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**Research Article**

# Machine Learning Techniques in Medical Diagnosis for Measles Symptoms in Jolo: Challenges and Opportunities

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**ABSTRACT**

Despite being preventable, measles remains a major health threat in Jolo due to persistent challenges in diagnosis and healthcare access, especially in resource-limited settings. This study assessed these challenges—specifically in diagnosis and medical data accessibility, healthcare workforce and communication, and infrastructure and ethical concerns—while designing a machine learning (ML)-based application tailored to local needs. Using a mixed-methods research design, the study combined quantitative and qualitative data to evaluate the system's feasibility and effectiveness. Developed through Agile methodology, the application underwent iterative refinement to remain responsive to user needs. Quantitative data, gathered through system testing and Likert-scale surveys among IT experts and healthcare workers, showed a "very acceptable" level of user satisfaction across functionality, usability, reliability, and performance. The ML model achieved approximately 93% validation accuracy over 50 training epochs, indicating strong generalization. Qualitative insights from interviews and observations revealed the system's cultural relevance, usability, and addressed ethical concerns. The results highlight the application's potential to improve diagnostic accuracy, enable early detection, and expand access to care in underserved areas. Although reliability and performance had modest areas for improvement, stakeholders strongly supported the tool's integration into local healthcare systems. Overall, the study demonstrates the viability and promise of ML-based solutions in addressing measles and broader healthcare challenges in remote communities.

**Keywords** machine learning, measles, diagnosis, healthcare, symptoms

## Introduction

This chapter discussed the overview of general and specific requirements, the scope and a list of important terms or acronyms that the developer defines Measles was a highly contagious viral infection that primarily affects children and may lead to serious health complications. Despite the availability of an effective vaccine, outbreaks still occurred in areas with low immunization coverage. Although there was no cure for measles, the illness may be significantly reduced by immunizing with the very effective measles vaccination (MHFW, 2017). The virus was often carried through the air, with most instances being self-limiting. The fact that the laboratory diagnosis of virus infections was a lengthy process was a constant complaint of our clinical practitioners. It has been established that the characteristic pathological feature of measles was the appearance of large multinucleated giant cells, particularly in areas of lymphoid tissue.Measles may affect individuals of all ages, but certain groups are more susceptible to severe complications. Children under 5 years old are particularly vulnerable, as they are at higher risk for severe complications such as pneumonia, encephalitis (brain inflammation), and death. Adults over 20 who have not been vaccinated or previously had measles are also at increased risk for complications and tend to experience more severe symptoms than children. Unvaccinated individuals, especially those who have not had measles before, are at high risk. Measles is highly contagious, and individuals who have not been vaccinated or previously infected may easily contract the disease from an infected person. The best protection against measles is vaccination (CDC.GOV., 2019). The National Center for Biotechnology Information (NCBI, 2019) notes that unvaccinated young children and pregnant women are at high risk for contracting measles, and measles most commonly affects young children. According to the World Health Organization (WHO, 2019), the clinical case definition for measles includes the presence of fever (typically ≥38.3°C), a maculopapular rash that starts on the

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face and spreads downward, and at least one of the following symptoms: cough, coryza (runny nose), or conjunctivitis (eye inflammation). These core clinical features are essential for identifying suspected measles cases and form the basis of the standard clinical case definition. Fever is a primary indicator, with temperatures at or above 38.3°C considered significant. The maculopapular rash was a hallmark sign, noted for its characteristic pattern of facial onset and downward spread. Additionally, the presence of at least one respiratory symptom—cough, coryza, or conjunctivitis—was necessary to meet the measles case criteria. The reality that almost all unvaccinated individuals who are exposed to the virus become infected underscores the critical need for prompt and accurate diagnosis. In my view, effectively controlling measles outbreaks depends on early detection, which may be challenging in areas with limited medical infrastructure. Although traditional diagnostic methods are reliable, they are often impractical in resource-constrained settings because they depend on specialized laboratories, advanced equipment, and skilled personnel. The virus affects respiratory mucosa and was transmitted by droplets released when an infected individual coughs or sneezes. People who have no immunity against the virus (thus, between seventy-five and ninety-five percent) become infected when they come into contact with the virus. Almost all people who are infected become clinically ill (Misin et al., 2020). Recognized as a highly contagious and potentially dangerous disease, measles may lead to severe health complications, particularly in young children. This demonstrates the importance of finding cases early and diagnosing them accurately for effective management as well as outbreak control. Classical diagnostic techniques are robust but time-consuming and reliant on healthcare infrastructure. Among potential strategies was machine learning techniques. Machine learning algorithms are becoming increasingly popular in various fields due to their ability to analyze large amounts of data and identify patterns that can aid in decision-making. Rao, et al. (2022) noted that measles disease is usually diagnosed through an RT-PCR test, which detects the measles-specific IgM antibody in serum samples. However, this approach was highly expensive and requires a lot of sample preprocessing, making it a laborious task. Identifying the most relevant demographic factors related to measles was essential since it substantially contributes to infant mortality. These factors include gender, age group, region, settlement type, and vaccination status. By increasing the fraction of measles patients detected at an early stage, early identification of the disease may play a crucial role in improving patient survival (Rao et al., 2022).The use of machine learning (ML) techniques in healthcare has revolutionized disease diagnosis, offering new approaches to early detection, treatment planning, and prediction of disease outcomes. In the context of infectious diseases, the application of ML has proven particularly valuable, enabling faster, more accurate diagnoses, even in resource-limited settings. Measles, a highly contagious viral disease, remains a major global health concern despite the availability of an effective vaccine. Early and accurate diagnosis was essential for managing measles outbreaks, especially in regions where immunization coverage is incomplete or where diagnostic infrastructure was inadequate (Zhou et al., 2019). While the clinical diagnosis of measles relies on a combination of symptom observation and laboratory testing, the rise of machine learning techniques offers the potential to enhance diagnostic accuracy and speed, particularly in complex or ambiguous cases. A key advantage of machine learning lies in its capacity to process vast amounts of data and detect patterns that might be missed using conventional diagnostic methods.

## Results And Discussions

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This chapter presents the findings derived from the study on the application of machine learning techniques in diagnosing measles symptoms within the context of Jolo. The analysis focuses on addressing the core research questions related to the challenges faced in measles diagnosis, the design and development of a machine learning-based diagnostic application, and its feasibility and effectiveness in a resource-constrained environment. Both quantitative and qualitative data collected through surveys, interviews, and system performance evaluations are systematically examined to provide insights into the diagnostic accuracy, usability, reliability, and acceptance of the proposed system by healthcare workers and IT professionals. Furthermore, this chapter discusses the implications of these findings within the broader context of healthcare delivery in rural settings, highlighting the potential opportunities and limitations of integrating machine learning into existing healthcare infrastructure. The discussion also explored how identified challenges—including data accessibility, workforce communication barriers, infrastructure constraints, and ethical considerations—impact the implementation and sustainability of such technology in Jolo. Through this comprehensive analysis, the chapter aimed to bridge theoretical knowledge and practical application, offering evidence-based recommendations to enhance measles diagnosis and management using machine learning in similar settings.

The findings were subsequently informing the conclusions and recommendations.

## Presentation of Results Based on Objectives

This section presents the findings of the study. The data were interpreted and analyzed according to the study's general and specific objectives. These findings provided a comprehensive understanding of the system's development, performance, and the contextual challenges and opportunities of implementing machine learning in the medical diagnosis of measles. The general objective of this study was to develop a machine learning-based system for diagnosing measles symptoms in Jolo, addressing local limitations in data quality, infrastructure, and healthcare capacity to enhance diagnostic accuracy and support effective disease management.

To Developed System Based on Functionality, Usability, Reliability, and Performance

The system's development and performance were evaluated using Python, Streamlit, NumPy, Pandas, and the Random Forest Classifier algorithm. Training conducted over 50 epochs resulted in steadily improving accuracy and decreasing loss, with validation accuracy stabilizing at 93%, indicating strong generalization and minimal overfitting. The confusion matrix showed perfect classification for all "RASH" cases with a recall and precision of 100%, and only one misclassified "NORMAL" case. This indicates the system's strong reliability in detecting rash-related symptoms, which was critical for measles diagnosis. Assessment of the machine learning system based on its functionality, usability, reliability, and performance yielded highly favorable results.

Functionality: Functionality received the highest score with a weighted mean of 4.89, reflecting excellent interface usability (5.00), immediate feedback (4.83), and fast loading speed (4.83).

Usability: Usability followed with a mean of 4.72, marked by clear content (4.67), intuitive interface (4.67), and appealing design (4.83).

Reliability: Reliability was rated at 4.42, where data input handling scored 4.33 and diagnostic accuracy 4.50, indicating general reliability with room for improvement.

Performance: Performance also scored 4.42, reflecting acceptable speed efficiency (4.33) and strong real-time updating (4.5). Overall, the system was rated "Very Acceptable" with a total weighted mean of 4.613.

This study concentrates on identifying challenges and exploring opportunities to enhance diagnostic accuracy. The following specific objectives guided the research and shaped the presentation of findings:

Objective 1: To Determine the Levels of Challenges Encountered by Respondents Regarding Measles Disease

Findings were grouped into three major domains: diagnosis and medical data accessibility, healthcare workforce and communication barriers, and infrastructure and ethical concerns.

Diagnosis and Medical Data Accessibility: Both IT professionals and healthcare providers reported this area as extremely challenging, with a general weighted mean of 4.868. Key concerns included the similarity of measles symptoms to other illnesses and limited access to patient records, both rated at 4.67. More severe challenges—such as outdated or missing health data systems, delayed lab results, and the lack of timely diagnostic tools—were rated with perfect scores of 5.00. These results highlighted the inadequacy of current diagnostic resources and the need for better data systems and rapid testing mechanisms.

Healthcare Workforce and Communication Barriers: The findings showed a general weighted mean of 4.002, indicating that this domain was very challenging. The lack of trained personnel and inadequate training in digital or AI tools were considered the most pressing issues, both receiving a perfect score of 5.00. These are followed by heavy workloads among healthcare workers (3.67) and limited public awareness (4.17). Interestingly, language barriers were seen as less significant, with a mean score of 2.17. These results indicate the importance of strengthening healthcare human resources, digital competency, and public education to support measles diagnosis.

Infrastructure and Ethical Concerns: The general weighted mean of 4.734 suggests extremely challenging conditions. Respondents rated the lack of internet access, digital devices, and ethical concerns over AI in healthcare with perfect scores of 5.00. Power outages and patient reluctance to share data were also major concerns, receiving mean scores of 4.67 and 4.83, respectively. Data security and privacy scored 4.17, showing the necessity for secure and ethically sound diagnostic solutions. These findings underscored the infrastructural limitations and ethical considerations that must be addressed for successful implementation of AI technologies.

Objective 2: To Design a Machine Learning-Based Application That Addresses the Diagnosis and Health Implications of Measles

The study assessed both the essential features and functionalities of the system and its potential to address access, ethical, and infrastructural issues.

Features and Functionalities: Respondents unanimously agreed (mean score of 5.00) that essential features must include real-time diagnostic capability, simple and fast symptom input, offline access, integration with existing health records, and a user-friendly interface. These are considered critical in making the system efficient and practical in a rural setting like Jolo.

Addressing Healthcare Access, Ethical Concerns, and Infrastructure Limitations: The study found strong agreement (general weighted mean of 4.9) on several priorities. Data privacy, ethical and cultural sensitivity, and minimizing administrative burden for healthcare workers all received perfect scores of 5.00. Compatibility with basic mobile devices was also highly valued (4.83), ensuring the system's accessibility in rural areas. Community involvement in the app's design was rated at 4.67, reflecting the belief that community perspectives are vital for effective implementation.

Ethical Considerations: Informed consent was regarded as essential, with a perfect score of 5.00. Privacy, data security, fairness, and non-discrimination scored 4.67 each, while transparency in the AI's diagnostic logic received a score of 4.5. These results affirmed the importance of embedding strong ethical standards in system development to build trust and acceptance.

Implementation and Support: Implementation and support considerations also received full endorsement from respondents, with a mean score of 5.00. These included the need for healthcare worker training, community acceptance, government or health authority support, and inclusion of feedback mechanisms. These findings suggest that for successful implementation, both technical readiness and social support are necessary.

### Opportunities for Implementation of the Machine Learning Model

The findings, with a weighted mean of 4.26, show a positive consensus among IT and healthcare professionals. They agreed that machine learning enhances diagnostic accuracy, supports early detection, reduces human error, improves healthcare access in remote areas, enables outbreak prediction, and offers long-term cost-efficiency. These results supported the conclusion that the machine learning-based system has both the technical capability and contextual relevance to serve as a practical diagnostic tool for measles in Jolo.

### Verification of the Studies

The verification of this study was conducted through a rigorous two-tiered validation process to ensure both the technical soundness of the machine learning system and its practical applicability in real-world healthcare settings. This process incorporated technical verification through model evaluation and user-centered verification through practitioner feedback, thereby reinforcing the reliability, effectiveness, and relevance of the developed system.

### Technical Verification

To establish the system's technical credibility, a machine learning model was developed using Python along with data processing libraries such as NumPy and Pandas, and the Streamlit framework for interface deployment. A Random Forest Classifier, known for its robustness in handling classification tasks and resistance to overfitting, was employed for symptom prediction.

The model underwent a comprehensive training process over 50 epochs, during which it consistently improved in accuracy. Results showed a validation accuracy of 93%, reflecting the model's strong predictive capacity. The

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confusion matrix analysis further demonstrated precise performance, with perfect classification of measles-related symptoms like "RASH", and only a single misclassification among "NORMAL" cases. These outcomes validate the model's ability to generalize well across unseen data and support its use as a reliable diagnostic aid.

In addition, the use of standardized performance metrics such as precision, recall, and F1-score (computed using scikit-learn) provided further evidence of the model's balanced and consistent performance across different symptom categories. These results affirmed that the model not only performs well statistically but also meets clinical expectations for sensitivity and specificity in the context of measles diagnosis.

### User-Centered Verification

Beyond technical performance, it was critical to verify the system's functionality and acceptability from the perspective of intended users—specifically, healthcare professionals and IT experts. This was accomplished through structured questionnaires that used a Likert-scale format to evaluate the system across four key dimensions: functionality, usability, reliability, and performance. Feedback from practitioners yielded a total weighted mean score of 4.613, classified as "Very Acceptable." Specifically, the system was praised for its intuitive user interface, real-time responsiveness, ease of use, and quick load times. Functionality scored highest (4.89), followed by usability (4.72), demonstrating the tool's practical utility in a clinical setting. Although reliability and performance were slightly lower (both at 4.42), these scores still fell within a high-performance range, indicating solid consistency and responsiveness under typical operating conditions.

Qualitative feedback also underscored the system's value in supporting rapid decision-making, minimizing diagnostic errors, and improving access to care in remote areas such as Jolo. Participants expressed confidence in the system's integration potential within existing medical workflows, especially if complemented by proper training and institutional support.

Software Architecture and System Components

| Component | Description |
|---|---|
| Python 3.8+ | Core programming language |
| Flask | Web framework |
| scikit-learn | Machine learning model (Random Forest) |
| Keras / TensorFlow | Deep learning models for rash and Koplik detection |
| pandas / numpy | Data manipulation and numeric processing |
| pickle | Model persistence for Random Forest |
| Jupyter Notebook | Used during model development and testing |
| HTML Templates | For renderi<br><br>ng user interface and diagnosis results |

The software system for this study integrates machine learning and web technologies to support the automated diagnosis of measles symptoms using both clinical data and image analysis. The system was implemented using Python and is built on a modular and scalable architecture. Below are the key software components and their respective functions:

| Component | Technology | Role |
|---|---|---|
| Front-End | HTML (via Flask templates), form elements | User input, display results |
| Back-End | Python, Flask, scikit-learn, Keras, pandas, numpy | Data processing, AI prediction, routing, logic |

Table 2. Core Technologies and Tools Used in the Development of the Measles Diagnostic System

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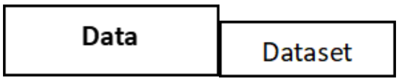
Table 3. System Architecture Components and Their Technologies with Functional Roles

The system developed for this study does not utilize a traditional external database such as MySQL, PostgreSQL, or MongoDB. Instead, it employs file-based data storage methods customized to the system's needs. The primary dataset, Measles_Dataset.csv, is a CSV file used to train the Random Forest classifier and is loaded using the pandas.read_csv() function within the load_dataset() function. For storing the trained machine learning model, a pickle (.pkl) file, named measles_model.pkl, was used. This file was created with pickle.dump() after training and loaded for prediction using pickle.load().

In addition, two deep learning models—rash_model.h5 and koplik_model.h5—are stored in HDF5 (.h5) format and loaded using keras.models.load_model() for detecting rash and Koplik spots in uploaded images. User-submitted images are temporarily saved in the uploads/ directory on the local file system, managed via Flask's file.save() method.




Design and Building of the Machine for Learning Model Measles Symptoms Diagnosis

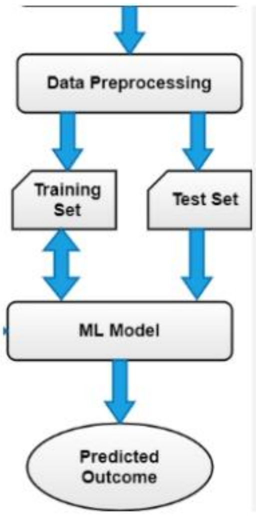



**Figure 13. Architecture Design of the input and output process.**

In this study, the researcher developed a measles symptoms diagnosis system using machine learning. Python served as the primary programming language, aiming to enhance healthcare diagnostics by improving the diagnosis of measles symptoms through machine learning. The software components from the Python ecosystem were utilized, including the Streamlit web application framework for building interactive, user-friendly interfaces. The scikit-learn library was employed for machine learning tasks, while essential libraries such as NumPy and Pandas facilitated data manipulation. A critical element in model development was the Random Forest Classifier (RFC) algorithm, available within scikit-learn. Model accuracy was evaluated using scikit-learn's metrics module and the accuracy score function. This integrated combination of Python, Streamlit, NumPy, Pandas, scikit-learn, and the RFC algorithm provides a robust foundation for diagnosing measles symptoms in a hospital setting. The system operated on a Windows 11 laptop optimized for 64-bit architecture, which supported the machine learning-based improvements in measles symptoms diagnosis.

Data Preprocessing and Model and System Building

Loading the Dataset and Handling Missing Values:

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The dataset (label.csv) was loaded into a Pandas DataFrame, where handling missing values was critical. In this instance, rows with missing values in the measles symptoms column were removed. Since missing values may negatively impact the model's performance, it was important to address them properly.

Feature Description of the Measles Symptoms

Fever: A temporary increase in body temperature, often due to an infection or illness, usually above the normal range of 98.6°F (37°C). It was a common symptom of various diseases, including viral and bacterial infections. The fever was entered as an input with values of 0 or 1, where 0 indicates the patient does not have a fever, and 1 indicates the patient has a fever.

Rash: A noticeable change in the skin's appearance, typically characterized by redness, bumps, blisters, or irritation. Rashes can be caused by many factors, including infections, allergic reactions, or skin conditions. This can be detected through computer vision using a webcam.

Cough: A sudden, forceful release of air from the lungs, usually as a reflex to clear the throat or airways of irritants. It was a common symptom of respiratory infections, allergies, or other conditions affecting the respiratory system. The cough was entered as an input with values of 0 or 1, where 0 indicates the patient does not have a cough, and 1 indicates the patient has a cough.

Koplik's Sign: Small, white or bluish-white spots that appear inside the mouth, typically on the inner lining of the cheeks. This was a characteristic early sign of measles, often appearing a few days before the characteristic rash. This may be detected through computer vision using a webcam.

Coryza: The medical term for the common cold, characterized by symptoms like nasal congestion, runny nose, sneezing, and sore throat. It was typically caused by viral infections like rhinovirus. The coryza was entered as an input with values of 0 or 1, where 0 indicates the patient does not have a coryza, and 1 indicates the patient has a coryza.

Conjunctivitis: Inflammation of the conjunctiva, the thin layer that lines the inside of the eyelids and covers the white part of the eyeball. It caused redness, itching, swelling, and discharge from the eyes, and may be caused by infections (bacterial or viral), allergies, or irritants. The conjunctivitis was entered as an input with values of 0 or 1, where 0 indicates the patient does not have a conjunctivitis, and 1 indicates the patient has a conjunctivitis.

Blood Test Results: Antibody tests are typically used to confirm a measles infection. IgM was typically indicative of an active infection, while IgG suggests past exposure or vaccination. It takes values of 0 or 1, where 0 indicates the absence of IgM, and 1 indicates the presence of IgM in the blood.

```
Dataset Preview:
   fever  rash  cough  koplik sign  coryza  conjunctivitis  measles_diagnosis
0      1     0      1            1       1               1                  1
1      0     1      1            0       1               1                  1
2      1     1      1            1       0               1                  1
3      1     0      1            1       1               1                  1
4      0     1      1            1       1               0                  1

Column Names: ['fever', 'rash', 'cough', 'koplik sign', 'coryza', 'conjunctivitis', 'measles_diagnosis']
```

Figure 14. Display the info about the Data set.

```
Missing values per column:
fever                0
rash                 0
cough                0
koplik sign          0
coryza               0
conjunctivitis       0
measles_diagnosis    0
dtype: int64
```

Figure 15. Check Null values in the Data set.

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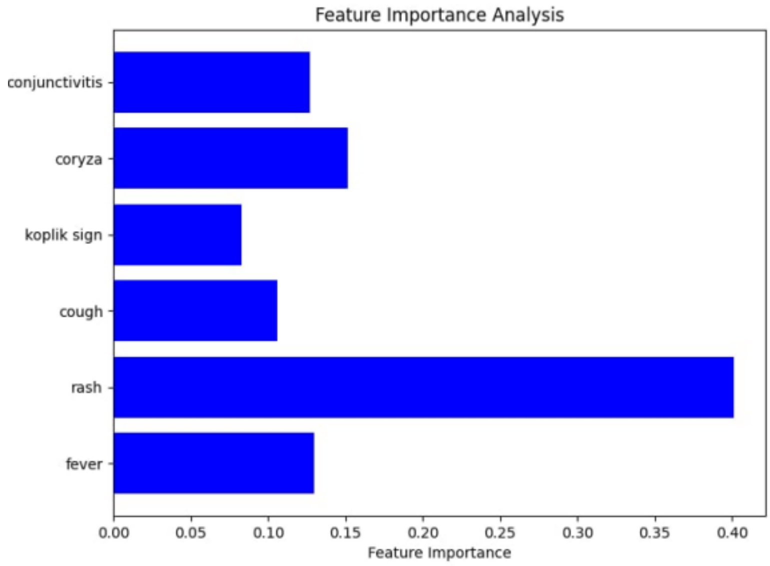


Figure 15 provides a visual representation of the dataset's completeness. It clearly indicates that there are no null values present, implying that each entry has all required information.

Figure 16. Feature importance of each variable or parameter in the Datasets using Random Forest Classifier.

The feature importance analysis revealed that rash was the most significant clinical indicator for measles diagnosis, with an importance score close to 0.40. This suggested that the presence of a rash played a dominant role in distinguishing measles cases within the model. Coryza, conjunctivitis, fever, and cough followed with moderate importance, indicating that while they were useful for diagnosis, they were not as influential individually as rash. Interestingly, Koplik sign, despite being a classic clinical sign of measles, showed the lowest importance among the features analyzed. This may have been attributed to its relatively rare documentation or its late appearance in the disease course, making it less impactful for early predictive modeling. Overall, the model prioritized highly visible and consistently reported symptoms such as rash, while still considering a combination of respiratory and systemic symptoms for accurate classification.

Model Training and Testing

A Random Forest classifier was initialized. The classifier was trained on the training data using classifierr.fit(x_test, y_train).

# Split the data into training and testing sets

X_train, X_test, Y_train, Y_test = train_test_split(features, labels, test_size=0.2, stratify=labels, random_state=2)

# Train the Random Forest model

classifier = RandomForestClassifier(n_estimators=100, random_state=2) classifier.fit(X_train, Y_train)

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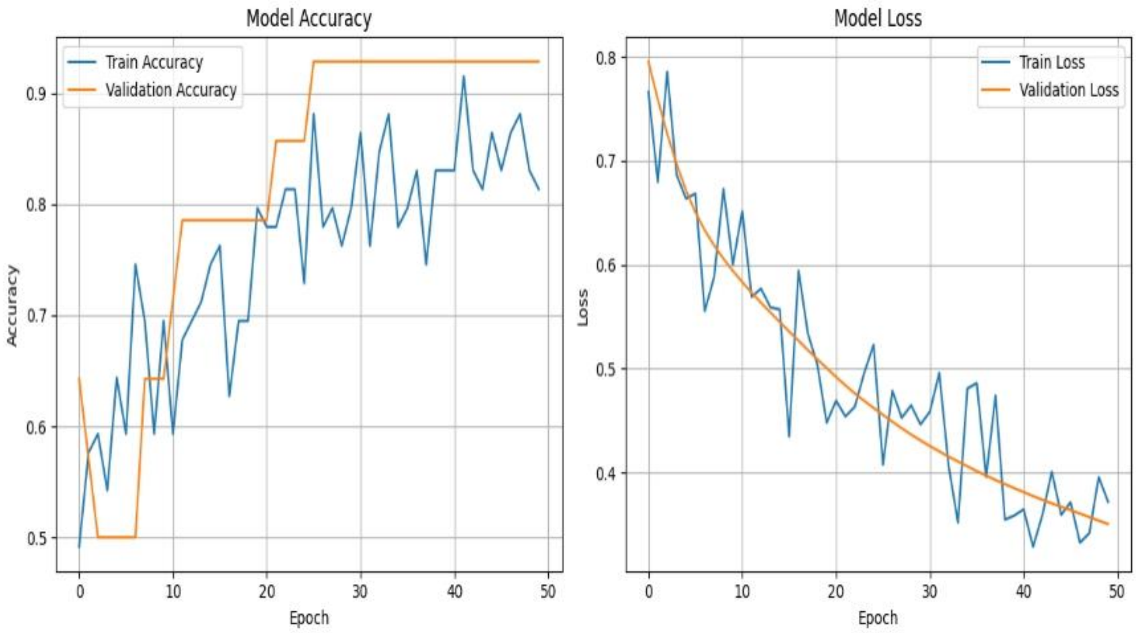


Figure 17. Model Accuracy and loss plots

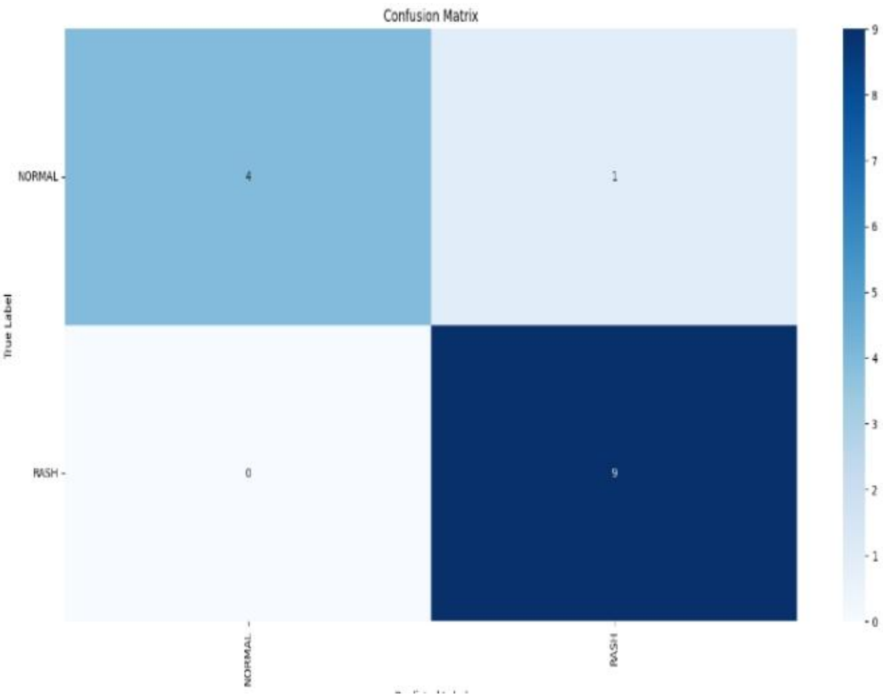


Figure 18. Confusion Metrix

The training performance of the model, as shown in the accuracy and loss plots, demonstrates effective learning over the course of 50 epochs. The training accuracy steadily increases, with validation accuracy closely following and eventually plateauing around 93%, indicating that the model generalizes well to unseen data. The loss curves for both training and validation also show a consistent downward trend, with validation loss closely matching training loss throughout training. This alignment suggests that the model is not overfitting and is learning relevant patterns rather than memorizing the training data. The relatively low final loss values and high validation accuracy indicate that the model achieves strong predictive performance and maintains stability during training, which was crucial for reliable clinical decision-making, such as measles diagnosis.

The matrix shows that out of 5 actual "NORMAL" cases, the model correctly identified 4 and misclassified 1 as "RASH". Conversely, all 9 actual "RASH" cases were correctly classified, with zero misclassifications. This resulted in a high overall accuracy and particularly strong performance in detecting "RASH" cases, with a recall of 100% for the "RASH" class. The precision for "RASH" was also high, as there were no false positives. However, the model demonstrated a slight weakness in classifying "NORMAL" instances, as indicated by one false positive. Despite this, the model showed strong diagnostic reliability, especially in correctly identifying cases associated with rash-related conditions, which was critical in the context of measles or similar infectious diseases.

| Term | Value | Explanation |
|---|---|---|
| True Positives (TP) | 9 | RASH correctly predicted as RASH |
| False Positives (FP) | 1 | NORMAL incorrectly predicted as RASH |
| False Negatives (FN) | 0 | RASH incorrectly predicted as NORMAL |
| True Negatives (TN) | 4 | NORMAL correctly predicted as NORMAL |

**Table 4. Confusion Matrix breakdown for the RASH**

| Metric | Formula | Calculation | Result |
|---|---|---|---|
| Precision (RASH) | TP / (TP + FP) | 9 / (9 + 1) | 0.90 |
| Recall (RASH) | TP / (TP + FN) | 9 / (9 + 0) | 1.00 |
| F1-Score (RASH) | 2 × (Precision × Recall) / (Precision + Recall) | 2 × (0.90 × 1.00) / (0.90 + 1.00) | 0.947 |

**Table 5. Performance Metrics calculation for the RASH class**

| Term | Value | Explanation |
|---|---|---|
| True Positives (TP) | 4 | NORMAL correctly predicted as NORMAL |
| False Positives (FP) | 0 | RASH incorrectly predicted as NORMAL |
| False Negatives (FN) | 1 | NORMAL incorrectly predicted as RASH |
| True Negatives (TN) | 9 | RASH correctly predicted as RASH |

**Table 6. Confusion Matrix breakdown for the NORMAL class**

| Metric | Formula | Calculation | Result |
|---|---|---|---|
| Precision (NORMAL) | TP / (TP + FP) | 4 / (4 + 0) | 1.00 |
| Recall (NORMAL) | TP / (TP + FN) | 4 / (4 + 1) | 0.80 |
| F1-Score (NORMAL) | 2 × (Precision × Recall) / (Precision + Recall) | 2 × (1.00 × 0.80) / (1.00 + 0.80) | 0.89 |

**Table 7. Performance Metrics calculation for the NORMAL class**

| Metric | NORMAL Class | RASH Class |
|---|---|---|
| True Positives (TP) | 4 | 9 |
| False Positives (FP) | 0 | 1 |
| False Negatives (FN) | 1 | 0 |

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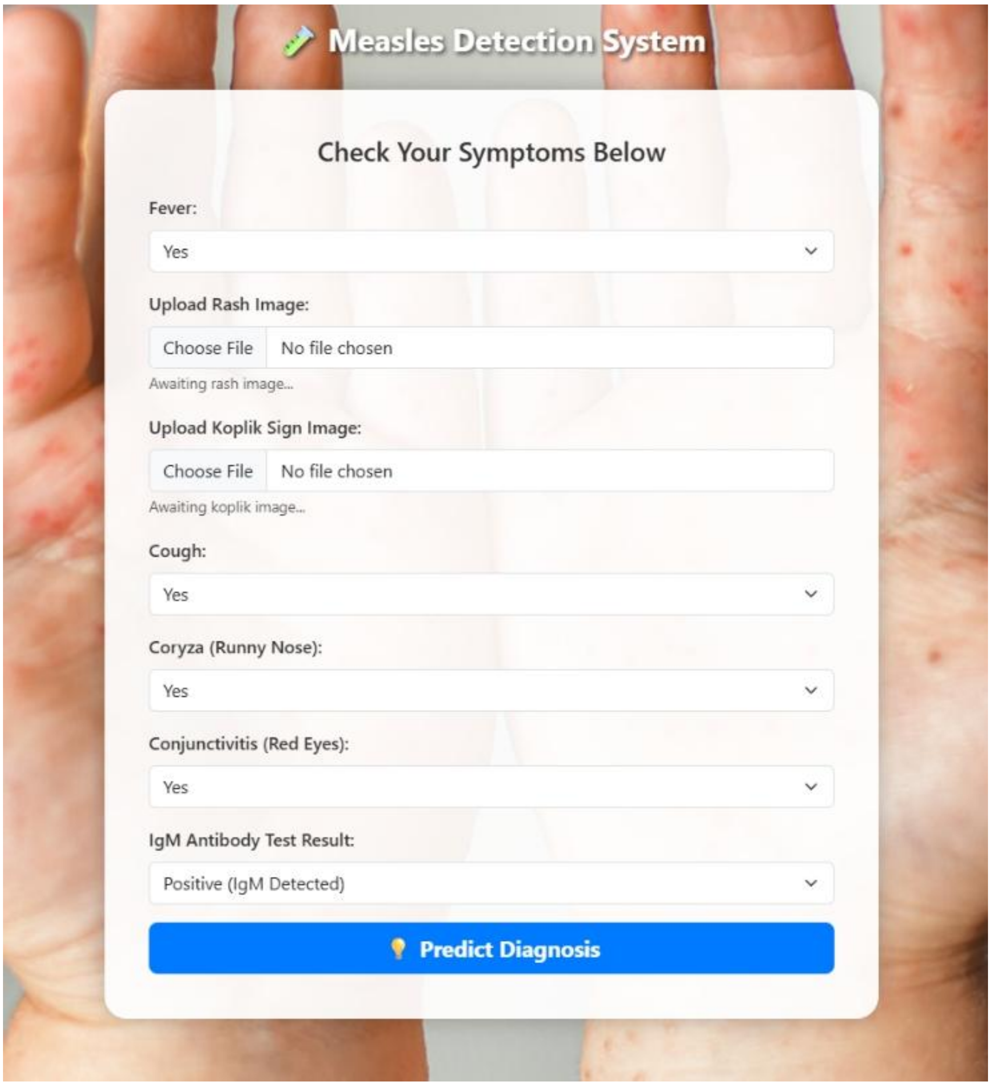
| | | |
|---|---|---|
| True Negatives (TN) | 9 | 4 |
| Precision | 1.00 | 0.90 |
| Recall | 0.80 | 1.00 |
| F1-Score | 0.89 | 0.95 |

**Table 8. Summary of the performance metrics for both the NORMAL and RASH classes**

| Metric | Formula | Calculation | Result |
|---|---|---|---|
| Accuracy (Overall) | (TP + TN) / Total Samples | (4 + 9) / 14 | 0.93 (93%) |

**Table 9. Overall accuracy calculation**



Prediction/Diagnosis

**Figure 19. Measles Symptoms Diagnostic System**

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Discussion

Evaluation of System Acceptability

Table 10, Table Evaluation results of respondents based on the response of level of acceptance of the proposed tool: Machine Learning Techniques in Medical Diagnosis for Measles Symptoms under ISO 9126-1 functionality

| Indicators | IT | Healthcare Providers | | | | | Respondents Response | |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | Mean | Description |
| The system interface is working (functionality) | 5 | 5 | 5 | 5 | 5 | 5 | 5 | Very acceptable |
| Feedback is immediate (functionality) | 5 | 5 | 5 | 5 | 5 | 4 | 4.83 | Very acceptable |
| The program loads quickly (functionality) | 5 | 4 | 5 | 5 | 5 | 5 | 4.83 | Very acceptable |
| General weighted mean | | | | | | | 4.89 | Very acceptable |

Table 10. Respondents' Evaluation of System Functionality Based on ISO 9126-1: Level of Acceptance of the Proposed ML-Based Diagnostic Tool

The table 10, presents the evaluation results of the system's functionality based on three key indicators: system interface performance, immediacy of feedback, and program loading speed. Respondents from both the Information Technology (IT) sector and healthcare providers assessed each indicator using a five-point Likert scale, where 1 denotes "very unacceptable" and 5 signifies "very acceptable." The results indicated that the indicator "The system interface is working" received a perfect mean score of 5.00, suggesting unanimous agreement among respondents that the system's interface is highly functional and meets user expectations. The indicators "Feedback is immediate" and "The program loads quickly" both received a slightly lower, yet still outstanding, mean score of 4.83, demonstrating that users perceive the system as responsive and efficient in terms of performance and speed. The general weighted mean across all indicators was calculated to be 4.89, which falls within the "very acceptable" range. These results collectively indicate a high level of user satisfaction with the system's overall functionality, affirming its reliability and effectiveness in practical use. The consistent ratings across different respondent groups further emphasized the system's robust performance and user-centered design.

Table 11, Table Evaluation results of respondents based on the response of level of acceptance of the proposed tool: Machine Learning Techniques in Medical Diagnosis for Measles Symptoms under ISO 9126-1 usability

| Indicators | IT | Healthcare Providers | | | | | Respondents Response | |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | Mean | Description |
| The system interface is user-friendly (usability) | 5 | 4 | 5 | 5 | 4 | 5 | 4.67 | Very acceptable |
| The content is readable and easy to understand. (usability) | 5 | 5 | 4 | 5 | 5 | 4 | 4.67 | Very acceptable |
| Color and text font style are appropriate (usability) | 5 | 5 | 4 | 5 | 5 | 5 | 4.83 | Very acceptable |
| General weighted mean | | | | | | | 4.72 | Very acceptable |

Table 11. Respondents' Evaluation of System Usability Based on ISO 9126-1: Level of Acceptance of the Proposed ML-Based Diagnostic Tool

The table 11, summarizes the respondents' evaluation of the system's usability, focusing on three key indicators: user-friendliness of the interface, readability and comprehensibility of the content, and appropriateness of the color

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and text font style. The indicator "The system interface is user-friendly" received a mean score of 4.67, indicating that respondents generally find the interface intuitive and easy to navigate. Similarly, the indicator "The content is readable and easy to understand" also garnered a mean score of 4.67, suggesting that the textual content is clear and accessible to users from varying professional backgrounds. The highest rating among the three was for "Color and text font style is appropriate," with a mean score of 4.83, reflecting a strong positive response to the system's visual design and aesthetic appeal. The general weighted mean across all usability indicators is 4.72, which falls under the category of "very acceptable." These findings indicate that the system excels in usability, offering a user-centered experience that is both visually appealing and functionally accessible, thereby enhancing its effectiveness and user satisfaction across diverse respondent groups.

Table 12, Table Evaluation results of respondents based on the response of level of acceptance of the proposed system: Machine Learning Techniques in Medical Diagnosis for Measles Symptoms under ISO 9126-1 reliability

| Indicators | IT | Healthcare Providers | | | | | Respondents Response | |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | Mean | Description |
| Data are acceptable by the system (reliability) | 5 | 4 | 4 | 5 | 4 | 4 | 4.33 | Acceptable |
| Display highly accurate diagnostic results for measles symptoms (reliability) | 5 | 5 | 5 | 4 | 4 | 4 | 4.5 | Very acceptable |
| General weighted mean | | | | | | | 4.42 | Acceptable |

Table 12. Respondents' Evaluation of System Reliability Based on ISO 9126-1: Level of Acceptance of the Proposed ML-Based Diagnostic Tool

Evaluation of the system's reliability was conducted based on two primary indicators: the system's capacity to accept input data and its accuracy in diagnosing measles symptoms. The indicator "Data are acceptable by the system" yielded a mean score of 4.33, suggesting that the system generally processes user inputs effectively, though there may be minor areas requiring optimization. In contrast, the indicator "Display highly accurate diagnostic results for measles symptoms" achieved a higher mean of 4.5, reflecting a strong level of trust in the system's diagnostic precision. With a general weighted mean of 4.42, the overall reliability of the system is deemed acceptable. These findings pointed to a system that is functionally dependable, particularly in delivering accurate medical assessments, while also highlighting potential improvements to enhance data input reliability.

Table 13, Table Evaluation results of respondents based on the response of level of acceptance of the proposed tool: Machine Learning Techniques in Medical Diagnosis for Measles Symptoms under ISO 9126-1 performance

| Indicators | IT | Healthcare Providers | | | | | Respondents Response | |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | Mean | Description |
| Speed Efficiency of displaying prediction when the cutoff is reached. (Performance) | 4 | 4 | 5 | 4 | 5 | 4 | 4.33 | Acceptable |
| Real-time update and auto refresh when the inputted data is submitted (Performance) | 4 | 5 | 5 | 4 | 4 | 5 | 4.5 | Very acceptable |
| General weighted mean | | | | | | | 4.42 | Acceptable |

Table 13. Respondents' Evaluation of System Performance Based on ISO 9126-1: Level of Acceptance of the Proposed ML-Based Diagnostic Tool Assessment of the system's performance was based on two specific indicators: the speed efficiency of displaying predictions when the cutoff is reached and the system's ability to perform real-time updates and auto-refresh upon data submission. The indicator "Speed efficiency of displaying prediction when the cutoff is reached" received a mean score of 4.33, categorized as acceptable, which suggests

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that while the system generally performs prediction tasks in a timely manner, there may be slight delays or inconsistencies that affect optimal speed. In comparison, the indicator "Real-time update and auto-refresh when the inputted data is submitted" attained a higher mean score of 4.5, classified as very acceptable, indicating that users perceive this functionality as efficient and responsive. The general weighted mean of 4.42 places the overall system performance within the acceptable range. This implies that the system is performing well in real-time operations and prediction generation but may benefit from further enhancements in processing speed to achieve uniformly high user satisfaction across all performance aspects.

Table 14, The Summary of the Weighted Mean of the Four (4) criteria for acceptance of the proposed tool: Machine Learning Techniques in Medical Diagnosis for Measles Symptoms

| Indicators | IT and Healthcare Response | |
|---|---|---|
| | Weighted Mean | Description |
| Functionality | 4.89 | Very acceptable |
| Usability | 4.72 | Very acceptable |
| Reliability | 4.42 | Acceptable |
| Performance | 4.42 | Acceptable |
| General weighted mean | 4.613 | Very acceptable |

Table 14. Summary of Weighted Mean Scores for ISO 9126-1 Acceptance Criteria of the Proposed ML-Based Diagnostic Tool for Measles Symptoms

The summary of the weighted mean across four key criteria—Functionality, Usability, Reliability, and Performance—demonstrates a strong level of acceptance for the proposed tool, Machine Learning Techniques in Medical Diagnosis for Measles Symptoms, among IT and healthcare respondents. The general weighted mean of 4.613 reflects an overall rating of "Very Acceptable," indicating favorable perceptions toward the tool's potential implementation. Functionality received the highest rating with a weighted mean of 4.89, suggesting that respondents view the tool as highly capable of effectively performing its intended tasks. Usability followed closely with a mean of 4.72, showing strong agreement that the tool is user-friendly and easy to interact with. Although slightly lower, the criteria of Reliability and Performance each received a mean score of 4.42, both categorized as "Acceptable." These results suggested that while there is confidence in the tool's consistency and operational effectiveness, there may still be room for further enhancements in these areas. Overall, the data reflected strong approval from respondents, supporting the viability of the proposed machine learning-based diagnostic system for measles symptoms in a healthcare context.

Table 15, showing the evaluation results based on respondents' agreement levels regarding the challenges in Measles Diagnosis and Management in terms of Diagnosis and Medical Data Accessibility

| Section I. Challenges in Measles Diagnosis and Management<br><br>A. Diagnosis and Medical Data Accessibility | IT | Healthcare Providers | | | | | | Respondents Response |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | Mean | Description |
| Measles is difficult to diagnose due to overlapping symptoms with other illnesses. | 5 | 5 | 5 | 4 | 4 | 5 | 4.67 | Extremely Challenging |
| Limited access to patient medical records hinders early diagnosis. | 5 | 5 | 5 | 5 | 4 | 4 | 4.67 | Extremely Challenging |
| Health data systems are outdated or non-existent in our facility. | 5 | 5 | 5 | 5 | 5 | 5 | 5 | Extremely Challenging |
| Delayed laboratory test results affect patient treatment decisions. | 5 | 5 | 5 | 5 | 5 | 5 | 5 | Extremely Challenging |
| Lack of timely and reliable diagnostic tools is a persistent problem. | 5 | 5 | 5 | 5 | 5 | 5 | 5 | Extremely Challenging |
| General weighted mean | | | | | | | 4.868 | Extremely Challenging |

Table 15. Respondents' Evaluation of Challenges in Measles Diagnosis and Medical Data Accessibility

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The responses under Challenges in Measles Diagnosis and Management, particularly in Diagnosis and Medical Data Accessibility, reveal significant obstacles perceived by both IT professionals and healthcare providers. The findings indicated that measles diagnosis was widely regarded as extremely challenging, primarily due to systemic issues in healthcare infrastructure and data management. The statement "Measles is difficult to diagnose due to overlapping symptoms with other illnesses" received a mean score of 4.67, emphasizing the diagnostic complexity arising from symptom similarities with other viral infections. Similarly, the issue of limited access to patient medical records was also rated 4.67, highlighting concerns about the lack of centralized or interoperable health information systems that could support timely and informed diagnoses. The challenges intensify with the indicators "Health data systems are outdated or non-existent in our facility" and "Delayed laboratory test results affect patient treatment decisions," both of which received a perfect mean score of 5.00. These responses underscored a critical deficiency in technological infrastructure and turnaround time for essential diagnostic procedures. Another key issue identified is the "lack of timely and reliable diagnostic tools," which also obtained a mean of 5.00, suggesting a widespread and persistent problem that severely impairs the effectiveness of measles diagnosis. The general weighted mean of 4.868 places this entire category within the "extremely challenging" range, reflecting deep-rooted and systemic barriers that must be addressed through improved diagnostic technologies, electronic health records, and faster laboratory services to enhance measles detection and patient management outcomes.

Table 16, showing the evaluation results based on respondents' agreement levels regarding the challenges in Measles Diagnosis and Management in terms of Healthcare Workforce and Communication Barriers

| Section I. Challenges in Measles Diagnosis and Management<br><br>B. Healthcare Workforce and Communication Barriers | IT | Healthcare Providers | | | | | | Respondents Response |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | Mean | Description |
| There are not enough trained personnel for measles-related healthcare services. | 5 | 5 | 5 | 5 | 5 | 5 | 5 | Extremely Challenging |
| Language differences complicate the communication of health information. | 2 | 2 | 2 | 2 | 3 | 2 | 2.17 | Slightly Challenging |
| Staff are not trained to use advanced digital or AI tools in healthcare. | 5 | 5 | 5 | 5 | 5 | 5 | 5 | Extremely Challenging |
| The workload of healthcare workers prevents thorough screening for measles. | 4 | 4 | 4 | 4 | 3 | 3 | 3.67 | Very Challenging |
| Public awareness and communication efforts about measles are insufficient. | 5 | 4 | 4 | 4 | 4 | 4 | 4.17 | Very Challenging |
| General weighted mean | | | | | | | 4.002 | Very Challenging |

Table 16. Respondents' Evaluation of Challenges in Measles Diagnosis and Management: Healthcare Workforce and Communication Barriers

Within Section I, which explored the challenges associated with measles diagnosis and management, the aspect on addressing healthcare workforce and communication barriers highlights several critical factors that hinder effective measles response, particularly in resource-limited healthcare settings. Among the identified challenges, the issue of insufficient trained personnel for measles-related healthcare services and the lack of staff training in the use of advanced digital or AI tools received the highest possible mean score of 5.00, categorizing them as extremely challenging. These findings pointed to a pressing need for capacity building and workforce development, especially in the integration of technology in disease diagnosis and management. Additionally, the indicator "The workload of healthcare workers prevents thorough screening for measles" yielded a mean score of 3.67, interpreted as very challenging, suggesting that the volume of patient care duties may compromise the depth and quality of measles screening. A similar concern was expressed regarding public awareness and communication efforts about measles, which received a mean of 4.17, also falling within the very challenging range. This highlighted the necessity for stronger community outreach and health education programs. In contrast, language differences as a barrier to effective communication received a much lower mean score of 2.17, indicating that it was perceived as only slightly challenging, and possibly less significant in the context of measles management within the surveyed facilities. The general weighted mean of 4.002 reflects an overall perception of the issues in this category as very challenging,

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underscoring the need for strategic investment in workforce training, workload management, and health communication to support effective measles diagnosis and control efforts.

| Section I. Challenges in Measles Diagnosis and Management<br><br>C. Infrastructure and Ethical Concerns | IT | Healthcare Providers | | | | | | Respondents Response |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | Mean | Description |
| Technological resources (e.g., internet, devices) are insufficient in our facility. | 5 | 5 | 5 | 5 | 5 | 5 | 5 | Extremely Challenging |
| Frequent power outages disrupt the use of digital systems. | 5 | 5 | 4 | 4 | 5 | 5 | 4.67 | Extremely Challenging |
| There are concerns about the ethical use of AI in medical decision-making. | 5 | 5 | 5 | 5 | 5 | 5 | 5 | Extremely Challenging |
| Patients are reluctant to share their personal health data digitally. | 4 | 5 | 5 | 5 | 5 | 5 | 4.83 | Extremely Challenging |
| Data security and patient privacy are not adequately addressed in current systems. | 5 | 4 | 4 | 4 | 4 | 4 | 4.17 | Very Challenging |
| General weighted mean | | | | | | | 4.734 | Extremely Challenging |

Table 17, showing the evaluation results based on respondents' agreement levels regarding the challenges in Measles Diagnosis and Management in terms of Infrastructure and Ethical Concerns

Table 17. Respondents' Evaluation of Challenges in Measles Diagnosis and Management: Infrastructure and Ethical Concerns

In the context of Section I: Challenges in Measles Diagnosis and Management, the aspect addressing Infrastructure and Ethical Concerns highlights significant barriers impeding the effective use of digital tools and AI technologies in measles care. The data from IT professionals and healthcare providers indicate that there are technological limitations, such as inadequate internet access and digital devices are among the most critical obstacles, receiving a perfect mean score of 5.00, thus categorized as extremely challenging. Additionally, the frequent power outages that disrupt the functionality of digital health systems were rated with a mean of 4.67, reflecting a substantial challenge to the continuous operation of these systems. Ethical concerns also emerge as a major issue, particularly regarding the use of AI in medical decision-making, which was again rated with a perfect score of 5.00, pointing to a significant level of concern about the transparency and accountability of AI systems in healthcare. The reluctance of patients to share personal health data digitally also stands out, with a mean score of 4.83, suggesting that trust in the security and management of personal health information remains a major barrier. Furthermore, the issue of data security and patient privacy inadequately addressed in current systems scored 4.17, highlighting ongoing vulnerabilities in the protection of sensitive health data. The general weighted mean of 4.734, falling under the "extremely challenging" category, indicates a pressing need for enhanced investment in digital infrastructure, improved power reliability, stronger cybersecurity measures, and clearer ethical guidelines to effectively integrate advanced technologies into healthcare systems, particularly for the accurate diagnosis and management of measles.

| Section II. Designing a Machine Learning-Based Application<br><br>A. Desired Features and Functionalities | IT | Healthcare Providers | | | | | | Respondents Response |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | Mean | Description |
| The application should allow fast and simple symptom input for diagnosis. | 5 | 5 | 5 | 5 | 5 | 5 | 5 | Strongly Agree |
| Real-time measles diagnosis from the system would improve response time. | 5 | 5 | 5 | 4 | 4 | 5 | 5 | Strongly Agree |

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| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Offline access is important due to unreliable internet in rural areas. | 5 | 5 | 5 | 5 | 5 | 5 | 5 | Strongly Agree |
| The app should integrate with existing health records for continuity of care. | 5 | 5 | 5 | 5 | 5 | 5 | 5 | Strongly Agree |
| The interface should be intuitive for healthcare staff with limited tech skills. | 5 | 5 | 5 | 5 | 5 | 5 | 5 | Strongly Agree |
| General weighted mean | | | | | | | 5 | Strongly Agree |

Table 18, showing the evaluation results based on respondents' agreement levels regarding the Designing a Machine Learning-Based Application in terms of Desired Features and Functionalities

Table 18. Respondents' Evaluation of Desired Features and Functionalities for a Machine Learning-Based Application in Measles Diagnosis

The responses from IT professionals and healthcare providers regarding the desired features and functionalities of a machine learning-based application for measles diagnosis indicate a strong consensus on the key requirements for its design. All respondents strongly agreed that the application should feature fast and simple symptom input for diagnosis, with a perfect mean score of 5.00, underscoring the importance of user-friendly and efficient data entry. The real-time measles diagnosis capability was also highly favored, with a mean score of 5.00, as it was believed to significantly enhance response time in clinical settings. Furthermore, the need for offline access, especially in rural areas where internet connectivity is unreliable, was emphasized, also receiving a perfect score of 5.00, highlighting the application's necessity for accessibility in diverse environments. Respondents also strongly supported the integration of the application with existing health records to ensure continuity of care, again achieving a mean score of 5.00, reflecting the importance of a seamless flow of patient information. Lastly, there was a consensus that the interface should be intuitive, particularly for healthcare staff with limited technical skills, with a perfect mean score of 5.00, indicating the necessity of simplicity in design to facilitate ease of use among all healthcare providers. The general weighted mean of 5.00 further reinforces that all proposed features were regarded as essential for the success of the application, aligning with the respondents' high expectations for its functionality and usability.

Table 19, showing the evaluation results based on respondents' agreement levels regarding the Designing a Machine Learning-Based Application in terms of Addressing Access, Ethics, and Infrastructure

| Section II. Designing a Machine Learning-Based Application<br>B. Addressing Access, Ethics, and Infrastructure | IT | Healthcare Providers | | | | | | Respondents Response |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | Mean | Description |
| The application should work on basic mobile devices used in rural clinics. | 5 | 5 | 4 | 5 | 5 | 5 | 4.83 | Strongly Agree |
| Data privacy protections must be built into the app. | 5 | 5 | 5 | 5 | 5 | 5 | 5 | Strongly Agree |
| The system should be designed with cultural and ethical sensitivity in mind. | 5 | 5 | 5 | 5 | 5 | 5 | 5 | Strongly Agree |
| The app should ease administrative burdens on healthcare workers. | 5 | 5 | 5 | 5 | 5 | 5 | 5 | Strongly Agree |
| Local community input should be considered in system development. | 5 | 5 | 5 | 4 | 4 | 5 | 4.67 | Strongly Agree |
| General weighted mean | | | | | | | 4.9 | Strongly Agree |

Table 19. Respondents' Evaluation of Access, Ethical, and Infrastructure Considerations in Designing a Machine Learning-Based Application

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Based on the views of IT and healthcare respondents regarding addressing access, ethics, and infrastructure in the design of a machine learning-based application for measles diagnosis indicate a high level of agreement on the critical considerations for the app's functionality. The majority of respondents strongly agreed that the application should be compatible with basic mobile devices commonly used in rural clinics, with a mean score of 4.83, emphasizing the importance of accessibility in underserved areas. Ensuring data privacy protections was regarded as a top priority, with a perfect mean score of 5.00, reflecting the critical need for secure handling of sensitive patient information. Additionally, respondents highlighted that the system should be designed with cultural and ethical sensitivity in mind, again scoring a perfect 5.00, which underscores the importance of creating a system that respects the diverse values and practices of different communities. The reduction of administrative burdens on healthcare workers was also strongly supported, with a perfect score of 5.00, indicating that the application should streamline operations and improve efficiency in healthcare settings. Furthermore, while there was strong agreement on the importance of considering local community input in the system's development, it received a slightly lower mean score of 4.67, suggesting some variation in opinion on the extent to which community involvement should influence the design process. The general weighted mean of 4.9 reflects an overwhelming consensus on the importance of addressing access, ethical, and infrastructure-related challenges to ensure the app's successful implementation and effectiveness in diverse healthcare settings.

Table 20, showing the evaluation results based on respondents' agreement levels regarding the Ethical Considerations in Application Design

| Section II. Designing a Machine Learning-Based Application<br><br>Ethical Considerations in Application Design | IT | Healthcare Providers | | | | | | Respondents Response |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | Mean | Description |
| The app should include clear consent processes before collecting patient data. | 5 | 5 | 5 | 5 | 5 | 5 | 5 | Strongly Agree |
| Patient privacy and data security must be a core design priority. | 5 | 5 | 5 | 5 | 4 | 4 | 4.67 | Strongly Agree |
| Ethical guidelines should be followed in AI-based decision-making (e.g., no discrimination). | 5 | 5 | 5 | 5 | 4 | 4 | 4.67 | Strongly Agree |
| The app should be transparent about how it reaches diagnostic conclusions. | 5 | 5 | 5 | 4 | 4 | 4 | 4.5 | Strongly Agree |
| General weighted mean | | | | | | | 4.71 | Strongly Agree |

Table 20. Respondents' Evaluation of Ethical Considerations in Designing a Machine Learning-Based Application

The findings presented in Section II, on Ethical Considerations in Application Design," highlight a strong consensus among information technology professional and healthcare providers regarding the ethical imperatives in the development of a machine learning-based application for healthcare. Across all four ethical criteria evaluated, respondents demonstrated a high level of agreement, as reflected in the general weighted mean of 4.71, which falls within the "Strongly Agree" category. The highest consensus was observed for the necessity of clear consent processes prior to data collection, receiving a perfect mean score of 5. This underscores the critical importance stakeholders place on informed consent in patient data handling. Similarly, the principles of patient privacy and data security (mean = 4.67), adherence to ethical guidelines in AI decision-making to prevent discriminatory outcomes (mean = 4.67), and transparency in diagnostic processes (mean = 4.5) were all strongly supported. These results suggested that ethical considerations are not only essential but are expected to be central to the application's design. Such a strong ethical foundation was vital for fostering trust, ensuring compliance with regulatory standards, and promoting responsible AI integration in healthcare settings.

| Section II. Designing a Machine Learning-Based Application<br><br>Implementation and Support | IT | Healthcare Providers | | | | | | Respondents Response |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | Mean | Description |
| Training programs should be provided for healthcare workers to use the application. | 5 | 5 | 5 | 5 | 5 | 5 | 5 | Strongly Agree |

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|---|---|---|---|---|---|---|---|---|
| Community acceptance should be considered before deployment. | 5 | 5 | 5 | 5 | 5 | 5 | 5 | Strongly Agree |
| Government or health department support is necessary for wide adoption. | 5 | 5 | 5 | 5 | 5 | 5 | 5 | Strongly Agree |
| The application should allow reporting and feedback from users. | 5 | 5 | 5 | 5 | 5 | 5 | 5 | Strongly Agree |
| General weighted mean | | | | | | | 5 | Strongly Agree |

Table 21, showing the evaluation results based on respondents' agreement levels regarding the Implementation and Support

Table 21. Respondents' Evaluation of Implementation and Support Considerations for a Machine Learning-Based Application

The results in Table 19 indicate that both IT professionals and healthcare providers, are unanimously expressed the highest level of agreement—scoring 5 (Strongly Agree) on all four implementation items. The data reflects a shared consensus on several critical factors. First, there was a strong belief that training programs are essential to prepare healthcare workers in effectively using the application, ensuring that technological tools are used competently and confidently in clinical settings. Secondly, all respondents emphasized the importance of community acceptance prior to deployment, recognizing that social and cultural alignment is crucial for the successful adoption of any new health technology. Third, the unanimous agreement on the necessity of government or health department support highlights the importance of institutional backing for achieving wide-scale implementation and sustainability. Lastly, respondents strongly agreed that the application must support reporting and feedback mechanisms, allowing users to communicate issues and contribute to the continuous improvement of the system. With a general weighted mean of 5.0, these results collectively underscore that successful implementation of a machine learning-based healthcare application requires not only technical readiness but also human, organizational, and societal preparedness. The findings provide clear guidance for developers, policymakers, and healthcare leaders on the foundational elements that must be addressed to ensure the system's effectiveness, acceptance, and long-term impact.

| III. Opportunities for Implementation | IT | Healthcare Providers | | | | | | Respondents Response |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | Mean | Description |
| Machine learning can improve the accuracy of measles diagnosis compared to traditional methods. | 5 | 4 | 5 | 4 | 4 | 5 | 4.5 | Strongly Agree |
| ML models can help identify measles cases earlier through symptom and pattern recognition. | 5 | 3 | 5 | 4 | 5 | 5 | 4.5 | Strongly Agree |
| Integrating ML into mobile apps can support faster diagnosis in remote or under-resourced areas. | 5 | 3 | 4 | 5 | 3 | 3 | 3.83 | Agree |
| ML can reduce human error in diagnosis by providing consistent and data-driven outputs. | 5 | 3 | 5 | 5 | 5 | 5 | 4.67 | Strongly Agree |
| The use of ML in measles diagnosis could free up healthcare workers to focus on treatment and outreach. | 5 | 4 | 5 | 4 | 4 | 4 | 4.33 | Agree |
| ML-based tools can assist in predicting potential measles outbreaks using historical and real-time data. | 5 | 4 | 4 | 4 | 4 | 3 | 4 | Agree |
| Integrating ML into measles diagnosis is a cost-effective solution for healthcare systems long-term. | 5 | 3 | 4 | 4 | 4 | 4 | 4 | Agree |
| General weighted mean | | | | | | | 4.26 | Agree |

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Table 22, showing the evaluation results based on respondents' agreement levels regarding the Opportunities for Implementation

Table 22. Respondents' Perceptions of Opportunities for Implementing Machine Learning in Measles Diagnosis

The data reflects a generally positive outlook among IT professionals and healthcare providers regarding the use of machine learning (ML) in measles diagnosis and healthcare delivery. The overall weighted mean of 4.26 indicates agreement on the opportunities that ML presents. Respondents strongly agreed that ML can enhance diagnostic accuracy compared to traditional methods (mean = 4.5), enable earlier detection of measles cases through symptom and pattern recognition (mean = 4.5), and reduce human error by providing consistent, data-driven outputs (mean = 4.67). These responses underscored confidence in the reliability and precision of ML-based systems. There was also notable agreement on the broader applications of ML in healthcare. Participants acknowledged that integrating ML into mobile applications may facilitate faster diagnosis in remote or under-resourced areas (mean = 3.83) and free up healthcare professionals to focus on treatment and outreach (mean = 4.33). Additionally, ML was seen as a valuable tool for predicting potential measles outbreaks using historical and real-time data (mean = 4.0) and as a cost-effective solution for healthcare systems over the long term (mean = 4.0). These findings suggested that both technological and healthcare stakeholders recognize the practical, clinical, and economic benefits of implementing ML in measles diagnosis.

## Implications for Practice and Policy

The outcomes derived from the study provide substantial insights with far-reaching implications for healthcare delivery and public health governance, particularly in resource-limited settings like Jolo. The integration of a machine learning-based diagnostic system revealed a transformative opportunity to modernize medical diagnostics, improve early detection of measles, and optimize healthcare operations.

For Clinical Practice, the study underscores the importance of integrating intelligent diagnostic systems that offer real-time symptom assessment, offline functionality, and compatibility with basic mobile devices. Healthcare practitioners in rural areas may benefit from reduced diagnostic workloads, faster decision-making, and improved early detection of measles, which was vital in managing potential outbreaks. The favorable usability and functionality scores suggest that the system is practical for adoption in frontline healthcare settings, especially when combined with targeted training and user support.

For Health Policy, the results call for the prioritization of digital infrastructure, including investment in mobile technologies, internet access, and data security protocols. Policymakers may also consider establishing regulatory frameworks that ensure ethical AI deployment, with clear guidelines on informed consent, transparency, and fairness. Moreover, the need for institutional support—highlighted by respondents—suggests that government and health agencies must be actively involved in both funding and advocating for AI-driven solutions. Policies that incentivized the use of digital health tools and promote capacity-building among healthcare workers may create an enabling environment for technological integration.

## Summary, Conclusion And Recommendation

This chapter presents the summary of the study's key findings, draws relevant conclusions based on the analysis, and offers practical recommendations for future research and implementation. As the study explored the application of machine learning techniques in diagnosing measles symptoms within the context of Jolo, it uncovered critical insights into both the potential benefits and limitations of these technologies in a resource-constrained and culturally unique setting. This chapter aimed to consolidate those insights to provide a clear understanding of the implications of the research and suggest pathways forward for stakeholders in healthcare, technology, and policy development.

## Summary of Findings

The evaluation of the model's accuracy using scikit-learn's metrics module and accuracy score function demonstrates a robust machine learning-based diagnostic system for measles symptoms, developed using Python, Streamlit, NumPy, Pandas, and the Random Forest Classifier (RFC) algorithm. Operated on a Windows 11 laptop optimized for 64-bit architecture, the model effectively identifies symptoms—particularly rash, a highly visible indicator—while integrating respiratory and systemic features to ensure comprehensive classification. Training over 50 epochs revealed steadily increasing accuracy and decreasing loss, with validation accuracy stabilized at 93%, suggesting strong generalization and minimal overfitting. Confusion matrix results show perfect classification of all "RASH" cases (recall and precision of 100%) and a minor misclassification of one "NORMAL" case, indicating high reliability in detecting rash-related conditions, essential for measles diagnosis.

The software system developed in this study integrates machine learning and web-based technologies to facilitate the automated diagnosis of measles symptoms using both clinical data and image analysis. The architecture was modular and scalable, implemented primarily in Python 3.8+, and designed to function efficiently in environments with limited infrastructure.

### Core Technologies and Tools

The back-end of the system was built using Flask, a lightweight Python web framework, which handles routing, logic, and server-side operations. The machine learning component employs the scikit-learn library to implement a Random Forest classifier trained on tabular data from a CSV file (Measles_Dataset.csv). Deep learning capabilities for image-based detection of rash and Koplik spots utilize Keras with TensorFlow as the backend. For data manipulation and numerical operations, pandas and numpy are employed, and pickle is used for saving and loading the trained Random Forest model. Model development and testing were conducted using Jupyter Notebook.

The front-end interface was constructed using HTML templates rendered by Flask. These templates enable user input via form elements and display diagnostic results based on the model's output. This client-server architecture supports user interaction with the system through a web browser without requiring installation of additional software on the client side.

### Conclusions

Analysis made in the system based on the functionality, usability, reliability and performance of machine learning techniques in medical diagnosis for measles symptoms The proposed machine learning tool for diagnosing measles symptoms is strongly accepted by both IT and healthcare professionals based on its functionality, usability, reliability, and performance. It is viewed as highly effective and user-friendly, with particularly strong ratings in functionality and usability. Although reliability and performance received positive evaluations, there is still room for improvement. These perspectives highlight the tool's potential suitability and readiness for use in healthcare settings.

Analysis made in statement of the problem 1 are the following:

### Recommendations

Considering the tool's evaluation as highly effective and user-friendly, further development and pilot testing in actual healthcare environments are recommended to validate its practical effectiveness and usability. Focus should be placed on improving reliability and performance, as these areas received positive but comparatively lower ratings. Additionally, offering thorough training and support to healthcare professionals will facilitate smooth adoption and help maximize the tool's impact on patient care. Although reliability and performance received positive evaluations, there is still room for improvement. These perspectives highlight the tool's potential suitability and readiness for use in healthcare settings.

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