model.

2.1.1 Existing Research: A Case-Based Reasoning Model

The CBR model starts the work steps by entering a new problem into the system; hence, the system will choose the old case that is most similar to the new problem to find a solution that will be used to solve the new problem [24,25]. The Case-Based Reasoning (CBR) similarity formula is applied to determine the degree of similarity between a new problem and an existing case. The stages of the CBR model are shown in Figure 1.

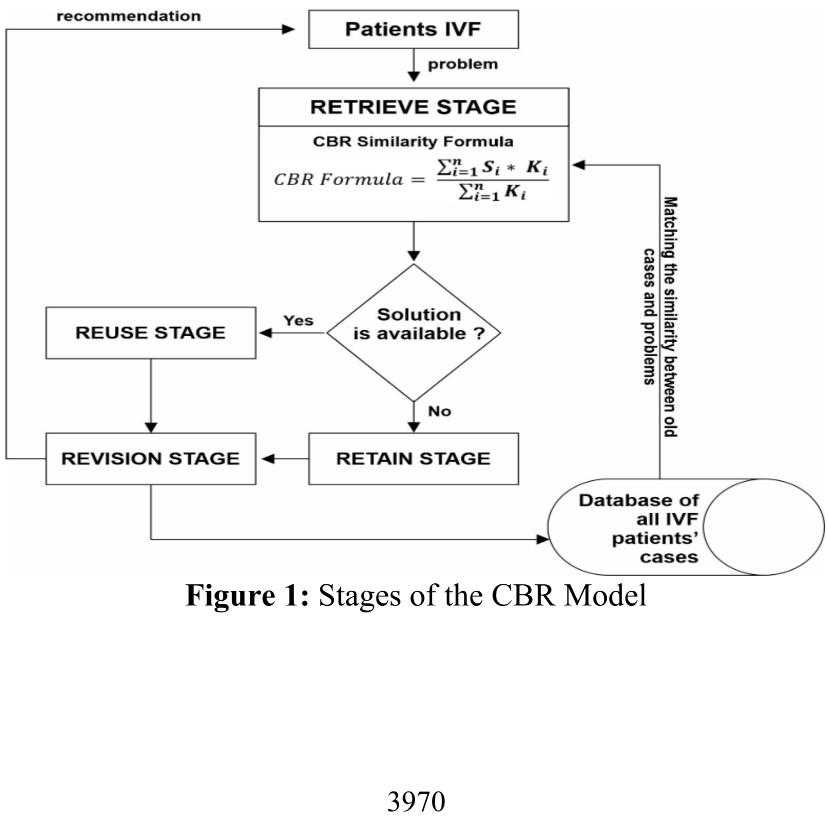

Figure 1: Stages of the CBR Model

The flow of stages contained in the CBR model in Figure 1 is used as the main basis for building a new model, which has several modifications, as was done in the first research and the third research.

2.1.2 First Research: Needs and Effects of Feedback from IVF Program Patients [6,7]

Questionnaires were distributed to IVF patients using Google Forms on October 21–28, 2019 and were responded to by 17 IVF patients. Table 1 contains the results of processing questionnaire data using SPSS software.

Table 1: Test Result

Type of Test	Value	Standard Threshold	Interpretation
Validity Testing	Lowest Pearson correlation coefficient = 0.458	> 0.3	Data is valid, as the correlation exceeds the minimum threshold.
Reliability Testing	Cronbach's alpha = 0.794	≥ 0.6	Data is reliable; the instrument demonstrates acceptable internal consistency.
Normalization Testing	Kolmogorov–Smirnov significance = 0.201	> 0.05	Data is normally distributed.
ANOVA Testing	F = 9.902, significance = 0.007	< 0.05	IVF patient feedback significantly influences the intelligent system.
Regression - Constant	a = -2.945	—	Without IVF patients, the intelligent system yields a negative (non-functional) score.
Regression - Coefficient	b = 0.398	—	Each additional unit of IVF patient feedback increases the system value by 0.398.

Two important facts were obtained:

1- IVF patients are willing to use an intelligent system to deal with their anxiety because they know the high activity of fertility doctors.

2- IVF patient feedback has a significant influence on the intelligent system for handling IVF patient anxiety.

The results of the first research support the results of literature studies, which state that feedback from system users has an important role. These results are the basis for modifying the flow of stages in the CBR model, namely by adding the role of system user feedback as a controller of system output, so that the system continues to perform well.

2.1.3 Second Research: CCBR Similarity Formula [8,22]

The CCBR similarity formula is a modification of the CBR similarity formula. Modifications are made by changing the point of view in calculating the level of similarity. The CBR similarity formula only has one point of view, which is then changed to two points of view: the point of view from the new problem to the old problem, and the point of view from the old problem to the new problem [26].

97 test data points are used to test the performance of two similarity formulas. Validation testing involved two fertility doctors who measured system performance using coefficient metrics. The results are in Table 2 and are evidence that the recommended standard value is at least 80% [27,28]. The test results found that the highest similarity value for the recommendation system, which was stated to be inaccurate by two fertility doctors, was 79.7%.

Table 2 : Comparison of the Performance

Types	Validation Testing	
	Valid	Invalid
CBR similarity formula	26.70%	73.30%
CCBR similarity formula	100%	0%

The results in Table 2 provide evidence that the CCBR similarity formula is the right formula to be applied to an intelligent system for handling the anxiety of IVF patients. The results of the second research were used to replace the CBR similarity formula contained in the CBR model's retrieval stage, so that the performance of this model was better.

2.1.4 Third Research: Combination of CBR Model with RBR Model [9,23]

In the CBR model, if the system recommendation similarity value is <80%, then the fertility doctor must improve and validate the system recommendation. However, the high activity of fertility doctors is a factor that slows down the improvement and validation process, resulting in IVF patients who have to wait, and the long wait can increase the anxiety level of IVF patients.

Based on the results of performance measurement using the Confusion Matrix as shown in Table 3, it turns out that the combination of the CBR model (using the CCBR similarity formula) with the RBR model is proven to increase the accuracy value of recommendations that have a similarity value of <80%, so it can help fertility doctors handle the repair and validation process at the revision stage.

Table 3" Improved System Performance

Model Combination	Performance Improvement	
	Improved Accuracy	Improved Precision
The CBR similarity formula + the RBR model	4%	7%
The CCBR similarity formula + the RBR model	47%	0% (The precision value produced in the results of the second research [8] is 100%)

The results of the third research improved the performance of the model because the combination of the CBR and RBR models was proven to help very busy fertility doctors, namely by delaying the involvement of fertility doctors in improving solutions, when the CBR model cannot produce accurate solutions. The ability to process IVF patient complaints and provide treatment recommendations is compromised, because RBR adopts the logic of fertility doctors in handling IVF patient complaints.

2.2 Methods

The current research is a combination of three research results that researchers have published [6–9,22,23]. Each existing research result (from the 1st research result to the 3rd research result) makes an important contribution to the modification of the CBR model (it is the result of existing research), so this research produces a new intelligent system model, called the Chris Case-Based Reasoning (CCBR) model. The research stages are shown in Figure 2:

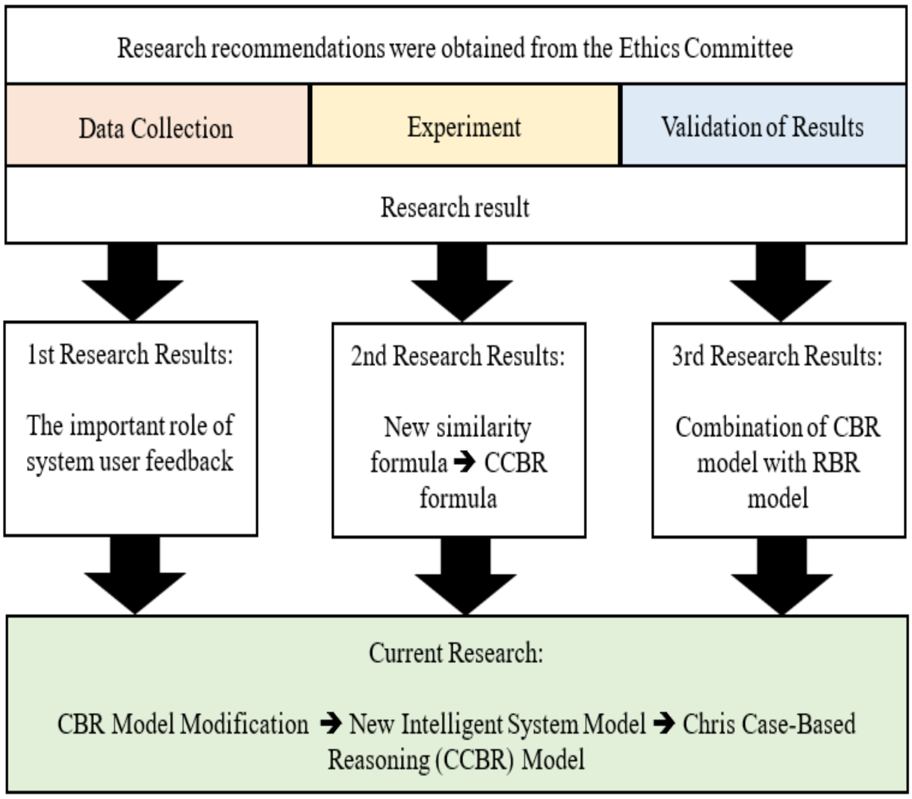

Figure 2: Research Stages

3. Results and Discussion

Here are some facts obtained from previous research results, which were then used as a basis for modifying the old model and strengthening the performance of the new model.

3.1 Result

Based on the results of previous research, several modifications were made to the CBR model, as follows:

1- To calculate the similarity value between the new and old cases, the CCBR similarity formula is used [8,22].

2- The minimum eligibility value standard is 80% [6–8,22]. If a system recommendation has a similarity value of <80%, then it does not immediately enter the revision stage but will be processed first using the RBR model.

3- The RBR model uses the logic flow from the results of previous studies [9,23], or refers to Table 4. If the RBR model does not find a solution, then the problem-solving is handled by a fertility doctor [9,23].

4- Feedback on IVF patients is given using a Likert scale divided into 5 criteria: very good, good, fair, not good, and very poor. Based on the interpretation of the feedback assessment, feedback with the criteria of very good and good has a minimum eligibility value of 80%. However, the criteria of enough, poor, and very bad have a feasibility value of <80% [29].

5- If the feedback has a feasibility value of <80%, then the system recommendations that have been given to IVF patients are immediately re-examined by the fertility doctor, and the results are informed to IVF patients.

The modified result is shown in Figure 3.

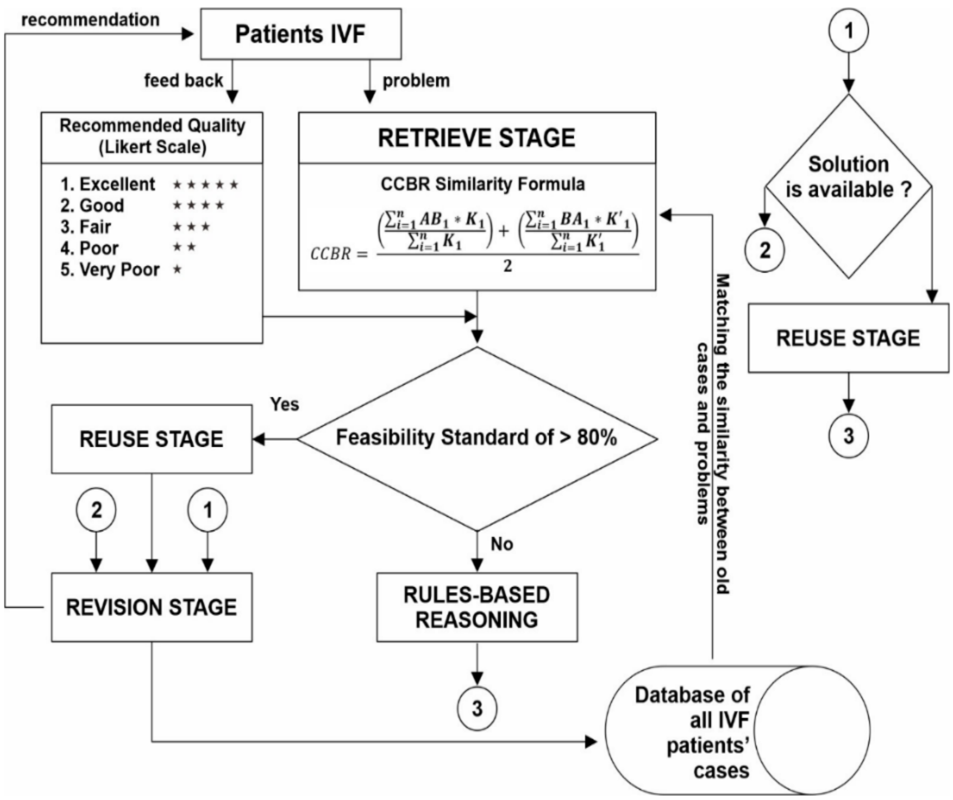

Figure 3 : CCBR models

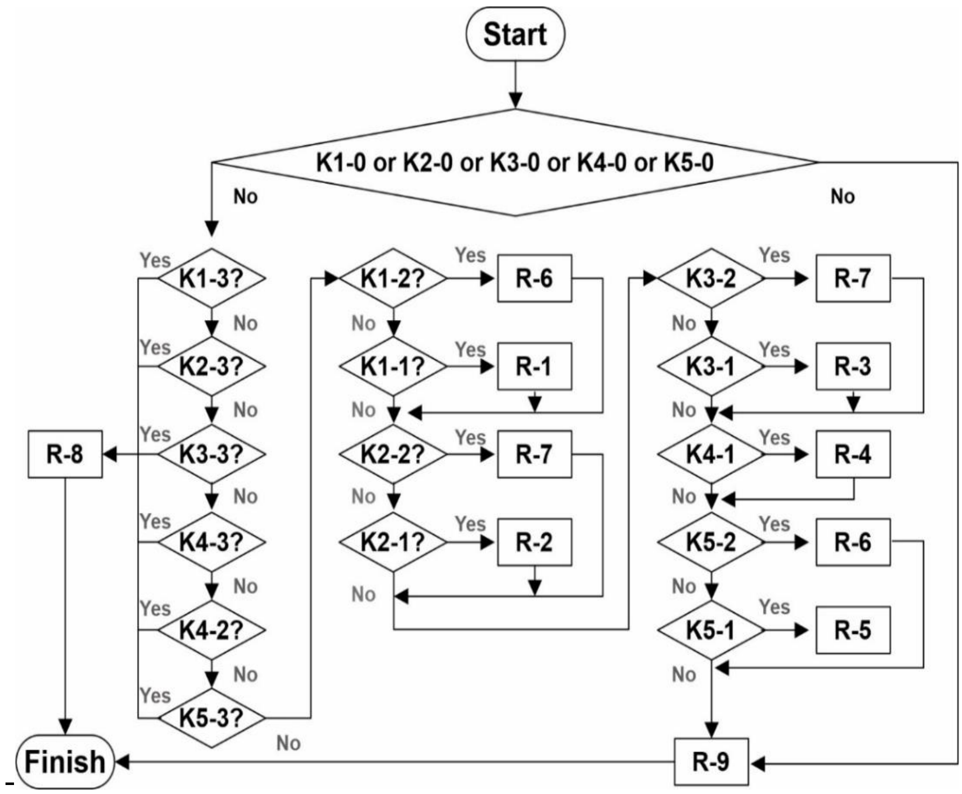

Figure 4 :RBR model flowchart

The codes contained in Figure 4 are explained in Table 4.

Table 4: Explanation of the code in the RBR flowchart

Type	Level		Handling	
Bleeding Per Vagina	Normal	K 1-0	No recommendations.	R-9
	Low	K 1-1	24-hour observation, IVF patients continue the treatment that the fertility doctor has given and get enough rest, if they do not improve or increase, then IVF patients immediately plan to go to the outpatient care (OPC).	R-1
	Medium	K 1-2	The IVF patient immediately plans to go to the OPC.	R-6
	High	K 1-3	IVF patients are immediately taken to the emergency room (ER).	R-8
Suprapubic Pain	Normal	K 2-0	No recommendations.	R-9
	Low	K 2-1	24-hour observation, IVF patients continue the treatment that the fertility doctor has given and get enough rest, if they do not improve or increase, then IVF patients immediately plan to go to the OPC.	R-2
	Medium	K 2-2	IVF patients immediately take paracetamol and plan to go to the OPC.	R-7
	High	K 2-3	IVF patients are immediately taken to the ER.	R-8
Fever	Normal	K 3-0	No recommendations.	R-9
	Low	K 3-1	24-hour observation, IVF patients continue the treatment that the fertility doctor has given and keep drinking a lot, if it does not subside or increase, IVF patients immediately plan to go to the OPC.	R-3
	Medium	K 3-2	IVF patients immediately take paracetamol and plan to go to the OPC.	R-7
	High	K 3-3	IVF patients are immediately taken to the ER.	R-8
Nausea and Vomiting	Normal	K 4-0	No recommendations.	R-9
	Low	K 4-1	24-hour observation, IVF patients continue the treatment that the fertility doctor has given, routinely measure the abdominal circumference, and reduce anxiety; if it does not subside or increase, then IVF patients immediately go to the ER.	R-4
	Medium	K 4-2	IVF patients are immediately taken to the ER.	R-8
	High	K 4-3	IVF patients are immediately taken to the ER. IVF patients are immediately taken to the ER.	R-8
Sleeping Difficulty	Normal	K 5-0	No recommendations.	R-9
	Low	K 5-1	24-hour observation, IVF patients continue the treatment that the fertility doctor has given, keep enough to eat and drink, keep normal activities, and reduce anxiety; if it does not subside or increase, IVF patients immediately plan to go to the OPC.	R-5
	Medium	K 5-2	The IVF patient immediately plans to go to the OPC.	R-6
	High	K 5-3	IVF patients are immediately taken to the ER.	R-8

One approach that can be applied in a clinical decision support system is Chris Case-Based Reasoning (CCBR), as shown in Figure 3. This approach is based on the principle of learning from previous experiences to solve similar problems in the present. Here are the stages based on case similarity.

1. System Stages: From Problem to Solution

The process begins when an IVF patient faces a clinical problem. The system receives this input and identifies it as a new case. The first step is the Retrieve stage, where the system will search for and compare the new case with old cases that have been stored in the database.

At this stage, the CCBR Similarity Formula is used, which calculates the level of similarity based on two main variables: new case attributes and previous solution attributes. The similarity results from each variable are then averaged to obtain the final similarity value. If the similarity value exceeds the feasibility limit of 80%, the system proceeds to the Reuse stage.

2. Utilization of Old and Revised Solutions

At the Reuse stage, the solution from the most similar previous case will be applied to the new case. However, the system does not stop there. Once the solution is implemented, the patient will provide feedback on the quality of the recommendations received, using a Likert scale ranging from Excellent to Very Poor. If the solution is considered suboptimal, the system will enter the Revision stage, where the solution that has been used is improved and adjusted.

3. Rule-Based Approach if Not Eligible

If the similarity level is less than the eligibility standard (≤ 80%), the system does not force the use of the old solution. Instead, the system will activate the Rules-Based Reasoning approach as shown in Figure 4 and Table 4, namely a rule-based reasoning system to formulate a more appropriate solution. This ensures that the recommendations provided remain relevant even though there have been no similar cases before.

4. Continuous Learning through Feedback

One of the strengths of this system is its ability to continue learning. Every new case, the solution used, and feedback from patients will be stored in the Database of IVF Patients' Cases. That way, the accuracy and effectiveness of the system will increase over time, in line with the increasing number of case references and empirical data.

Based on the data in Figure 3, Figure 4, and Table 4, the algorithm is compiled in pseudocode form as follows:

```
INPUT:
  - new_cases     : symptom and level data from new IVF patients
  - old_cases           : old case collection (CBR basis)
  - feedback_patient      : Patient response after receiving recommendations (Likert Scale)
                            → [Very Good, Good, Fair, Not Good, Very Poor]

PROSES:
1. Calculate Similarity Value (CCBR)
   For each old_cases in cases_basis
      sim1         = similarity (new_cases → old_cases)
      sim2         = similarity (old_cases → new_cases)
      sim_avg      = (sim1 + sim2) / 2
      saved sim_avg into the list_similarity

take the old case with the highest sim_avg
similarity_highest = maximum value from list_similarity

2. Check Similarity Value
IF similarity_highest ≥ 80 THEN
initial recommendation ← solution of the most similar old case
recommended_source ← "CCBR"
ELSE
  // Use RBR logic (Rule-Based Reasoning)
 initial recommendation ← RBR RULES(new case, using the logic flow in figure 4)
 recommended_source ← "RBR"
```

3. Check Patient Feedback
IF feedback_patient = ["Fair", "Not Good", "Very Poor"] THEN
status_feedback ← "RECOMMENDATION ACCEPTED"
ELSE
status_feedback ← "RECOMMENDATION REVIEWED BY DOCTOR"

4. Output
Print "Similarity Score:", highest_similarity
Print "Recommendation:", initial_recommendation
Print "Recommendation Source:", recommendation_source
Print "Feedback Status:", feedback_status

3.2 Discussion

Experimental data were collected from 2 hospitals providing IVF program services, located in Central Java Province and Yogyakarta Province. The data collected were 256 patient data points along with complaints and their treatment (not accompanied by patient personal data). The limited number of patient data collected was because not all hospitals had IVF program services and were willing to open their patient data. Of the 256 data points, for the experiment, it was divided into 2 groups, namely 159 data points as training data and 97 data points as test data. Fertility doctors validated the experimental results, and then performance measurements were carried out using the Confusion Matrix. The results are in Table 5.

Table 5: Experiment Results

Test Models	Test Model Description	Accuracy Value	Precision Value
Model 1	CBR model with CBR similarity formula	19.59%	16.85%
Model 2	CBR model with CCBR similarity formula	52.58%	100%
Model 3	Combination Model 1 with RBR model	23.59%	23.85%
Model 4	Combination Model 2 with RBR model	100%	100%

The most significant performance increase was seen in the model that combined the CBR model (using the CCBR similarity formula) with the RBR model, which resulted in an increase in accuracy values of 47.42% with a precision value of 100%. This significant performance improvement was caused by the RBR model, which effectively adopted the work pattern of fertility doctors in dealing with IVF patient anxiety, so that all system recommendations whose similarity value was <80% were corrected accurately. These findings show that the CCBR model is very suitable for intelligent systems designed to handle IVF patient anxiety, and can support the performance of busy fertility doctors in still being able to provide treatment recommendations for IVF patient anxiety. To keep the quality of recommendations high, feedback from IVF patients is used as a quality control tool. Based on the interpretation of the value, the feedback with the criteria of excellent and good stated that IVF patients were satisfied with the system recommendations obtained. However, the fair, poor, and very poor criteria state that IVF patients are dissatisfied, so the system recommendations must be checked immediately by a fertility doctor, and the results are communicated to IVF patients. [30].

4. Conclusions

By using several previous research results, namely on the novelty produced (CCBR formula, combination of CBR with RBR, the role of system user feedback and determination of minimum standard values to determine information quality), and the impact of novelty in the form of increased intelligent system performance, modifications were made to the CBR model to improve the performance of the model, which was then named the CCBR model. The CCBR model can help busy fertility doctors answer anxious questions from IVF patients, thereby reducing the anxiety levels of IVF patients and increasing the chances of success of the IVF program. The researcher realized that because there was a limitation in the amount of data, the CCBR model needed further research with more data and different coverage, so that the performance of the CCBR model could be further tested.

Acknowledgment

The author thanks Dr. Doddy Sutanto, M.Kes, SpOG(K)Fer, who provided many research inputs.

Authors' Declaration

- Researchers have no conflict of interest in the research results.
- All the tables and figures used in this manuscript are the researcher's work.
- Research recommendations were obtained from the Faculty of Health Ethics Committee, the University of Pekalongan, and the Duta Wacana Christian University.

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