

Integration of local wisdom and modern medicine in a treatment recommendation system for toddlers based on the Case-Based Reasoning-Fuzzy Method

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Abstract: This study aims to develop a treatment recommendation system for toddlers based on Case-Based Reasoning (CBR) combined with Fuzzy Logic, by integrating modern medical knowledge and local wisdom. The system was developed to address the need for adaptive initial diagnosis recommendations, particularly in addressing ambiguous symptoms. At the case representation stage, disease, symptom, and drug data from medical and traditional perspectives are used as the knowledge base. The CBR process serves as the primary mechanism for searching for similar cases, while fuzzy logic is used at the revision stage to provide degrees of symptom intensity so that the diagnosis results are more flexible. System evaluation was conducted through blackbox testing, accuracy measurements, and the System Usability Scale (SUS) method involving 50 respondents. The results showed that all system functions ran as planned, the accuracy level reached 88%, and the average SUS score was 78.4 in the Good Usability category, indicating the system is easy to use and user-acceptable. This study proves that the CBR-Fuzzy integration is effective in providing accurate, adaptive, and culturally relevant initial diagnosis recommendations. For further research, it is recommended to expand the case base, refine fuzzy rules, develop a broader interface, and implement the system on a mobile platform to improve accuracy, ease of access, and wider user acceptance.

Keywords: Case-Based Reasoning, Fuzzy Logic, Local Wisdom, Toddler Treatment, Recommendation System, Usability

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Introduction

Toddlers are an age group that is highly susceptible to various diseases due to their immune systems still developing [1]. This situation is further complicated in Indonesia, which is geographically located in a tropical region with a diversity of disease-causing microorganisms [2]. This condition causes toddlers to often suffer from various diseases, including pneumonia, acute respiratory infections (ARI), diarrhea, measles, fever, skin diseases, and influenza [3], [4], [5], [6], [7], [8], [9]. According to UNICEF, diseases such as diarrhea, pneumonia, and malaria are the main causes of infant mortality worldwide, contributing around 29% of the total death rate [10]. In Indonesia, pneumonia even causes the highest medical costs, reaching 8.7 trillion rupiah per year [9].

Apart from the high prevalence of disease, another major challenge is the limited access of people to modern health services, especially in rural areas and 3T (outermost, frontier, and disadvantaged) regions [11]. This condition encourages some people to utilize traditional medicine based on local wisdom [12]. Traditional healing practices have important cultural and historical value, but many of the methods used have not been scientifically verified, thus posing clinical risks [13], [14]. As a result, there is a gap between traditional medicine and modern medicine, both in terms of effectiveness and safety [13]. This shows that there is an urgent need

to present innovations that are able to systematically integrate the advantages of traditional medicine with modern medicine.

As technology advances, artificial intelligence (AI) is increasingly being used in healthcare to support diagnosis and treatment recommendations. The Case-Based Reasoning (CBR) method is considered relevant because it can provide solutions based on similar cases that have occurred previously [15], [16]. Meanwhile, Fuzzy Logic is effective in handling uncertain or ambiguous data, such as subjective symptoms [17], [18]. The combination of these two methods is considered capable of providing a system that is accurate but remains flexible.

Various previous studies have discussed expert systems and AI-based applications for toddler health. For example, Ananda et al. developed a toddler disease diagnosis system using fuzzy logic and forward chaining to facilitate self-diagnosis [18]. Alam et al. developed a system for diagnosing malnutrition in toddlers using the CBR method [15]. Meanwhile, Arundy and Mardiani implemented CBR to detect heart disease [16]. Numan et al. also developed a system for diagnosing pneumonia in children [17], and Umami and Wibisono designed an application for early detection of toddler diseases [2].

Christian and Winarsih created an application for processing toddler data [19]. Meanwhile, Ulum Fajar et al. developed a screening application for hearing disorders [20]. Some studies apply other algorithms, such as Kharisa et al. [21] who used the weighted Sörrensen algorithm and Nasri et al. [22] who developed the diagnosis of infant illness using the Dempster-Shafer method. On the other hand, Marques et al. discussed the use of traditional medicine [20], Anggresani et al. analyzed the use of traditional and modern medicines in self-medication [21], Ningrum & Purnamasari research the benefits of medicinal plants for maternal and child health [23], and Azizah & Kurniati developed research on traditional medicine to relieve coughs and colds in toddlers [24].

Previous research on intelligent systems for diagnosing childhood illnesses has generally used Case-Based Reasoning (CBR) or Fuzzy Logic methods separately, with only a few combining the two. Even then, these methods are limited to modern medical approaches without considering traditional healing practices widely used by the community. This research offers a more comprehensive approach by integrating CBR and Fuzzy Logic with modern medical knowledge and verified local wisdom, enabling the system to provide initial diagnoses and treatment recommendations that are more accurate, adaptive, and culturally relevant. This system is supported by a structured case base containing diseases, symptoms, and medical and traditional solutions, as well as a fuzzy-based revision mechanism to handle symptom ambiguity. Thus, this research contributes to the development of more contextual and applicable health recommendation systems. The main objective of this research is to develop a treatment recommendation system for toddlers that integrates modern medical data and local wisdom within a single artificial intelligence framework to produce more precise and tailored diagnoses and treatment recommendations tailored to the community's conditions. This study used data consisting of four main components: disease data, symptom data, treatment data (modern and traditional), and a collection of cases (case base) which is the core of the Case-Based Reasoning (CBR) process. Overall, there are 10 types of toddler diseases, 20 main symptoms, 25 medical solutions, and 18 treatment solutions based on local wisdom that are used as a knowledge base. From the total data, 95 structured cases were created consisting of 50 cases based on medical data, 30 cases based on local medical practices, and 15 cases resulting from integration through verification by local pediatricians and herbalists. In the evaluation stage, 50 test case scenarios were used to measure the accuracy of the system and its conformity with expert diagnoses.

Methodology

This research is an applied research approach using computational intelligence. The primary method used is Case-Based Reasoning (CBR) to generate solutions based on previous cases, complemented by fuzzy logic as a revision mechanism to address the uncertainty of toddler symptoms. The stages of this research are shown in [Figure 1](#).

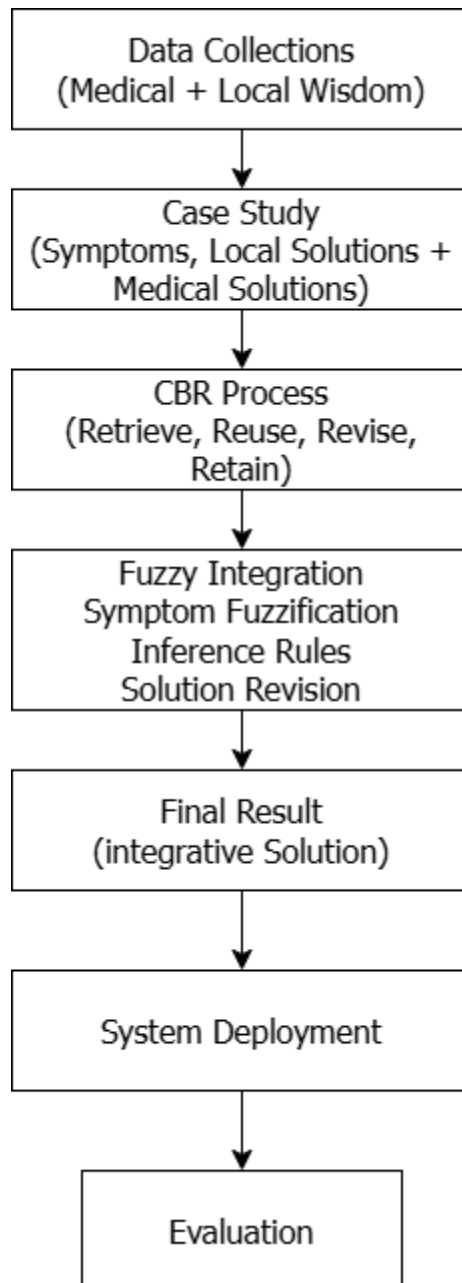


Figure 1. Research stages

Figure 1 shows the research stages carried out in this study, starting from data collection, case representation, CBR process, integration with fuzzy, obtaining integration results, system development to evaluation.

1. Data Collection

At this stage, medical data related to this research is collected, such as disease data, symptom data, medical treatment data and also local wisdom treatment data.

2. Case Study

After modern medical data and local wisdom have been successfully collected, the next step is to build a uniform case representation for use in the Case-Based Reasoning system. Each case consists of several important attributes that represent the toddler's condition, such as body temperature, cough, diarrhea, appetite, and other relevant medical history. Each of these attributes is arranged in the form of a case vector, where each vector contains a combination of attribute values and the treatment solution provided, either in the form of modern medical therapy or treatment based on local wisdom. The equation used in the case representation can be seen in Equation (1) [25].

$$C_i = \{a_1, a_2, \dots, a_n, S\} \tag{1}$$

a_j = j-th attribute value (e.g. temperature, cough, diarrhea, appetite)

S = treatment solution (local + medical combination)

3. CBR Mechanism

The next stage is the application of the Case-Based Reasoning (CBR) method, which serves as the primary mechanism in the recommendation system. Generally, CBR works through four stages: Retrieve, Reuse, Revise, and Retain. In the Retrieve stage, the system calculates the similarity level between new cases and a collection of old cases in the database. The equation used to calculate the similarity value is the Nearest Neighbor Similarity method, which is written as [26]:

$$Sim(Q, C_i) = \frac{\sum_{j=1}^n w_j \times sim(q_j, c_{ij})}{\sum_{j=1}^n w_j} \tag{2}$$

Where Q is a new query or case, C_i is an old case, q_j and c_{ij} is the value of the j-th attribute of each case, and w_j is the attribute weight. For numeric attributes, the similarity calculation is performed using Equation (3).

$$Sim(q_j, c_{ij}) = 1 - \frac{|q_j - c_{ij}|}{Range_j} \tag{3}$$

For categorical attributes, similarity is assigned a value of 1 if the cases are the same and 0 if they are different. The Reuse stage then selects the initial solution based on the case with the highest similarity level. The Revise stage is enhanced with fuzzy logic to address uncertainty, while the Retain stage stores the new case and the revised solution in the knowledge base.

4. Fuzzy Integration

The revision stage in CBR is enriched with fuzzy logic integration, particularly to handle continuous or ambiguous attributes, such as toddler body temperature, cough, and others. Each incoming numeric value is mapped to a membership function (fuzzification). The equation used can be seen in Equation (4) [27].

$$\mu_{tri}(x; a, b, c) = \begin{cases} 0, & x \leq a \text{ or } x \geq c \\ \frac{x - a}{x - b}, & a < x < b \\ \frac{c - x}{c - b}, & b < x < c \end{cases} \tag{4}$$

Information:

x : Input Value

a = starting point (starting from 0)

b = peak point (value $\mu=1 \rightarrow$ meaning 100% membership)

c = end point (value drops back to 0)

The fuzzification results are then processed with inference rules. Examples of rules used are: "If the fever is moderate and the cough is present, then the solution is herbal medicine + compress + monitor hydration," or "If the fever is high and the diarrhea is present, then the solution is medical medication + oral rehydration salts + medical referral." In this way, fuzzy logic can provide finer adjustments to the initial solution obtained from CBR.

5. Final Result

The system's output is a treatment recommendation that combines previous case experience and fuzzy logic-based adjustments. For example, if the system receives input of symptoms of a toddler with a body temperature of 38 °C, cough = yes, and diarrhea = no, then in the CBR stage the system will find the case most similar to the initial solution of herbal medicine + compress. Next, fuzzy logic detects that the temperature of 38 °C is in the "moderate" category with a membership value of 0.67, so the inference rule adds a hydration monitoring

factor to the practice suggestion. Thus, the final recommendation given by the system is herbal medicine + compress + hydration monitoring.

6. System Deployment

At this stage, system development is carried out to implement a recommendation system developed using a combination of CBR and Fuzzy Logic methods. The developed system has two types of users, each with their own functional needs. These users and their functional needs are depicted in the use case diagram shown in Figure 2.

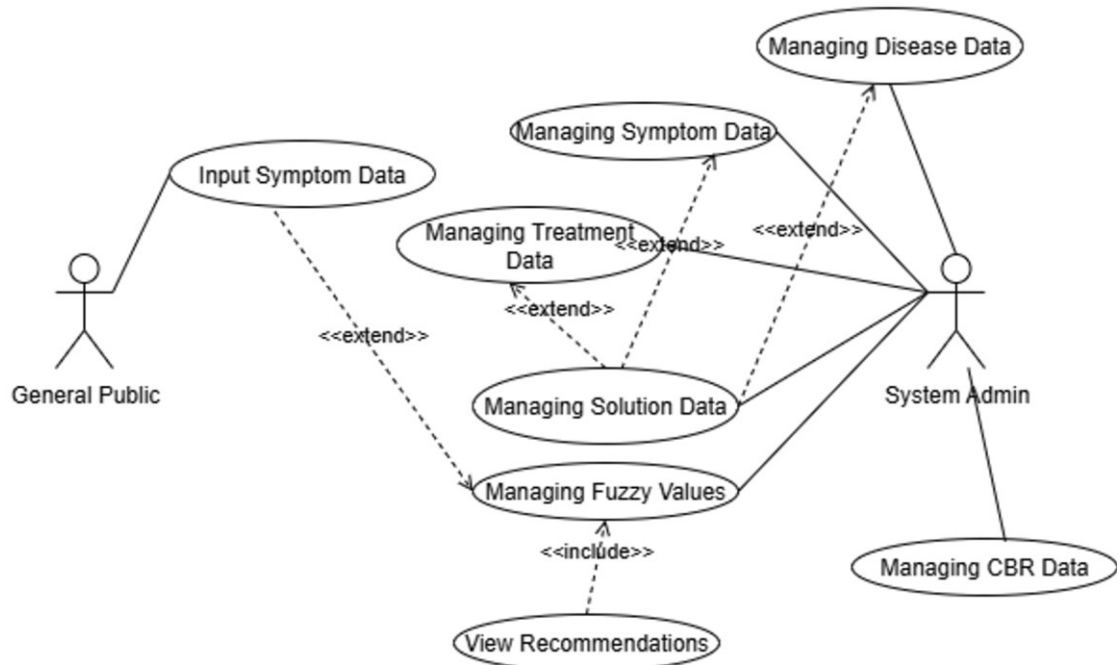


Figure 2. Use case diagram

Figure 2 shows the use case diagram used in the development of this system. The figure shows eight use cases. These use cases identify data requirements that can be used as a reference in developing the system's database. The resulting database design can be seen in Figure 3.

Table 1. Disease data

No	Code	Disease	Information
1	P008	Asthma	A respiratory tract infection that causes difficulty breathing.
2	P004	Coughs and Colds	An upper respiratory tract infection that usually heals on its own.
3	P013	Chickenpox	A varicella-zoster virus infection that causes a skin rash and fever.
4	P012	Measles	A contagious disease characterized by fever, cough, runny nose, and a rash all over the body.
5	P001	Dengue Fever	A disease caused by the dengue virus through the bite of the Aedes aegypti mosquito.
6	P006	Diabetes Mellitus	A chronic metabolic disease that requires treatment and blood sugar control.
7	P011	Singapore Flu	A viral infection that affects children, accompanied by a rash and mouth ulcers.
8	P010	Gastritis	Inflammation of the stomach lining, often called an ulcer.
9	P007	Hypertension	High blood pressure that requires ongoing medical treatment.
10	P002	Malaria	A parasitic disease transmitted through the bite of the Anopheles mosquito.

Table 1 shows some examples of disease data used in this study. In addition to disease data, there is also symptom data. Examples can be seen in Table 2.

Table 2. Symptoms data

No	Code	Symptoms	Fuzzy Value	Fuzzy Status
1	G01	High fever ($\geq 38^{\circ}\text{C}$)	0.90	Very Important
2	G02	Cough with phlegm	0.70	Important
3	G03	Shortness of breath	0.80	Very Important
4	G04	Diarrhea ($> 3\text{x/day}$)	0.75	Important
5	G05	Repeated vomiting	0.70	Important
6	G06	Skin rash	0.65	Important
7	G07	Nasal congestion	0.50	Moderate
8	G08	Sore throat	0.60	Important
9	G09	Decreased appetite	0.55	Moderate

Table 2 shows some examples of symptoms discussed in this study. In addition to symptom data, treatments, both medical and traditional, are also listed. Examples can be seen in Table 3.

Table 3. Treatment

No	Code	Drug	Type
1	BH009	Young Coconut Water	Traditional
2	OBT009	Amlodipine	Medical
3	OBT002	Amoxicillin	Medical
4	OBT005	Cetirizine	Medical
5	BH006	Guava Leaves	Traditional
6	BH007	Papaya Leaves	Traditional
7	BH005	Betel Leaves	Traditional
8	OBT003	Ibuprofen	Medical
9	BH001	Ginger	Traditional
10	BH004	Ginger	Traditional

Table 3 shows examples of treatment data and Table 4 shows examples of treatment solution data used in this study.

Table 4. Solutions

Disease	Solution Type	Solution (Summary)	Content	Trust Level	Related Drugs	Status
Dengue Fever (P001)	Medical	1. Give paracetamol for fever 2. Ensure adequate fluid intake 3. Get enough rest 4. If shortness of breath consult a doctor		90.0% (Very High)	Paracetamol, ORS	Very Effective
Dengue Fever (P001)	Traditional	1. Drink young coconut water 2. Guava juice to increase platelets 3. Warm chicken soup 4. Get enough rest		60.0% (High)	Young Coconut Water, Papaya Leaves	Effective
Malaria (P002)	Medical	1. Antimalarial medication according to doctor's prescription 2. Get enough rest 3. Drink plenty of water		95.0% (Very High)	Paracetamol, Amoxicillin	Very Effective
Malaria (P002)	Traditional	1. Drink boiled papaya leaf water 2. Fresh fruit juice 3. Warm nutritious soup 4. Body compress		50.0% (Moderate)	Papaya Leaves	Fairly Effective
Typhus (P003)	Medical	1. Antibiotics as prescribed by the doctor 2. Soft diet that is easy to digest 3. Complete rest 4. Monitor body temperature		90.0% (Very High)	Amoxicillin, Paracetamol	Very Effective
Typhus (P003)	Traditional	1. Warm chicken soup 2. Turmeric boiled water 3. Bananas to bind stool 4. Get enough rest		40.0% (Moderate)	Turmeric	Fairly Effective

Table 4 shows examples of treatment solutions used in this study.

Case Representation

In this study, each case is represented as a knowledge package consisting of the disease identity, associated symptoms, and solution content in the form of modern medical treatments or treatments based on local/traditional wisdom. Case representation is used as the primary knowledge base in the Case-Based Reasoning (CBR) method. An example can be seen in [Table 4](#).

CBR Mechanism

The Case-Based Reasoning (CBR) method works by mimicking human thought patterns, using past experiences (old cases) to solve new problems (new cases). In this study, CBR was used to generate treatment recommendations for toddlers by referring to a case database containing information on the disease, symptoms, medical and traditional solutions, related medications, and the solution's level of confidence. An example is shown below:

1. Retrieve: The system calculates the similarity of the query with the cases of Dengue Fever (P001) and Malaria (P002). Results:
 - a. $\text{Sim}(\text{Query}, \text{Dengue Fever}) = 0.85$
 - b. $\text{Sim}(\text{Query}, \text{Malaria}) = 0.70$

The most similar case is Dengue Fever (0.85).
2. Reuse: Initial solution → *Paracetamol, Oralit, Get enough rest (Medical, 90% confidence)*.
3. Revise: Fuzzy detects temperature 38.5°C → moderate–high category with membership 0.6. Fuzzy rule: IF (moderate–high fever) AND (cough=yes) → add "Monitor hydration + warm compress". Revised solution → Paracetamol + ORS + Rest + Warm compress + Monitor hydration.
4. Retain: This new case is saved to the case base with the revised solution.

Fuzzy Integration and Final Results

This stage involves entering a new case in the form of symptoms experienced by toddlers, namely high fever ($\geq 38^\circ\text{C}$), diarrhea more than 3 times per day, and decreased appetite. After selecting the symptoms, the user is asked to determine the intensity level of each symptom. The results of the fuzzy intensity input from the user are: high fever = 0.7; diarrhea = 0.5; decreased appetite = 0.6. These values are then processed in the fuzzification stage, so that each symptom is not only expressed binary (present/absent), but with a certain degree of membership in the medium or high category.

The system calculates similarity with the case base through the CBR mechanism. The case with the highest similarity level is Typhus (P003) with a similarity value of 0.78 or 78.3%, while Dengue Fever and Malaria cases have lower similarity values. Based on these results, the system takes the initial solution for Typhus disease contained in the case base, in the form of medical recommendations (antibiotics, paracetamol, soft diet, adequate rest) and traditional recommendations (warm chicken soup, turmeric boiled water, bananas). The revision stage is then carried out using fuzzy integration. Fuzzification applied to a value of 0.7 for high fever places the toddler's condition in the medium-high group, while diarrhea with a value of 0.5 and decreased appetite with a value of 0.6 are categorized as moderate. The active fuzzy rules are:

1. If the fever is moderate and the diarrhea is moderate, the system adds a suggestion to monitor hydration and apply warm compresses.
2. If the appetite decreases moderately, the system adds a solution to provide nutritious soft foods to support the diet.
3. If the fever is approaching high, then medical solutions are given greater priority weight.

The final result was a diagnosis of typhus with a 78.3% confidence level (high). Solutions were divided into two categories: medical solutions with a 90% confidence level (very effective) and traditional solutions with a 40% confidence level (fairly effective).

Details of the recommendations provided include:

- a. Medical Solution: use of Paracetamol as a fever-reducing drug (dose 10–15 mg/kgBW every 4–6 hours), Amoxicillin as the main antibiotic (dose 20–40 mg/kgBW/day in 2–3 doses), accompanied by complete rest and a soft diet.

- b. Traditional Solution: consume warm chicken soup, boiled turmeric water (1–2 cm of rhizome boiled per glass of water), and consume bananas to bind stool.

System Development

At this stage, the recommendation system is developed. Several system displays can be seen in the following image:

Choose the Symptoms Experienced

Instructions:
Choose all the symptoms experienced by toddlers. The more complete the information given, the more accurate the recommendation will be given.

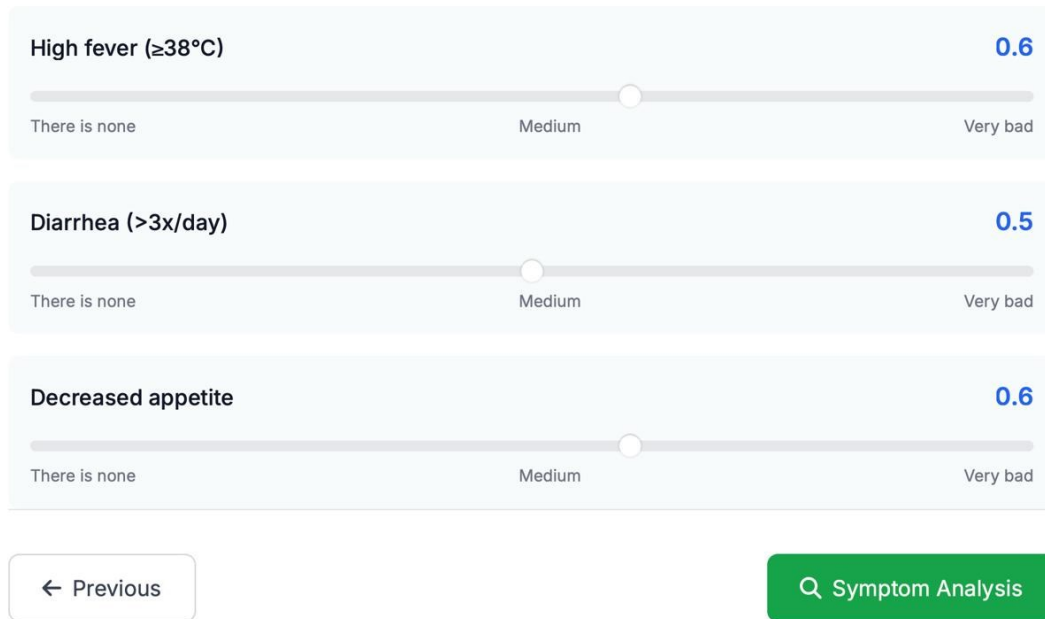
<input checked="" type="checkbox"/> High fever ($\geq 38^{\circ}\text{C}$)	<input type="checkbox"/> Cough with phlegm
<input type="checkbox"/> Shortness of breath	<input checked="" type="checkbox"/> Diarrhea ($>3\text{x/day}$)
<input type="checkbox"/> Repeated vomiting	<input type="checkbox"/> Skin rash
<input type="checkbox"/> Stuffy nose	<input type="checkbox"/> Sore throat
<input checked="" type="checkbox"/> Decreased appetite	<input type="checkbox"/> Lethargic and weak

Figure 4. Symptom selection page

Figure 4 shows the symptom selection page that can be used in the developed recommendation system. Users enter the symptoms experienced by their toddler on this page. The user then determines a fuzzy value based on the symptoms experienced. The fuzzy page can be seen in Figure 5.

Determine the Intensity of Symptoms

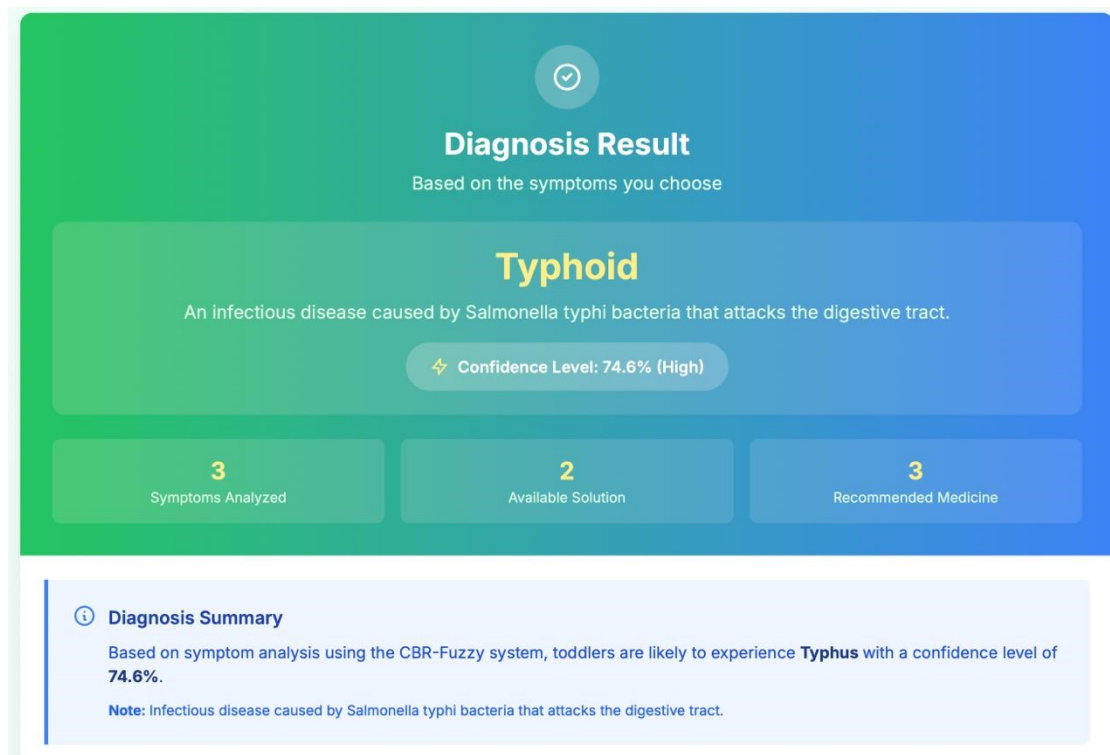
How severe are the symptoms experienced? (0 = None, 1 = Very bad)



Symptom	Intensity Value
High fever ($\geq 38^{\circ}\text{C}$)	0.6
Diarrhea (>3x/day)	0.5
Decreased appetite	0.6

Figure 5. Fuzzy page

Figure 5 shows the page used to determine the fuzzy value by looking at the intensity of the symptoms experienced. The results of the combination of CBR and Fuzzy based on the selected symptoms and intensity can be seen in Figure 6.



Diagnosis Result
Based on the symptoms you choose

Typhoid
An infectious disease caused by *Salmonella typhi* bacteria that attacks the digestive tract.

⚡ Confidence Level: 74.6% (High)

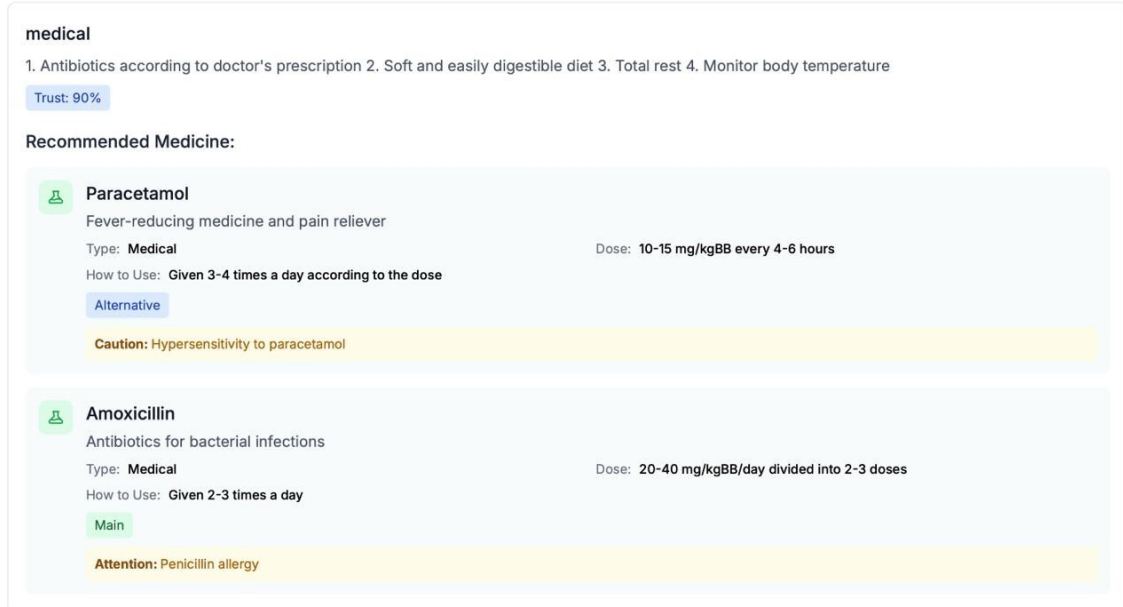
3 Symptoms Analyzed | 2 Available Solution | 3 Recommended Medicine

Diagnosis Summary
Based on symptom analysis using the CBR-Fuzzy system, toddlers are likely to experience **Typhus** with a confidence level of **74.6%**.
Note: Infectious disease caused by *Salmonella typhi* bacteria that attacks the digestive tract.

Figure 6. Diagnosis result page

Figure 6 shows the diagnostic results obtained based on the previous input. The image shows that, based on the symptoms and intensity entered, a diagnosis of typhus was obtained. Treatment recommendations can be seen in Figure 7.

Treatment Recommendation for Typhus



medical

1. Antibiotics according to doctor's prescription 2. Soft and easily digestible diet 3. Total rest 4. Monitor body temperature

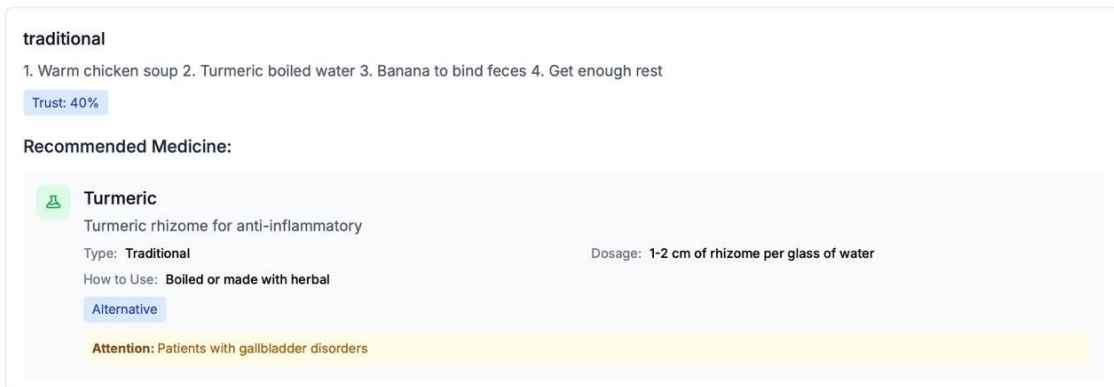
Trust: 90%

Recommended Medicine:

Paracetamol
Fever-reducing medicine and pain reliever
Type: **Medical** Dose: 10-15 mg/kgBB every 4-6 hours
How to Use: Given 3-4 times a day according to the dose
Alternative
Caution: Hypersensitivity to paracetamol

Amoxicillin
Antibiotics for bacterial infections
Type: **Medical** Dose: 20-40 mg/kgBB/day divided into 2-3 doses
How to Use: Given 2-3 times a day
Main
Attention: Penicillin allergy

Figure 7. Treatment recommendations page



traditional

1. Warm chicken soup 2. Turmeric boiled water 3. Banana to bind feces 4. Get enough rest

Trust: 40%

Recommended Medicine:

Turmeric
Turmeric rhizome for anti-inflammatory
Type: **Traditional** Dosage: 1-2 cm of rhizome per glass of water
How to Use: Boiled or made with herbal
Alternative
Attention: Patients with gallbladder disorders

Figure 8. Traditional treatment recommendations page

Evaluation

The system evaluation aimed to assess the performance, reliability, and user acceptance of the CBR-Fuzzy-based medication recommendation system for toddlers. In this study, the evaluation was conducted using three approaches: blackbox testing, system accuracy calculations, and the System Usability Scale (SUS), involving 50 respondents. The results of the blackbox testing are shown in Table 5.

Table 5. Blackbox testing result

Test Scenario	Input Steps	Expected Output	Test Results	Status
Input toddler symptom data	The user selects several symptoms (e.g., high fever, diarrhea, decreased appetite).	The system saves the symptoms to a new case query	Compliant	Successful
Symptom analysis using the CBR method	The user clicks the Symptom Analysis button.	The system calculates similarity with the case base	Compliant	Successful
Revise results using Fuzzy Login	The system receives the symptom intensity (0–1) as input.	The system calculates the fuzzy membership degree and revises the solution	Compliant	Successful
Display diagnosis results	After analysis, the system displays the detected disease along with the confidence level.	The results page displays the disease name + confidence percentage	Compliant	Successful
Recommended medical solutions	When a disease diagnosis is made (e.g., typhoid), the system calls up medical solutions from the knowledge base.	Displays a list of medical drugs + dosage & instructions	Compliant	Successful
Recommended traditional solutions	When a disease is detected, the system also calls up traditional solutions.	Displays herbal ingredients and instructions for use	Compliant	Successful
Alert/user education features	After the diagnosis results are displayed, the admin logs in with a valid account.	The system displays a warning message to consult a doctor	Compliant	Successful
Admin login	The admin adds/changes/deletes disease, symptom, or medication data.	The system displays the admin dashboard	Compliant	Successful
Manage case database (CRUD)	The user clicks the logout button.	New data is saved/changed/deleted in the case base	Test Results	Successful
Admin/user logout	Input Steps	The system returns to the login page	Compliant	Status

Table 5 shows the results of blackbox testing conducted with 10 scenarios. The table shows that all scenarios performed yielded results as expected, resulting in a 100% score for the blackbox testing. The next step is accuracy testing. This testing is conducted by comparing the system's results with those of an expert. The accuracy test can be seen in Table 6.

Table 6. Accuracy test result

No	Main (Input)	Symptoms	Systemic Diagnosis	Expert Diagnosis	Status
1	High fever, skin rash, joint pain		Dengue Fever	Dengue Fever	Appropriate
2	High fever, diarrhea >3 times, decreased appetite		Typhus	Typhus	Appropriate
3	Recurring fever, chills, night sweats		Malaria	Malaria	Appropriate
4	High fever, headache, vomiting		Dengue Fever	Malaria	Not Appropriate
5	High fever, weakness, repeated vomiting		Typhus	Dengue Fever	Not Appropriate
....
50	Gastritis: stomach pain, nausea		Gastritis	Gastritis	Appropriate

Table 6 shows the accuracy tests performed. Of the 50 scenarios tested, 6 results were inconsistent, resulting in an accuracy rate of 88%. The next test was conducted using SUS [28]. The summary of SUS data can be seen in Table 7.

Table 7. SUS value summary

Resp	Q1	Q2*	Q3	Q4*	Q5	Q6*	Q7	Q8*	Q9	Q10*
R1	4	4	4	4	5	4	4	4	4	4
R2	5	4	5	3	5	3	5	4	5	4
R3	4	3	4	4	4	4	4	3	4	3
R4	3	4	4	3	4	3	4	4	4	4
R5	4	3	5	4	5	4	5	3	5	4
...
R50	4	3	5	4	5	3	5	4	5	4

Table 7 shows the results of the SUS summary, where the values were then converted into SUS rules, resulting in an average SUS value of 78.4.

Discussions

The findings of this study indicate that the integration of Case-Based Reasoning (CBR) and Fuzzy Logic in a toddler treatment recommendation system provides significant improvements in both technical performance and user acceptance. This integration enables the system to deliver accurate initial diagnostic recommendations, adapt to uncertainty in symptom data, and remain culturally sensitive through the incorporation of modern medical knowledge and verified local wisdom.

In the case representation stage, the knowledge base was successfully structured to include information on diseases, symptoms, and both medical and traditional treatment solutions. This structured representation allows the system to consistently perform case retrieval and generate recommendations based on previous case experiences with measurable similarity levels. Although the CBR mechanism proved effective in identifying relevant cases, its deterministic nature limits its ability to handle ambiguous symptoms. This limitation is addressed through the incorporation of fuzzy logic in the revision stage, enabling symptoms to be expressed as degrees of membership rather than binary values. As a result, the system can more realistically account for symptom intensity, producing recommendations that are more flexible and aligned with actual patient conditions.

The system achieved an accuracy score of 88%, indicating a high level of reliability in generating initial diagnostic results. Most inconsistencies were found in diseases with overlapping clinical manifestations, highlighting the need for expanding the case base and refining fuzzy membership functions to improve the system's discriminatory capability. Furthermore, blackbox testing confirmed that all system functionalities operate according to design specifications, demonstrating functional feasibility.

From the usability perspective, evaluation using the System Usability Scale (SUS) involving 50 respondents resulted in an average score of 78.4, categorized as *Good*. This shows that the system is easy to use, quick to learn, and provides a satisfying user experience. However, a small number of respondents indicated that some features could still be simplified, suggesting that interface improvements may help achieve an *Excellent* usability rating.

The use of traditional treatment data in this system poses potential biases, as herbal practices are influenced by cultural variations, availability of ingredients, and differing interpretations among practitioners. In addition, several traditional recommendations lack strong medical documentation, which may lead to overgeneralization. To mitigate these issues, this study intentionally selected herbal treatments commonly used across multiple regions and verified by experienced herbal practitioners while still prioritizing standardized medical recommendations. The system also provides warnings for users to seek medical consultation when necessary.

Overall, the results confirm that the integration of CBR and Fuzzy Logic provides a balanced framework for supporting decision-making in toddler treatment recommendations. CBR contributes by leveraging past case experiences, while fuzzy logic enhances the system's ability to manage uncertainty. Although the system demonstrates strong technical performance and good user acceptance, further development is required, particularly in expanding the case base, refining fuzzy rules, and improving the user interface to enhance intuitiveness and broaden system acceptance. It is also important to note that the system has not yet been tested in real field conditions, so practical effectiveness and user behavior in actual healthcare settings remain to be evaluated in future studies.

Conclusion

This research successfully developed a Case-Based Reasoning (CBR)-based treatment recommendation system for toddlers combined with Fuzzy Logic and integrating modern medical knowledge and local wisdom. The system provided initial diagnosis results with an accuracy rate of 88%, obtained a System Usability Scale (SUS) score of 78.4 in the Good Usability category, and blackbox testing results showed that all main functions ran according to design, so the system was considered quite reliable, adaptive, and acceptable to the community. For further research, it is recommended that the system be developed by expanding the case base, refining fuzzy rules, improving the user interface to be more intuitive, and implementing it on a mobile platform so that it can improve accuracy, expand user reach, and achieve an Excellent Usability level in a wider usage context.

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