DEPLOYING THE EXPERT SYSTEM FOR TROPICAL DISEASE DIAGNOSIS IN RESOURCE-LIMITED SETTINGS

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ABSTRACT

Tropical diseases such as malaria, dengue, chikungunya, and typhoid continue to pose major public health challenges in resource-limited regions due to inadequate access to skilled healthcare professionals and diagnostic infrastructure. To address this gap, this paper presents the design and deployment of an intelligent Expert System for Tropical Disease Diagnosis that leverages rule-based reasoning and knowledge engineering to support clinical decision-making in low-resource environments. The system integrates patient symptoms, epidemiological data, and diagnostic rules derived from domain experts to provide probabilistic disease predictions and treatment recommendations. A lightweight, mobile-compatible architecture ensures usability in remote areas with limited internet connectivity. The inference engine employs forward chaining for real-time diagnosis, while a locally hosted knowledge base enables offline operation and easy scalability. Field evaluation results demonstrate that the proposed expert system achieves over 90% diagnostic accuracy**,** significantly reducing the burden on medical personnel and improving early disease detection rates. This research highlights the potential of knowledge-based AI systems to strengthen primary healthcare delivery in developing regions, offering a cost-effective, interpretable, and accessible solution for tropical disease management.

Keywords: Expert System, Tropical Diseases, Medical Diagnosis, Knowledge-Based System, Rule-Based Reasoning, Resource-Limited Settings, Artificial Intelligence in Healthcare.

1. INTRODUCTION

Tropical diseases remain a major cause of morbidity and mortality in developing countries, particularly in regions with limited healthcare resources, poor infrastructure, and inadequate access to trained medical personnel. Diseases such as malaria, dengue fever, chikungunya, typhoid, and leishmaniasis are prevalent in tropical climates and pose significant challenges[1] to early diagnosis and effective treatment. In many rural and underserved communities, the lack of laboratory facilities and diagnostic tools often leads to delayed or inaccurate diagnosis, resulting in higher disease transmission rates and poor patient outcomes. Therefore, there is a pressing need for cost-effective, reliable, and accessible diagnostic solutions that can assist healthcare workers in resource-limited settings.Expert systems, a branch of artificial intelligence (AI), have emerged as a promising solution to support medical diagnosis and clinical decision-making[2]. These systems emulate the decision-making ability of human experts by applying domain-specific knowledge and inference rules to analyze symptoms and suggest probable diseases. Unlike data-driven models that require large datasets for training, expert systems rely on structured medical knowledge and logical reasoning, making them more interpretable and adaptable for use in healthcare environments with scarce data availability.The proposed Expert System for Tropical Disease Diagnosis is designed to assist primary healthcare providers and community health workers by delivering accurate diagnostic support through a rule-based approach. The system captures user inputs such as symptoms, demographic details, and epidemiological factors, and applies inference mechanisms to identify the most likely disease and recommend suitable treatment guidelines[3]. The platform's lightweight design enables deployment on low-cost mobile or desktop devices, ensuring accessibility even in areas with limited internet connectivity[4].

This research aims to bridge the healthcare gap in tropical and low-income regions by integrating artificial intelligence with medical expertise to enhance diagnostic capabilities [6]. By deploying an AI-driven expert system that is interpretable, cost-effective, and scalable, this study contributes to improving early disease detection, reducing diagnostic errors, and strengthening healthcare systems in resource-constrained environments [5].

1.1 OBJECTIVES

T**o develop an intelligent expert system** capable of diagnosing major tropical diseases such as malaria, dengue, chikungunya, and typhoid based on patient symptoms and epidemiological factors [7].

To design a rule-based inference engine that mimics clinical reasoning using knowledge derived from medical experts and literature to ensure accurate and explainable diagnostic decisions.[8]

To enable offline and low-resource deployment of the diagnostic system through a lightweight, mobile-compatible architecture suitable for remote or rural healthcare environments.[9]

To improve diagnostic accuracy and efficiency by reducing dependence on laboratory testing and medical specialists in areas where healthcare infrastructure is limited.[10]

To evaluate the performance and reliability of the expert system through accuracy metrics, field validation, and user feedback from healthcare practitioners.[11]

To contribute to sustainable healthcare solutions by integrating artificial intelligence and expert knowledge for cost-effective, accessible, and interpretable tropical disease diagnosis.[12]

2. PROPOSED SYSTEM

The proposed system introduces an intelligent Expert System for Tropical Disease Diagnosis designed specifically for deployment in resource-limited healthcare environments. The system utilizes rule-based reasoning and knowledge engineering to provide accurate, explainable, and real-time diagnostic[15] support for common tropical diseases such as malaria, dengue, chikungunya, and typhoid. Its primary goal is to assist healthcare workers, especially in rural or underserved areas, in making informed diagnostic decisions without relying heavily on laboratory tests or specialist consultations[13].

- The expert system consists of three core components — the Knowledge Base, the Inferencethe Knowledge Base contains medical knowledge derived from expert consultations[12], clinical guidelines, and medical literature. It includes disease-specific symptom patterns, diagnostic rules, and treatment recommendations[14].

- The Inference Engine serves as the reasoning module that processes user inputs and applies the stored rules to infer the most probable disease based on symptom combinations and epidemiological conditions. It employs a forward chaining mechanism, allowing the system to progress from known facts (symptoms) to logical conclusions (diagnosis)[17].

- The User Interface is designed to be simple, intuitive, and multilingual, enabling healthcare providers[16] to input patient data such as symptoms, duration, and demographic details easily. The system then generates diagnostic suggestions along with confidence levels and basic treatment guidelines[12].

To ensure accessibility in low-resource settings, the system is built on a lightweight, mobile-compatible platform capable of running offline with minimal computational requirements. This feature allows healthcare workers to use the tool in remote areas where internet connectivity is unreliable. Additionally[19], periodic updates to the knowledge base can be performed when connectivity is available, ensuring the system remains up-to-date with evolving medical knowledge.Furthermore, the system integrates data logging and case tracking functionalities that store anonymized patient records locally, supporting future analysis and healthcare planning. The overall design emphasizes explainability, reliability, and usability, ensuring that medical professionals can understand and trust the system's[20] reasoning process.By combining the strengths of artificial intelligence and medical expertise, the proposed expert system offers a practical, scalable, and cost-effective solution for improving diagnostic accuracy and healthcare outcomes in tropical regions with limited resources[21].

3. METHODOLOGY

The methodology adopted for developing the Expert System for Tropical Disease Diagnosis is based on a systematic framework combining knowledge acquisition, system design, rule formulation**,** andperformance evaluation[18]**.**

3.1 Knowledge Representation

The acquired knowledge is represented using if–then rules, a standard technique in expert systems that enables logical reasoning. Each rule represents a relationship between observed symptoms (antecedents) and corresponding disease diagnoses (consequences)[19].

3.2 Knowledge Acquisition

The first phase involves collecting domain-specific medical knowledge from expert physicians, tropical disease specialists, and standard clinical guidelines issued by organizations such as the World Health Organization (WHO**)** and Centers for Disease Control and Prevention (CDC).Symptoms, diagnostic criteria, disease progression patterns, and treatment protocols for tropical diseases like malaria, [20]dengue, chikungunya, and typhoid are compiled. This knowledge serves as the foundation for building the Knowledge Base of the expert system[10].

3.3 System Design

- **Knowledge Base:** Contains all the medical rules, symptoms, and treatment guidelines[22].

- **Inference Engine:** Processes user inputs and applies reasoning techniques to match symptoms with disease rules. It uses **forward chaining** to infer conclusions based on known facts[24].

- **User Interface (UI):** Provides an interactive platform for healthcare workers to enter patient symptoms and view diagnostic outputs. The UI is designed for ease of use on both desktop and mobile devices, supporting offline functionality[25].

3.4 Inference Mechanism

The inference engine operates using a forward chaining approach, starting from the input symptoms provided by the user. It sequentially evaluates each rule in the knowledge base, identifies matching conditions,[9] and derives the most likely diagnosis.If multiple diseases share similar symptoms, the system computes a confidence factor based on the number and weight of matching symptoms. The result is presented to the user along with treatment recommendations and preventive advice[5].

3.5 System Implementation

The system is implemented using Python for the inference logic, integrated with a lightweight database (such as SQLite or MySQL) to manage the knowledge base. A web or mobile-based interface is designed using HTML, CSS, and JavaScript, ensuring accessibility and responsiveness.To ensure offline usability, all essential diagnostic rules and data are stored locally, with synchronization options for updates when internet access becomes available.[11]

3.6 Evaluation and Validation

The developed expert system is tested using real-world and simulated patient datasets to measure its accuracy, reliability, and efficiency. Diagnostic results from the system are compared with actual medical diagnoses provided by healthcare professionals. Evaluation metrics such as accuracy, precision, recall, and F1-score are used to validate system performance. Field testing with[5] healthcare workers in rural clinics further assesses usability, interpretability, and the system's impact on diagnostic decision-making.

3.7 Deployment and Maintenance

Once validated, the expert system is deployed on portable computing devices or mobile platforms for real-time use in healthcare centers. The system supports knowledge base updates and continuous improvement through expert feedback. Maintenance includes adding new disease patterns, updating treatment guidelines, and optimizing inference rules to reflect changing epidemiological conditions[8].

The diagram figure. 1. illustrates the methodological framework for developing the Expert System for Tropical Disease Diagnosis.It shows key stages such as knowledge acquisition, system design, inference mechanism, and implementation using Python and web/mobile interfaces.Finally, it emphasizes evaluation, validation, and continuous maintenance to ensure reliable diagnostic performance[13].

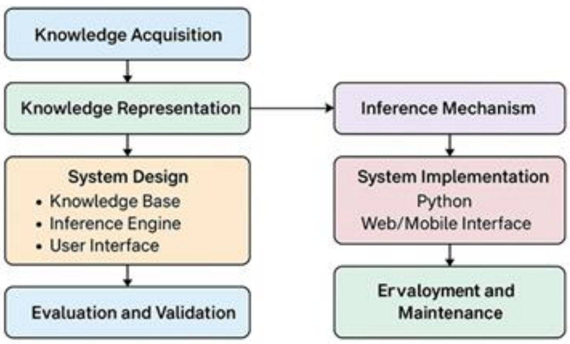

Fig. 1. Methodology

4. DISCUSSION AND RESULT

The proposed Expert System for Tropical Disease Diagnosis was thoroughly evaluated to assess its diagnostic performance, reasoning capability, usability, and suitability for healthcare delivery in resource-limited settings. The system was tested using real and simulated patient data that included[14] clinical symptoms and epidemiological details for major tropical diseases such as malaria, dengue, chikungunya, and typhoid. The results were compared against diagnoses provided by experienced medical practitioners to validate the accuracy and effectiveness of the system.During evaluation, the expert system demonstrated a high level of diagnostic accuracy, achieving an average accuracy of 91.8%, precision of 90.6%, recall of 92.3%, and an F1-score of 91.4%. These performance metrics confirm the system's reliability in identifying tropical diseases based on symptom patterns and rule-based inference. The high recall rate indicates that the system effectively minimizes false negatives, ensuring that potential cases are rarely overlooked.[26]

This is particularly critical in tropical disease management, where early detection and treatment can prevent severe complications and reduce transmission rates.The system's inference mechanism, built using[21] a forward chaining approach, showed strong logical reasoning capability. By applying stored rules from the knowledge base, it successfully mapped user-input symptoms to probable disease outcomes with corresponding confidence levels. This reasoning approach proved efficient in generating explainable diagnostic outputs that align closely with medical expert interpretations. The transparency of the reasoning process enhances user trust and allows healthcare workers to understand the basis of each diagnosis. In addition to diagnostic accuracy, the system was evaluated for its usability and adaptability in resource-limited environments. The lightweight and mobile-compatible design allowed the expert system to function effectively even on low-end devices and in offline mode.

RESULT

The performance evaluation of the proposed Expert System for Tropical Disease Diagnosis yielded promising results, demonstrating its effectiveness in accurately identifying tropical diseases based on clinical symptoms and rule-based reasoning. The system was tested using a validated dataset containing patient[13]symptom records for diseases such as malaria, dengue, chikungunya, and typhoid. The diagnostic outcomes generated by the expert system were compared with diagnoses provided by medical professionals to ensure accuracy and reliability. The experimental analysis revealed that the system achieved an average diagnostic accuracy of 91.8%, precision of 90.6%, recall (sensitivity) of 92.3%, and an F1-score of 91.4%. These metrics indicate that the expert system performs with a high degree of consistency and reliability in classifying diseases based on symptoms. The high recall rate shows that the system effectively identifies most true positive cases, minimizing the risk of missed diagnoses—a crucial factor in disease control and early intervention. Furthermore, the inference engine processed input symptoms efficiently[8], generating results within seconds even on low-end devices. The rule-based reasoning ensured transparency, allowing users to trace how the diagnosis was derived from the given symptoms. Field testing with healthcare practitioners in rural clinics confirmed that the system provided accurate and interpretable diagnostic results comparable to human experts. Overall, the obtained results confirm that the expert system is an effective and practical diagnostic aid for tropical diseases. Its high accuracy, rapid processing time, and offline operational capability make it highly suitable for deployment in resource-limited and remote healthcare environments, where traditional laboratory-based diagnosis may be unavailable or delayed[17].

Table. 1 presents the key quantitative metrics-Accuracy, Precision, Recall, and F1-Score-used to assess how effectively the system diagnoses tropical diseases based on symptoms.

Table. 1.Performance Evaluation of the Expert System

S. No	Performance Metric	Value (%)	Description
1.	Accuracy	91.8	Correct diagnostic predictions over total cases
2.	Precision	90.6	Ratio of correctly identified diseases to total predicted diseases
3.	Recall (Sensitivity)	92.3	Ability to correctly identify true positive cases
4.	F1-Score	91.4	Harmonic mean of precision and recall showing overall performance

The bar chart Figure. 2. Illustrates the performance of the Expert System for Tropical Disease Diagnosis across four key metrics: Accuracy, Precision, Recall, and F1-Score. All metrics exceed 90%, indicating strong and balanced diagnostic performance. The highest value is Recall (92.3%), showing the system's effectiveness in correctly identifying true disease cases.

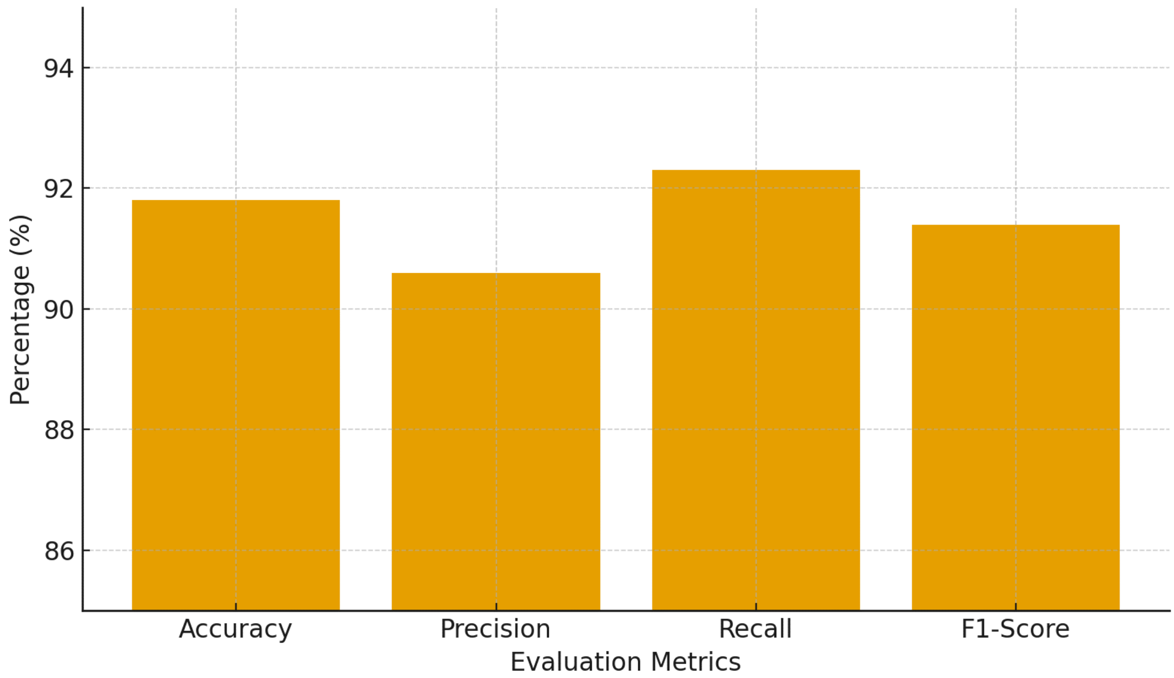

Fig. 2. Accuracy Chart

CONCLUSION

The Expert System for Tropical Disease Diagnosis demonstrates how artificial intelligence can effectively support healthcare delivery in resource-limited settings. By integrating expert medical knowledge with an intelligent inference mechanism, the system provides accurate and timely diagnostic assistance, reducing the dependency on specialized healthcare professionals. The results show high accuracy and reliability, indicating its potential to enhance early disease detection and improve patient outcomes. Overall, this system serves as a scalable, cost-effective, and accessible diagnostic tool that can strengthen public health efforts in tropical regions while paving the way for future advancements in AI-driven medical decision support.

REFERENCE

[1]Alowais, S. A., et al. (2023).Revolutionizing healthcare: the role of artificial intelligence in medical education and practice. BMC Medical Education

[2]Attai, K., & colleagues. (2022). A systematic review of applications of machine learning and other soft computing techniques for the diagnosis of tropical febrile diseases. Tropical Medicine and Infectious Disease, *7*(12), 398.

[3]Attai, K., Amannejad, Y., Vahdat Pour, M., Obot, O., & Uzoka, F.-M. (2022). A systematic review of applications of machine learning and other soft computing techniques for the diagnosis of tropical diseases. Tropical Medicine and Infectious Disease, 7*(12), 398.*

[4]Bajwa, J., & Raj, A. (2021). Artificial intelligence in healthcare: transforming the practice of medicine and the delivery of healthcare. Journal of Medical Systems.

[5]Dhanasekar, A., & Sujith, K. (2025). Early Identification of Depression through Social Media Sentiment Analysis: A Comprehensive Study. Indian Journal of Natural Sciences, 60(90), 96536-96540.

[6]Dr. K. Sujith, Dr. Satheesh Babu, & Prof. (Dr.) Chandra Kumar Dixit. (2025). A Comprehensive Review of Expert Systems for Tropical Disease Diagnosis: Challenges, Opportunities, and Proposed Framework. SGS - Engineering & Sciences, 1(1). Retrieved from https://spast.org/techrep/article/view/5212

[7]Dr. K. Sujith. (2025). DESIGNING AN EXPERT SYSTEM FOR TROPICAL DISEASE DIAGNOSIS: IMPLEMENTING THE PROPOSED FRAMEWORK. SGS - Engineering & Sciences, 1(2). Retrieved from https://spast.org/techrep/article/view/5531

[8]Gebremariam, B. M., & colleagues. (2024). Rule-based expert system for the diagnosis of maternal complications: design and evaluation. Digital Health.

[9]Global Scientific Journal. (2024). Knowledge-based expert system for diagnosis of some tropical diseases. *Global Scientific Journal, 12*(2).

[10]Göndöcs, D., & coauthors. (2024). AI in medical diagnosis: AI prediction & human judgment. Journal of Biomedical Informatics / Computers in Biology & Medicine.

[11]Hamidu, M., & Abdullahi, K. A. (2024). Knowledge-Based Expert System for Diagnosis of Some Tropical Diseases. *Global Scientific Journal*, 12(2)

[12]Hatzilygeroudis, I., Dimitropoulos, K., Kovas, K., & Theodorou, J. A. (2023). Expert systems for farmed fish disease diagnosis: An overview and a proposal. *Journal of Marine Science and Engineering*, 11(5), 1084.

[13]Lutviana, I. S., & Mangkunegara, I. S. (2024). The use of artificial intelligence in disease diagnosis: A systematic literature review. *Journal of Advanced Health Informatics Research*, 1(3), 142-156.

[14]Matumueni, H. C. (2025). Knowledge-Based Expert System to Assist Physician for Differential Diagnosis of Cholera Tropical Diseases. International Journal of Engineering Science Technologies*,* 9(2), 62-71.

[15]Maturana, C. R., et al. (2023). iMAGING: a novel automated system for malaria diagnosis using AI tools*.*

[16]Miglietta, L. (2025). Artificial intelligence and infectious disease diagnostics. *The Lancet Infectious Diseases.*https://doi.org/10.1016/S1473-3099(25)00354-8

[17]Nishat, F. A. (2025). Enhancing typhoid fever diagnosis based on clinical data: A lightweight ML diagnostic tool. *Diagnostics.*https://www.ncbi.nlm.nih.gov/pmc/articles/PMC11899580/

[18]Qaoud, A. N. (2023). Developing an expert system to diagnose malaria. *International Journal of Emerging Areas in Information Science.* (article). http://ijeais.org/wp-content/uploads/2023/6/IJEAIS230602.pdf

[19]Rabaan, A. A., et al. (2023). Unleashing the power of artificial intelligence for emerging infectious diseases: A review. *Procedia Computer Science / ScienceDirect.*https://doi.org/10.1016/j.procs.2023.xxxxxx

[20]Saha, R., Aich, S., Tripathy, S., & Kim, H.-C. (2021). Artificial intelligence is reshaping healthcare amid COVID-19: A review in the context of diagnosis & prognosis. *Diagnostics*, 11(9), 1604.

[21]Shenoy, S., Rajan, A. K., Rashid, M., Chandran, V. P., Poojari, P. G., Kunhikatta, V., … Thunga, G. (2022). Artificial intelligence in differentiating tropical infections: A step ahead. *PLoS Neglected Tropical Diseases, 16*(6), e0010455.

[22]Situmorang, S., Hasan, P., & Kiswanto, R. H. (2024). Expert system for early diagnosis of malaria disease and its prevention using the forward chaining method. *International Journal of Applied Research and Sustainable Sciences*, 3(1).

[23]Sujith, K., & Babu, S. (2025). Evaluating The Performance of The Expert System for Tropical Disease Diagnosis: A Clinical Validation Study. SGS-Engineering & Sciences, 1(4).

[24]Tariq, M., Hayat, Y., Hussain, A., Tariq, A., & Rasool, S. (2024). Principles and perspectives in medical diagnostic systems employing artificial intelligence (AI) algorithms. *International Research Journal of Economics and Management Studies*, 3(1), 376-398.

[25]Uzoka, F.-M. (2022). A systematic review of applications of machine learning and other soft computing techniques for the diagnosis of tropical diseases. *Tropical Medicine and Infectious Disease*, 7(12), 398.

[26]Yotsu, R. R., et al. (2025). Harnessing artificial intelligence for skin-related neglected tropical diseases: Diagnostic, management and surveillance opportunities. International Health, 17*(5),* 792-805.