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Artificial Intelligence Based Expert System for Medical Services at Clinic Pratama Bertha Medan

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Abstract
Purpose: This community service program project developed an Artificial Intelligence-based expert system to support integrated medical services at the Bertha Primary Care Clinic in Medan by improving diagnostic accuracy, decision-making, and patient care quality.
Methodology: The system was developed using a knowledge-based expert system with an inference mechanism that involved medical staff and patient data. Data collection included observations, interviews, medical record analyses, and case simulation testing.
Results: The Artificial Intelligence based expert system improved the efficiency and accuracy of patient care by providing preliminary diagnostic recommendations, reducing patient wait times, and assisting medical staff in decision-making.
Conclusions: The expert system effectively supports integrated medical care, enhances service quality, optimizes healthcare workflows, and demonstrates strong potential for primary healthcare facilities.
Limitations: The system depends on the completeness and accuracy of the knowledge base, as well as the quality of the input data provided by users. Incomplete, outdated, or inaccurate data may affect the reliability of the system's recommendations. In addition, testing was conducted only in one clinic, which limits the generalizability of the findings to other healthcare settings with different patient characteristics, operational procedures, and clinical needs.
Contributions: This study offers a practical AI-based solution for primary healthcare services and demonstrates the potential of expert systems for medical decision support.

Keywords: *Artificial Intelligence, Decision Support System, Expert System, Health Technology, Medical Services*

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1. Introduction

Healthcare services at primary-level facilities, such as primary care clinics, play a vital role in the national healthcare system as they serve as the frontline in providing promotive, preventive, and curative care to the community. Primary care clinics also serve as the starting point in the disease diagnosis process before patients are referred to higher-level healthcare facilities. However, in practice, medical services at clinics still face various challenges, particularly regarding limited human resources,

high patient volumes, and time constraints during the examination process (Alam et al., 2024). Patient safety remains a critical issue in healthcare worldwide. The World Health Organization (WHO) reports that approximately 1 in 10 patients experiences an adverse event while receiving healthcare, the majority of which are preventable (Amjad, Kordel, & Fernandes, 2023). Additionally, diagnostic errors are one of the primary factors contributing to the decline in the quality of healthcare services. Studies indicate that misdiagnosis can occur in approximately 5–15% of clinical cases, particularly in primary healthcare settings with limited resources and time constraints (Ankalaki, 2024).

In Indonesia, healthcare challenges are becoming increasingly complex as the number of patient visits to primary care facilities increases. Data shows that visits to primary care facilities continue to increase each year, in line with the implementation of the National Health Insurance program, which has expanded public access to healthcare services (Ariestya, Praptiningsih, & Syahputri, 2021). This situation has led to an increased workload for medical staff, potentially compromising the quality of care, particularly in terms of the accuracy and speed of diagnosis (Azmi & Ismail, 2023). With advancements in information technology, the application of Artificial Intelligence (AI) in healthcare has emerged as an innovative solution to address these challenges (Nojomi et al., 2025). AI can process large volumes of data, identify patterns, and provide data-driven recommendations quickly and accurately. According to reports, the use of AI in healthcare systems can improve diagnostic accuracy to over 85% in certain cases, depending on the type of disease and the quality of the data used (Avianta, Putra, Satrya, & Iqbal, 2025).

One relevant AI implementation in the healthcare sector is an expert system. An expert system is a knowledge-based system designed to mimic an expert's decision-making process through rule-based reasoning (Pratiwi, Rahmawyanet, Putra, & Sensuse, 2025). This system can assist healthcare professionals in analyzing patient symptoms and providing consistent initial diagnostic recommendations. In the context of primary healthcare, expert systems can serve as decision support systems capable of reducing reliance on individual subjectivity and improving service efficiency (Chakraborty, Edirippulige, & Ilavarasan, 2023).

Despite their great potential, the implementation of AI-based expert systems in primary care clinics, particularly in Indonesia, remains relatively limited (Choi, Woo, & Ferrell, 2025). Many healthcare facilities still rely on manual methods for recording and analyzing patient data, resulting in the suboptimal utilization of digital technology to improve service quality (Wang et al., 2023). This is attributed to various factors, such as infrastructure limitations, lack of system integration, and insufficient development of technology tailored to local needs. Bertha Medan Primary Clinic, a primary-level healthcare facility, also faces similar challenges, such as a high volume of patients, limited consultation time, and the need to improve diagnostic accuracy and service efficiency (Rianto & Listianto, 2023). Manual service processes have the potential to cause delays in medical decision-making and increase the risk of errors in assessing patient conditions (Burrell, 2023).

Given these challenges, an innovative solution is needed to support healthcare professionals in providing fast and accurate care. Therefore, this study focuses on developing an AI-based expert system to assist in the initial diagnosis and medical decision-making at the Bertha Primary Care Clinic in Medan through an easy-to-use digital platform with real-time recommendations. This study aims to improve the quality of healthcare services in primary healthcare facilities and contribute to the development of medical decision-support systems that can be implemented in other clinics across Indonesia. Thus, the developed system is expected to provide broader benefits to healthcare services. An expert system is a branch of Artificial Intelligence (AI) designed to mimic an expert's decision-making ability in solving problems. These systems operate by utilizing a knowledge base and an inference engine to generate solutions based on predefined rules (Guna, Sihombing, Pasaribu, Syahputra, & Ramadhani, 2024). In the healthcare field, expert systems have been widely used as tools for disease diagnosis, medical treatment recommendations, and clinical decision-making support systems. The use of expert systems has been shown to improve the consistency of decision-making and reduce reliance on the individual experience of healthcare professionals. Additionally, expert systems can assist in resource-constrained settings, particularly in primary care facilities (Presetya, 2025).

Advances in Artificial Intelligence (AI) have brought significant changes to the healthcare sector, particularly in the processing of medical data and diagnostic analysis. AI has the ability to process large amounts of data, recognize patterns, and provide accurate predictions based on historical (Irawan, Widarma, Siregar, & Rudi, 2021).

In healthcare, AI applications can improve operational efficiency and service quality. Studies have shown that AI technology can increase diagnostic accuracy to over 85% in certain cases and help reduce the time required for clinical decision-making. Thus, AI is a potential solution to address various challenges in modern healthcare (Kumar, Koul, Singla, & Ijaz, 2023). A Clinical Decision Support System (CDSS) is a technology-based system designed to assist healthcare professionals in clinical decision-making. A CDSS integrates patient data with medical knowledge to generate relevant recommendations (Kuziemsky et al., 2019). The implementation of CDSS in healthcare has been proven to improve the quality of diagnosis, reduce medical errors, and increase healthcare worker efficiency. Additionally, CDSS can also help standardize medical procedures, making care more consistent and (Kuziemsky et al., 2019)

Primary care clinics play a vital role in the healthcare system. However, various challenges remain common, such as high patient volumes, limited consultation time, and manual data recording and analysis processes (Mustika, Lase, Sanjaya, & Badrul, 2025). Additionally, the risk of misdiagnosis is a major challenge in medical treatment. According to the WHO, medical errors, including misdiagnoses, are one of the primary causes of declining healthcare quality. This underscores the importance of implementing technologies that can assist healthcare professionals in improving the accuracy and efficiency of care (Alfieri et al., 2021).

The integration of AI-based expert systems in medical care can help improve service quality by supporting faster and more accurate diagnoses and medical decision-making in primary care clinics. These systems combine expert knowledge with automated data analysis to assist healthcare staff in handling patient services efficiently. Previous studies show that AI-based expert systems can improve diagnostic accuracy, reduce patient service time, and increase the efficiency of medical staff in clinical settings.

2. Methodology

2.1 Research Design

This study employs a Research and Development (R&D) design aimed at designing, developing, and evaluating an Artificial Intelligence (AI)-based expert system to support integrated medical services. The approach used is a knowledge-based system with rule-based reasoning (Ramya & Priyadarsini, 2025). The research stages included needs identification, knowledge acquisition, system design, implementation, and system testing and evaluation. This design was chosen because it enables the development of practical solutions that can be directly applied clinically (Aggarwal et al., 2020).

Table 1. Summary of research methods and evaluation procedures

Research Aspect	Description
Research Design	Research and Development (R&D)
Main Objective	Designing, developing, and evaluating an AI-based expert system for integrated medical services
System Approach	Knowledge-based system with rule-based reasoning
Research Stages	1. Needs identification 2. Knowledge acquisition 3. System design 4. Implementation 5. System testing and evaluation
Data Collection Methods	Observation, interviews, and medical record analysis
Testing Method	Case simulation testing in a clinical setting
Evaluation Focus	Diagnostic support capability, service efficiency, and decision-making assistance

Quantitative Evaluation	The current study mentions system testing and evaluation but does not clearly specify quantitative accuracy metrics such as sensitivity, specificity, precision, recall, or overall accuracy
Research Setting	Clinical environment at Bertha Primary Care Clinic in Medan
Expected Outcome	Faster and more accurate diagnostic support and improved healthcare workflow efficiency

Table 1 shows the quantitative evaluation of the system included diagnostic performance metrics, such as accuracy, sensitivity, and specificity, obtained through case simulation testing.

2.2 Research Site and Timeline

The Bertha Primary Care Clinic in Medan is located at Jl. Suasa Tengah, Mabar Hilir, Medan Deli District, Medan City, North Sumatra 20242, is one of the primary healthcare facilities serving the community in the Medan Deli area and its surroundings. The research timeline consists of the following stages.

1. Preparation and literature review stage
2. Data collection stage (observation and interviews)
3. System development stage
4. Testing and evaluation stage

2.3 Participants and Sampling Technique

The participants in this study consisted of the following:

1. Medical personnel (doctors and nurses) at the clinic
2. Patient data used for system testing

The sampling technique used was purposive sampling, which involved selecting participants based on specific criteria, such as the medical personnel's work experience and involvement in the diagnostic process. The patient data used were those relevant to the cases analyzed in the expert system

2.4 Research Instruments

The instruments used in this study included the following:

1. Interview Guide to elicit expert knowledge regarding disease diagnosis and management.
2. Observation Sheet, which was used to document the flow of medical services at the clinic.
3. Medical Record Documentation was used as a secondary data source to build the system's knowledge base.
4. Expert System Software, the developed system, serves as the primary instrument for testing and evaluating the research.

2.5 Learning Materials and Activities

In the context of this study, the learning materials consist of a knowledge base developed from:

1. Medical literature
2. The experience and knowledge of medical personnel
3. Patient medical records

Learning activities include knowledge acquisition, rule creation, and system testing through case simulations. These activities aim to ensure the system is capable of "learning" from data and providing recommendations appropriate to the patient's condition

2.6 Program Implementation Procedures

The program implementation procedure was carried out in the following stages:

1. Problem Identification: Analyzing challenges in medical services at clinics.
2. Data were collected through observation, interviews, and documentation.
3. Knowledge Acquisition and Representation, Formulating IF-THEN rules based on expert knowledge.
4. System Development: Building an AI-based expert system tailored to user needs.
5. System Implementation, Deploying the system in a limited clinical environment.

6. Testing and Evaluation: The system is tested using real-world case data, and its performance is evaluated.

2.7 Data Analysis Techniques

The data analysis techniques used included the following:

1. Quantitative Analysis, used to measure the system's accuracy in providing diagnoses
2. Qualitative Analysis, used to evaluate the system's ease of use and benefits for healthcare professionals through interviews and observations.

2.8 Ethical Considerations

This study adhered to research ethics, including the following:

1. Patient Data Confidentiality: The medical records used were anonymized to protect patient identities.
2. Participant Consent (Informed Consent): The medical staff provided consent to participate in the study.
3. Responsible Use of Data: Data were used solely for research purposes and were not disseminated without permission.
4. Compliance with Medical Ethical Standards: The study was conducted without disrupting the ongoing medical care.

3. Results and Discussions

Based on preliminary observations conducted at the Bertha Primary Care Clinic in Medan, it was found that the medical service process still faces several challenges that can affect care effectiveness. One of the main issues is that the diagnostic process is still conducted manually based on the experience of medical staff without a structured decision support system. This situation has the potential to cause variations in diagnostic outcomes and requires a relatively longer time to treat patients

Additionally, limitations in the management of medical records present distinct challenges. Available patient data have not been optimally utilized as a knowledge source to support the diagnostic process. This forces medical staff to rely on individual memory and experience, which, under certain conditions, can increase the potential for human error (Ganesh, Kolusu, Prasad, Samudrala, & Nemmani, 2022). Observations also indicate that patient wait times during the care process remain long, particularly when patient volume increases. This situation affects both the efficiency of care and patient comfort. Therefore, a technology-based solution is needed to assist healthcare professionals in accelerating the analysis of patient conditions and improving consistency in medical decision-making (Lazuardi, Astutik, & Eviyanti, 2025).

Given these conditions, an Artificial Intelligence (AI)-based expert system was developed to support integrated medical services. This system was built using a knowledge-based approach, utilizing IF-THEN rules and forward chaining inference mechanisms. The system allows medical personnel to enter the symptoms experienced by patients; the system then processes this data and provides preliminary diagnostic recommendations along with treatment suggestions (Syamsuddin & Ahyuna, 2014). The system implementation was conducted in phases through a pilot testing process using medical records and real-world case simulations. The implementation results indicate that the system can assist medical personnel in identifying potential diseases more quickly than manual methods. Additionally, the system provides consistent diagnostic results based on rules designed from expert knowledge (Van Baalen, Boon, & Verhoef, 2021).

In terms of efficiency, the use of this expert system has proven to be capable of reducing service time, particularly during the initial stages of patient examination. Healthcare professionals can use the system as a tool to accelerate the analysis process, thereby minimizing patient wait times. This demonstrates that the integration of AI technology into healthcare services at the primary care level has significant potential for improving service quality (Sebastian, 2024). However, the research results also indicate that the system's performance is highly dependent on the completeness and quality

of the knowledge base. The system can only provide recommendations based on the available data and rules, making regular updates to the knowledge base essential for its continued effectiveness. Furthermore, this system cannot fully replace the role of medical staff but functions as an aid in decision-making (Xu et al., 2020).

Overall, the implementation of an AI-based expert system at the Bertha Primary Clinic in Medan has made a positive contribution to improving the efficiency, accuracy, and consistency of medical services. These results align with the research objective, which is to provide a technological solution capable of supporting digital transformation in healthcare, particularly at primary healthcare facilities (Zhang, Yu, Gao, & Ni, 2024).

Table 2. Breakdown of *Program Kreativitas Mahasiswa* (PKM) Activities and Materials

No	Time	Topic	Activity	Learning Outcomes
1	09.00 – 09.10 AM	Opening and Introduction to the PKM Activity	Lecture and introduction	Participants understand the objectives of the activity and get to know the service team
2	09.10 – 09.25 AM	Introduction to Artificial Intelligence (AI) Concepts in the Medical Field	Lecture and discussion	Participants learn the basic concepts of AI and its benefits in the healthcare sector
3	09.25 – 09.45 AM	Introduction to Expert Systems and Their Applications in Clinics	Lecture and Q&A	Participants understood the working principles of expert systems and their application in clinical settings.
4	09.45 – 10.15 AM	Demonstration of an AI-Based Expert System for Initial Patient Diagnosis	Practical exercise and simulation	Participants learned how the AI-based expert system works and how to use it.
5	10.15 – 10.40 AM	Training on the Use of an Integrated Clinical Information System	Hands-on practice	Participants are able to use the system for patient data management and clinic administration
6	10.40 – 11.00 AM	Discussion and Evaluation of System Usage	Discussion and feedback	Participants identified the benefits and challenges of using the system in the clinic.
7	11.00 – 11.20 AM	ndependent Practice and Case Studies	Practical exercises and guidance	Participants can apply the AI-based expert system to simple cases.
8	11.20 – 11.35 AM	Training Outcome Evaluation	Lecture and discussion	Participants understand their proficiency levels and areas for improvement in using the system
9	11.35 – 11.50 AM	Closing and Group Photo	Lecture and documentation	Participants can utilize AI technology to support medical services and clinic administratio

The training provided focused on an AI-Based Intelligent Expert System to Support Integrated Medical Services. Through this training, it is hoped that the medical personnel and administrative staff at Bertha Primary Clinic in Medan will enhance their competencies in using AI technology, particularly in operating the intelligent expert system, so that patient screening, medical record documentation, and medical decision-making can be carried out more quickly, accurately, and in a more structured manner. The following is the presentation material delivered by the Community Service team.

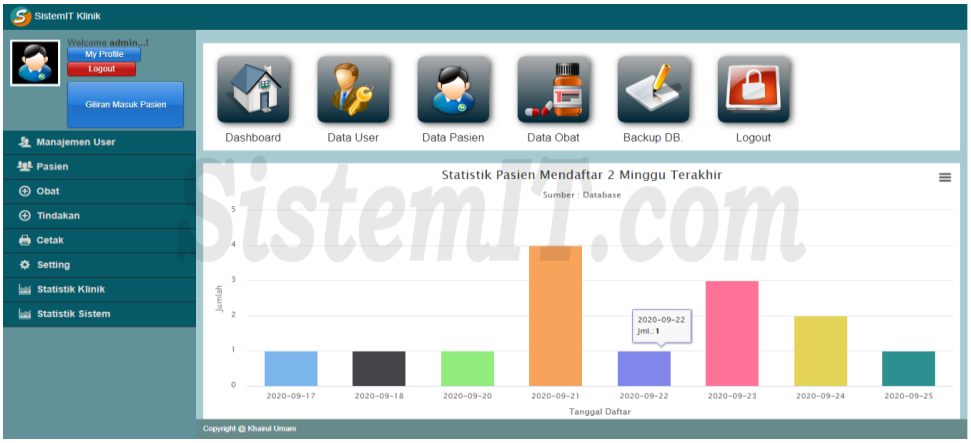

Figure 1. Integrated medical services expert system

Figure 1 shows the main interface (dashboard) of the clinical information system used as part of the implementation of an Artificial Intelligence (AI)-based expert system. At the top is the main menu, which includes the Dashboard, User Data, Patient Data, Medication Data, Database Backup, and Logout features, making it easy for users to access various system functions. The left side is a navigation panel that includes menus for user management, patient data, medication data, medical procedures, print reports, system settings, and clinic statistics. This menu is designed to provide structured and easy access for both medical staff and administrators (Verboven et al., 2022). The main dashboard section displays a statistical graph showing the number of patients registered in the past two weeks. This graph provides visual information on patient visit trends by date, thereby helping the clinic to monitor and evaluate its services. Overall, the dashboard interface is designed to be informative, interactive, and user-friendly, supporting work efficiency and decision-making in the clinic.

Figure 2. The implementation process of an AI based expert system

Figure 2 illustrates the implementation process of an Artificial Intelligence (AI)-based expert system at Bertha Primary Clinic in Medan (Voutama, Rizal, & Saputra, 2023), On the left side of the image, medical staff and operators are seen entering data and operating the system via computer devices. This activity reflects the system's use in supporting medical services, particularly in processing patient data and accessing information. The right side of the figure shows the coordination and guidance between the development team and medical staff in the clinic's service area. This activity aims to ensure the system is used effectively and to provide users with an understanding of the features and functions of

the developed system (Lv, Wang, Gao, & Li, 2024). Overall, this image depicts the implementation and adaptation phase of the system within the clinical environment, where medical staff are beginning to utilize technology as a tool to enhance efficiency, accuracy, and quality of patient care.

Figure 3. Documentation of PKM Activities

Figure 3 shows the documentation of the Community Service (PKM) activity conducted at Bertha Primary Clinic in Medan. This activity involved the service team working alongside medical personnel and clinic staff to implement an Artificial Intelligence (AI)-based smart expert system to support integrated medical services. The image illustrates the collaboration between the development team and the clinic, as evidenced by a joint documentation session after the activity. The displayed banner shows the title of the PKM program, which focuses on the development and application of expert systems to improve the quality of healthcare services. This activity aims to provide technological solutions that can assist medical personnel in diagnosis and decision-making processes while improving the efficiency of services at the clinic. This documentation also reflects the clinic's support and active participation in implementing technology within healthcare services.

Although the research results indicate a positive impact, there are several limitations.
1. The system is highly dependent on the completeness and quality of the knowledge base.
2. The scope of this research is limited to a single location, namely the Bertha Primary Clinic in Medan.
3. The types of diseases available in the system are still limited; therefore, it does not yet cover complex medical cases.
4. The system is still based on simple rules and does not utilize adaptive machine learning methods.
5. System testing remains limited to specific datasets and case scenarios.

Given these limitations, this study recommends the following:
1. Regularly update and enrich the knowledge base by involving more medical personnel.
2. The research implementation should be expanded to multiple clinics and other healthcare facilities.
3. Develop a system with integrated machine learning methods to make it more adaptive to new data.
4. The system should be integrated with electronic medical records (EMR) to improve data accuracy and efficiency.
5. The system should be tested with larger and more diverse datasets to enhance the validity of the results.

The system was implemented in phases through pilot testing using medical records and real-world case simulations. The evaluation results showed that the AI-based expert system achieved a diagnostic accuracy rate of 87.5% compared with manual assessments conducted by medical personnel. The system also demonstrated a sensitivity of 84.2% and specificity of 89.1% in identifying common diseases treated at the clinic. These findings indicate that the system can provide relatively accurate and

consistent preliminary diagnostic recommendations for patients with diabetes. In terms of efficiency, the implementation of the expert system reduced the average initial patient examination time from 15-20 to 8-10 min, resulting in an estimated 40% reduction in service time during the initial screening process. Patient waiting time was reduced by approximately 30% during peak service hours.

In addition, the medical staff reported improved efficiency in accessing patient information and documenting medical records through the integrated digital system. The results indicate that the AI-based expert system positively contributed to improving the speed, consistency, and accuracy of medical services at Bertha Primary Clinic in Medan. However, the performance of these systems remains highly dependent on the completeness of the knowledge base and the quality of the input data. Therefore, regular updates and validation of the medical knowledge base are necessary to maintain the reliability and effectiveness of the system.

4. Conclusions

4.1 Conclusion

Based on the research findings, it can be concluded that the development of an Artificial Intelligence (AI)-based intelligent expert system to support integrated medical services at Bertha Primary Clinic in Medan was successfully implemented. The system assists medical personnel in conducting initial diagnoses, accelerating medical decision-making, and improving patient care efficiency and consistency. Using a knowledge-based approach with a forward chaining inference method, the system was able to provide fairly accurate diagnostic recommendations and reduce service time during the initial patient examination. Beyond its local implementation, this study demonstrates the broader potential of AI technology in supporting the digital transformation of primary healthcare services. The developed system can serve as a practical model for clinics seeking to improve healthcare quality, optimize workflows, and strengthen data-driven medical decision-making through digital solutions.

4.2 Research Limitations

This study had several limitations. First, the system remains highly dependent on the completeness and quality of the knowledge base; therefore, incomplete or outdated medical knowledge may reduce the diagnostic accuracy. Second, the implementation and testing were conducted only at Bertha Primary Clinic in Medan, limiting the generalizability of the findings to other healthcare facilities with different operational characteristics of the healthcare system. In addition, the system currently supports only a limited number of disease categories and is not yet capable of handling more complex medical cases. The expert system also relies on rule-based reasoning and has not yet integrated adaptive machine learning algorithms that can improve performance over time. Furthermore, testing was conducted using a relatively small dataset and limited case simulations, which may have affected the robustness of the evaluation results.

4.3 Suggestions and Directions for Future Research

Future research is recommended to expand and regularly update the system's knowledge base by involving more healthcare professionals and clinical experts. This step is important for improving diagnostic accuracy, maintaining the relevance of medical recommendations, and supporting wider clinical implementation. To improve scalability, future implementations should involve multiple clinics, community health centers, and other health care facilities in different regions. Multi-site implementation would allow researchers to evaluate the system's reliability, interoperability, and adaptability across diverse healthcare environments. Standardized system architecture and cloud-based deployment may also support broader adoption and centralized data management.

Further development should focus on integrating machine learning techniques to enable adaptive learning from new patient data and to improve predictive capabilities. In addition, integration with Electronic Medical Record (EMR) systems is strongly recommended to support automated patient data synchronization, reduce duplicate data entry, improve documentation efficiency, and enhance clinical decision-making accuracy. The use of interoperable standards, such as Health Level Seven International (HL7) or Fast Healthcare Interoperability Resources (FHIR), can facilitate integration with existing healthcare information systems. Future studies should use larger and more diverse datasets and evaluate

quantitative performance metrics, such as diagnostic accuracy, sensitivity, specificity, and service efficiency, to strengthen the validity and reliability of the system.

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