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Smart Diagnosis: Android Expert System for Detecting ADHD Behavior Types in Children

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ABSTRACT

This study aims to develop an application capable of detecting ADHD behavioral disorders in children aged 3–8 years. This study employs a Research and Development (R&D) approach using forward chaining. The application was tested through functional testing using black-box testing, expert validation, and system effectiveness testing—the effectiveness testing aimed to evaluate the system's accuracy and user satisfaction. The results of this research indicate that the application functions as intended based on the functional testing. According to expert validation, the application accurately reflects the symptoms associated with ADHD behavior. In terms of effectiveness, the application demonstrated a reliable level of accuracy and was found to be user-friendly. This application helps accelerate the early identification process in children suspected of having ADHD behavior so that professionals can immediately follow it up.

INTRODUCTION

The prevalence of around 8% means that out of every 100 children and adolescents, around eight are estimated to experience ADHD (Attention Deficit Hyperactivity Disorder) symptoms [1]. Of the 70 children with ADHD, 33 children (47.1%) never attended a mental health appointment within 3–6 months of initial diagnosis. In contrast, 37 children (52.9%) participated in an appointment with a psychologist, psychiatrist, or other physician within that time frame. Nearly 50% of parents did not continue treatment or follow-up, highlighting barriers such as Limited access to services in certain areas, Cost or social stigma, and Lack of understanding of the importance of follow-up interventions [2].

ADHD is a common neurodevelopmental disorder in children that can persist into adulthood. It is characterized by behavioral patterns involving inattention, hyperactivity, and impulsivity. Accurately diagnosing the specific ADHD behavioral type is crucial for determining the most appropriate treatment and intervention strategy [3]. In Indonesia, many parents have limited access to psychologists [2]. Consequently, there is a pressing need for innovative solutions that empower communities to perform early detection of ADHD independently through expert systems. This system would not only provide a preliminary diagnosis but also serve as an educational tool to support early intervention for ADHD

symptoms in children. Following the initial diagnosis provided by the expert system, parents are encouraged to consult specialists for confirmation and subsequent treatment.

This study utilizes an expert system as a component of a decision support system to assist in identifying behavioral types associated with ADHD in children [4][5]. The system is implemented as an Android-based application to ensure accessibility for parents and educators. Using the forward chaining method, the system processes initial facts—namely the child's observed behavioral symptoms—and concludes with one of the three ADHD behavior types: inattention, hyperactivity, or impulsivity. The system is implemented as an Android-based application to ensure accessibility for parents and educators.

Forward chaining is frequently used for data classification, such as identifying types of reasoning in models of intelligence [6] and diagnosing physical or mental illnesses in living beings [4], [7], [8], [9], [10]. In previous studies, expert systems were mainly web-based and did not explicitly focus on detecting ADHD behavioral types. This research develops the expert system as an Android application to enhance usability. Forward chaining is chosen for its ability to reason from observable symptoms to an ADHD behavior-type diagnosis. This approach is considered more natural and intuitive for non-expert users, such as parents and teachers, and facilitates implementation in mobile applications. Compared to backward chaining, which begins from a hypothesis, forward chaining is more flexible and better supports early intervention based on real, observable symptoms.

This application helps accelerate the early identification process in children suspected of having ADHD behavior so that professionals can immediately follow it up. It contributes to increasing awareness and early detection of child development disorders. This system supports the development of digital health services in Indonesia, which are still minimal for ADHD cases. It shows the potential for implementing innovative technology in the child health sector.

METHOD

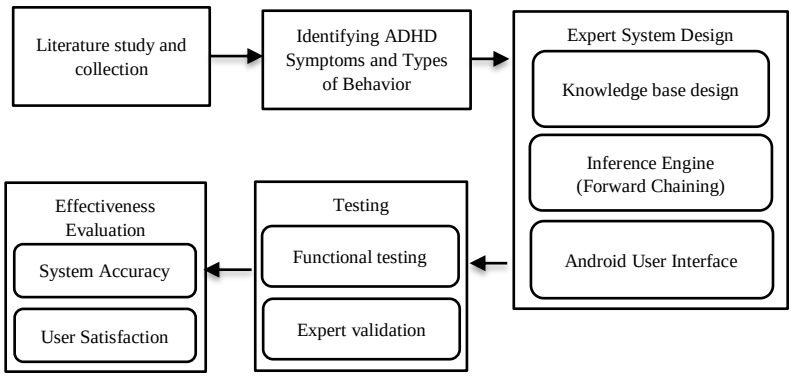

Figure 1. Research Stages

This research adopts a Research and Development (R&D) approach, following a structured process. The initial stage involved a literature review and data collection through academic sources related to ADHD classification. In addition, interviews were conducted by consulting with child psychology experts to validate behavioral indicators. The next phase was the identification of ADHD symptoms and behavioral types. ADHD can be classified into three main types: Hyperactive, Inattentive, and Impulsive [3][11].

Children with hyperactive-type ADHD tend to display uncontrollable physical activity, constantly moving as if they never tire, and are unable to remain still. Observable symptoms include restlessness during play, difficulty sitting still, excessive physical activity such as running or climbing in inappropriate situations, and an inability to stay seated calmly. Children with inattentive-type ADHD generally struggle to maintain focus. Common symptoms include difficulty sustaining attention, appearing not to listen when spoken to, being easily distracted, making careless mistakes, struggling to follow instructions, misplacing items, and exhibiting behaviors such as daydreaming or appearing mentally absent.

The impulsive type is characterized by hasty actions performed without consideration of consequences. Observable symptoms include extreme difficulty waiting for turns, blurting out answers prematurely, interrupting others, and engaging in actions without thinking—such as running in the middle of formal events or chasing dangerous objects. In the knowledge base design phase, the researcher formulated rules and constructed a decision tree based on Table 1. This decision tree was built to reflect the symptoms' logical structure and corresponding ADHD types, providing the inference path for the expert system.

Table 1. Symptoms Based on ADHD Behavioral Patterns

Symptom Description	Symptom Code	ADHD Type Code		
		Hyperactive (P001)	Inattentive (P002)	Impulsive (P003)
Fails to pay close attention to details	G001	*	*	*
Dislikes playing with LEGO or puzzles	G002	*	*	*
Lacks discipline	G003	*	*	*
Avoids doing homework or school tasks	G004	*	*	*
Frequently anxious or fearful	G005	*	*	*
Does not listen when others are speaking	G006	*	*	*
Highly sensitive to criticism	G007	*	*	*
Often forgets daily activities	G008	*	*	*
Difficulty focusing during play	G009	*	*	
Easily distracted	G010	*	*	
Difficulty following instructions	G011	*	*	
Frequently interrupts others	G012	*		*
Often walks around unnecessarily	G013	*		*
Fails to follow directions	G014	*		*
Unable to stay still	G015	*		*
Frequently causes disruptions	G016	*		*
Always wants to touch objects in view	G017	*		*
Talks excessively	G018	*		
Frequently shakes legs when seated	G019	*		
Careless in completing tasks or chores	G020	*		
Often squirms	G021	*		
Frequently grabs toys from others forcefully	G022		*	*
Easily irritated and angry	G023		*	*
Impatient when waiting for their turn	G024		*	
Appears very insecure and withdrawn	G025		*	
Often loses items	G026		*	
Cannot organize daily tasks/activities	G027		*	
Answers questions impulsively	G028		*	
Frequently takes toys from fiends forcefully	G029			*
Often retaliates when provoked	G030			*
Repeats what friends have said	G031			*
Often disturbs classmates	G032			*
Demonstrates defiance or disobedience	G033			*
Frequently disobeys rules	G034			*

Forward Chaining is commonly used in expert systems to identify or trace solutions from a set of problems. The process begins with the system receiving input in the form of facts or symptoms provided by the user. These facts are stored in the system's working memory. The system then evaluates all rules within the knowledge base (rule base), attempting to match the IF conditions of each rule with the current set of facts. When a rule's conditions are satisfied, the rule becomes active (a firable rule). If multiple rules are activated simultaneously, the system employs a conflict resolution strategy to select the most appropriate rule, typically based on predefined priorities or ordering criteria.

Once a rule is selected, its THEN clause is executed, adding a new fact to the working memory. The system repeats this cycle of rule matching and execution using the updated set of facts. This iterative process continues until no additional rules can be fired or until a predefined goal (conclusion) is reached. When the system cannot generate new facts, it delivers a conclusion based on the facts retained in working memory. The flow of the forward chaining process is illustrated in Figure 2.

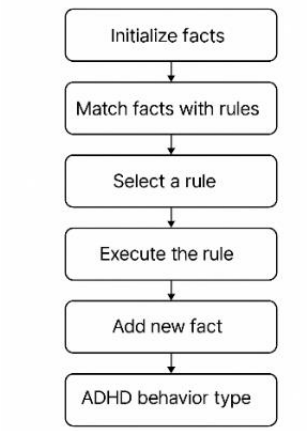

Figure 2. Forward Chaining Flowchart

By employing system design techniques such as UML (Unified Modeling Language), ERD (Entity Relationship Diagram), and mock-ups, a comprehensive system design is developed for the application to be built. This design encompasses the application's workflow, database structure, and user interface. In the testing phase, system evaluation is conducted through black-box testing [12][13] and expert validation using a Likert scale questionnaire (scale of 1 to 5). One psychologist is involved in the expert validation. System validation was conducted by one expert, a certified child psychologist and experienced in handling ADHD cases. Although validation by one expert is sufficient for the initial stage of system development, further research will involve more than one expert to reduce the potential for subjectivity and increase the system's validity. The expert is provided with the symptom rules and ADHD behavior classifications and then asked to use the system. The following are the questions that will be presented to the expert validator.

Table 2. Expert Validator Questionnaire Items

No	Expert Validator Questionnaire Items
1.	The system’s diagnostic results align with the behavioral characteristics of ADHD based on the symptoms provided.
2.	The system can accurately distinguish between Hyperactive, Inattentive, and Impulsive types.
3.	The inference logic used in the system complies with established behavioral diagnosis principles for ADHD.
4.	The rules implemented in the system reflect knowledge consistent with clinical psychology practices.
5.	The symptoms addressed in the system represent common indicators observed in children with ADHD.
6.	The system omits no significant symptoms.
7.	The system can assist in the early identification of ADHD-related behaviors in children.
8.	The system is understandable and usable by non-expert users (e.g., parents or teachers).
9.	The system can serve as a supporting tool for providing preliminary recommendations for further consultation.

In the evaluation phase, user satisfaction and system accuracy testing are conducted. The system's accuracy is assessed by creating five symptom scenarios and ensuring that the diagnoses align with an expert's. The diagnostic results generated by the system are then compared with the expert's assessments. The number of expert validator questionnaire items is 9 items. Accuracy is measured using the following formula.

$$Accuracy = \frac{Number\ of\ correct\ diagnosesumlah\ diagnosis\ yang\ sesuai}{total\ number\ of\ cases}\ x\ 100\%$$

Table 3. User Satisfaction Testing

No	Questionnaire Item
1.	The application is easy to use without requiring special training.
2.	The application's interface is simple and easy to understand.
3.	Navigation within the application is not confusing.
4.	The time required to use the system is relatively short.
5.	The diagnostic process is fast.
6.	The explanation of the diagnostic results is clear and easy to understand
7.	The application helps me recognize potential ADHD-related behaviors in children.
8.	I feel supported by this system prior to consulting a professional.

User satisfaction testing was conducted with 14 participants, consisting of parents and teachers, using a questionnaire based on a 5-point Likert scale. The number of user satisfaction questionnaire items is 8 items. In mobile health (mHealth) application testing, a participant number ranging from 10 to 23 is considered adequate to identify initial interface and usability issues [14].

RESULTS AND DISCUSSION

The Mediku application adopts a modular architecture consisting of three layers: the User Interface Layer, the Application Logic Layer, and the Data Storage Layer. The User Interface Layer provides three main features designed for parents and teachers: (1) an ADHD Diagnosis module that guides users through structured symptom-based questions; (2) a Diagnosis History feature that stores and presents past diagnoses to monitor behavioral patterns over time; and (3) an Educational Resources section offering curated articles, videos, and a directory of nearby psychologists to support parental education and facilitate access to professional care. The Application Logic Layer implements a rule-based expert system using the forward chaining inference engine, where the user's responses are evaluated against a predefined knowledge base of ADHD symptom rules, and logical reasoning is applied to determine the ADHD behavior tye hyperactive, inattentive, or impulsive. The Data Storage Layer utilizes a local SQLite database to ensure secure user data storage, including responses, diagnosis results, and application settings, thereby supporting offline access and maintaining data privacy. This layered architecture is designed to deliver an accessible, user-friendly, and effective diagnostic tool that empowers parents and educators to conduct early screening of ADHD symptoms and take appropriate next steps.

In practice, Mediku is designed to be used by three main user groups: administrators, psychologists, and parents, with tailored functionalities to suit their respective needs in conducting ADHD assessments and tracking child development. As illustrated in Figure 4, symptoms G1 through G7 represent general characteristics commonly observed in children with ADHD. Symptom G8 serves as a distinguishing factor. If a child does not exhibit symptom G8, the subsequent questions will lead toward identifying impulsive behavior. Conversely, if the child does exhibit symptom G8, follow-up questions will be directed toward identifying inattentive and hyperactive behavior.

Symptoms G8 to G11 are general indicators of inattentive and hyperactive subtypes. If a child shows symptom G12, the system will present additional questions targeting hyperactive behavior. However, if symptom G12 is absent, the questions will instead focus on inattentive behavior. The designed decision tree implemented the following rules using the forward chaining approach. The following pseudocode structure illustrates the system logic, which outlines how user responses are processed to generate a diagnosis. The inference process of the system is illustrated by the pseudocode structure, which describes how user responses are processed to create a diagnosis. This process is visually represented in Figure 4.

Pseudocode 1. Forward Chaining Inference Process

```
initialize working_memory with user_responses
repeat
   for each rule in knowledge_base do
      if rule.conditions are met in working_memory then
         apply rule.conclusion
         update working_memory
         if diagnosis reached then
            exit loop
until no more applicable rules
return diagnosis
```

Example Rule Implementation:

IF (symptom.G005 == TRUE) AND (symptom.G018 == TRUE) AND (symptom.G019 == TRUE) AND (symptom.G020 == TRUE)
THEN diagnosis_type = "Hyperactive"

Rule 1:
IF Frequently anxious and fearful= True
Talks excessively= True
Often fidgets or moves feet when sitting still = True
Careless in completing tasks at home = True
THEN Hyperaktif

Rule 2:
IF Frequently repeats words = True
Often disturbs peers= True
Exhibits defiant and noncompliant behavior = True
Frequently disobeys rules = True
THEN Inattentive

Rule 3:
IF Impatient when waiting for turns = True
Appears highly insecure and withdrawn = True
Frequently loses personal items = True
Unable to organize tasks = True
THEN Impulsive

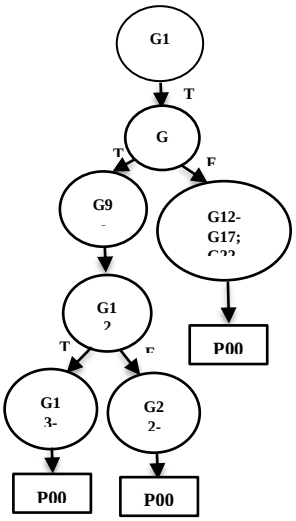

Figure 4. Decision Tree

As illustrated in Figure 5, the application includes three main features: diagnosis, diagnosis history, and a list of diseases. An information menu has also been added, which

provides details about nearby psychologists and educational content about mental health conditions through YouTube.

Figure 5. Application User Interface

During the black-box testing phase, the results summarized in Table 4 indicate that all system features produced outputs consistent with the functional specifications. No bugs were found in the core features (diagnosis, results, navigation), and input validation was performed effectively. Furthermore, expert validation yielded a score of 4.2 out of 5, indicating that the system is reasonably accurate and relevant, user-friendly, and features an interface and workflow aligned with user needs, making it suitable for diagnosing ADHD behavior in children.

Table 4. Black-Box Testing Results

No	Feature Tested	Input	Expected Output	Status
1	Login	Valid Username & Password	User is directed to the main page	Passed
2	Login	Empty / Incorrect credentials	Error message: "Incorrect username or password"	Passed
3	Start Diagnosis	Click “Start” button	ADHD symptom questions appear	Passed
4	Diagnosis Process	Answers to all questions	Diagnosis result displayed: Inattentive / Hyperactive / Impulsive	Passed
5	Diagnosis Process	Incomplete answers	Warning message: “Please complete all questions”	Passed
6	Diagnosis History	Click “Diagnosis History”	Diagnosis history is displayed	Passed
7	About Application	Click “Information”	Application description is displayed	Passed

The system accuracy testing results are as follows, based on the evaluation of five symptoms. As shown in Table 5, the system achieved an accuracy rate of 80%. It indicates that the system functions with a reasonably reliable level of performance

Table 5. Expert Diagnosis vs. System Diagnosis

No	Expert Diagnosis	System Diagnosis
1	Inattentive	Inattentive
2	Impulsive	Hyperactive
3	Hyperactive	Hyperactive
4	Inattentive	Inattentive
5	Impulsive	Impulsive

In scenario 1, children with symptoms fail to pay attention (G001), dislike playing LEGO or puzzles (G002), lack discipline (G003), avoid school tasks (G004), and are frequently anxious (G005). This symptom includes all types of ADHD (P001 – Hyperaktif, P002 – Inattentif, P003 – Impulsif). Expert dan system diagnoses are inattentive type. In scenario 2, children with symptoms frequently interrupt others (G012), often walk unnecessarily (G013), fail to follow directions (G014), and frequently cause disruptions (G016). G012, G014, and G016 include hyperactive and impulsive types, and G013 includes a hyperactive type. Expert diagnosis is impulsive, but system diagnosis is hyperactive. In this case, the system tends to be recognized as hyperactive due to the dominance of active motor symptoms. In scenario 3, children with symptoms are unable to stay still (G015), cause disruptions (G016), touch objects (G017), talk excessively (G018), and shake their legs when seated (G019)—all symptoms,

including hyperactivity by expert and system diagnosis. Scenario 4 is the same as scenario 1 for validation purposes and produces the same results. In scenario 5, children with symptoms grab toys forcefully (G022), are irritable/angry (G023), impatient for their turn (G024), and answer impulsively (G028)—all symptoms including impulsive by expert and system diagnosis.

The user satisfaction assessment, conducted with 14 participants, yielded an average score of 4.3 out of 5. It indicates that all respondents rated the application's interface as either very good or good, with some considering it adequate. Similar results were observed for the question regarding the application's alignment with program needs. Furthermore, users gave very high ratings for the application's ease of use, the usefulness of its features, the smooth functioning of each feature, and their overall evaluation of the program. The results of this study are supported by previous studies that confirm that the forward chaining method has been proven effective in the domain of developmental disorders. It shows that the application is relevant for teachers, therapists, and parents [15].

Symptom G012, 'Frequently interrupts others,' is observed in both hyperactive and impulsive types of ADHD. The system's rule set is not sufficiently precise to differentiate between these subtypes, which may result in misclassification. This represents a limitation of the current study. Future work should address this issue by focusing on identifying symptoms specific to each ADHD subtype, thereby reducing diagnostic ambiguity.

CONCLUSION

This application can detect ADHD behavioral disorders in children aged 3 to 8 years. Based on the black-box testing results, the Android-based expert system for ADHD behavior diagnosis functions effectively, including input processing, validation, and diagnostic result display. Expert validation yielded a score of 4.2 out of 5, indicating that the system is reasonably accurate and relevant, easy to use, and features an interface and workflow aligned with user needs, making it well-suited for ADHD behavior diagnosis in children. The system effectiveness evaluation revealed an accuracy rate of 80%, demonstrating a reliable performance. User satisfaction scored 4.3 out of 5, reflecting a very positive reception by the respondents.

The developed application facilitates access to subsequent steps, particularly by enabling consultations with professionals for further intervention. It is designed to be both informative and user-friendly, encouraging parents to pay closer attention to their children's behavioral patterns and to seek early treatment when necessary. Future research should focus on regularly updating the application based on user needs and improving diagnostic accuracy through the use of a confusion matrix.

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