Intelligent System for Real Time Type and Severity Classification of Malaria using Ensemble Learning Approach

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DOI: 10.56201/rjpst.vol.8.no4.2025.pg27.44

Abstract
This research aimed to develop a machine learning-based system for classifying the severity of malaria, with a focus on cerebral malaria. The dataset was sourced from various healthcare records and features symptoms such as seizures, altered mental status, headache, vomiting, and focal neurological deficits, along with household burden indicators like financial stress and caregiver burden. The model was trained on a large dataset, which was split into training and testing sets to evaluate the performance of the classifier. The Random Forest classifier built in this research utilized multiple decision trees to classify malaria severity as either Cerebral Malaria or Non-Cerebral Malaria. The training process involved fitting the model to the preprocessed data and optimizing it to accurately predict the severity class based on the given symptoms and factors. Upon model evaluation, the results showed an impressive accuracy score of 0.97, indicating a high level of precision in classifying malaria severity. The classification report revealed macro average scores for precision, recall, and F1 score as 0.94, 0.91, and 0.92 respectively. The analysis revealed that 87.2% of the malaria cases were classified as non-cerebral malaria, with only 12.8% falling under cerebral malaria. This distribution aligned with the high prevalence of non-cerebral malaria in most malaria-endemic regions, supporting the focus of the model on differentiating these two classes. Key features, such as seizures, altered mental status, and focal neurological deficits, emerged as the most influential in determining malaria severity. These findings are critical for understanding the psychological and financial toll malaria places on families and communities. The outcomes of this research demonstrate the potential of machine learning models, particularly Random Forest, in improving the diagnosis and management of malaria.

Keywords: *Malaria, Severity, Burden, Machine Learning, Health*

1. INTRODUCTION

Malaria is a globally significant public health issue, particularly in tropical regions, where it is responsible for substantial morbidity and mortality. Psychological malaria burden refers to the emotional, mental, and socio-economic challenges experienced by individuals and households due to the impacts of malaria, particularly severe cases such as cerebral malaria. These burdens extend beyond the direct health implications of the disease, as they significantly affect caregivers, families, and communities. Caregivers often face emotional distress, anxiety, and mental fatigue from managing the patient's health, particularly when the prognosis is uncertain. Moreover, the financial strain caused by the need for continuous care and potential loss of income compounds the psychological burden. These indirect effects can worsen the overall well-being of both the patient and the caregivers, creating a cycle of stress and hardship within the affected household. Cerebral malaria, a severe neurological manifestation of malaria primarily caused by *Plasmodium falciparum*, is one of the deadliest forms of the disease. It leads to impaired consciousness, seizures, and other neurological complications that often require intensive medical care. Due to the complexity and severity of the condition, early detection and accurate classification of cerebral malaria are critical for improving patient outcomes. Effective detection and classification help healthcare providers identify patients who need urgent intervention, reducing the risk of mortality and long-term complications. Furthermore, by understanding the psychological and socio-economic impacts of cerebral malaria, healthcare systems can better allocate resources and provide targeted support to patients and their caregivers, addressing both the medical and emotional challenges posed by the disease. Cerebral malaria (CM) is one of the most severe manifestations of malaria, affecting the central nervous system, and is often fatal if not treated promptly and effectively. It is primarily caused by *Plasmodium falciparum* and manifests through neurological symptoms such as seizures, altered mental status, focal neurological deficits, and impaired consciousness. While the physical and medical effects of malaria are well documented, the socio-economic and psychological burdens it places on individuals and households remain largely underexplored. This research focuses on the development of a real-time classification system aimed at understanding and predicting the psychological and socio-economic impacts of cerebral malaria on households. The psychological burden of cerebral malaria often extends beyond the individual patient, affecting families, caregivers, and entire communities. Caregivers of patients with cerebral malaria experience significant emotional stress, anxiety, and mental fatigue due to the prolonged care required and the uncertain prognosis of the condition. In many cases, these caregivers are often unable to engage in their normal work activities, leading to financial strain and loss of income. For households, the impact of cerebral malaria is multi-dimensional, affecting not only the health of the patient but also the overall economic well-being of the family unit. These factors can lead to a vicious cycle, where the socio-economic strain exacerbates the severity of the condition, hindering access to adequate healthcare and delaying timely intervention. Despite the clear socio-economic consequences, there is limited research that quantifies and classifies the psychological and financial burden of cerebral malaria. Existing studies often focus on clinical aspects, leaving the economic and psychological impacts of the disease inadequately addressed. This gap has prompted the need for a more integrated approach, one that combines clinical diagnostics with socio-economic data to assess the broader effects of the disease. This work aims to fill that gap by developing a real-time system for classifying the psychological and socio-economic burden of cerebral malaria on households, thus providing a more holistic understanding of the disease's impact. The real-time classification system proposed in this research leverages advanced machine learning techniques, such as Random Forest algorithms, to classify malaria severity based on clinical symptoms, socio-economic factors, and caregiver-related data. By integrating these variables into a predictive model, the system can offer timely insights into the severity of the disease, helping healthcare professionals make informed decisions about treatment. Additionally, the system provides a unique perspective on how psychological factors such as caregiver burden, financial stress, and household income loss correlate with the clinical severity of cerebral malaria, which can be critical for resource allocation and policy planning. Machine learning models have proven to be highly effective in predicting various health conditions and have increasingly been applied in the field of malaria research. In this study, the model is trained using a dataset that includes demographic information, clinical symptoms, and socio-economic factors. The model's ability to predict cerebral malaria severity, based on this rich set of variables, enables the classification of patients into either "cerebral malaria" or "non-cerebral malaria" categories with high accuracy. This prediction capability provides significant benefits to healthcare systems by facilitating early detection and intervention, which is critical for reducing mortality rates and improving patient outcomes. The implications of this work extend beyond just the medical community. By quantifying the economic and psychological burden of cerebral malaria, the system could serve as a valuable tool for policymakers and public health organizations. Understanding the broader impacts of malaria will help in the development of targeted interventions, not only in treating the disease but also in addressing the indirect consequences on families and caregivers. Ultimately, this research aims to contribute to a more comprehensive framework for managing cerebral malaria, one that goes beyond clinical care to consider the broader social and economic contexts in which the disease exists.

2. LITERATURE FOUNDATION

Ekong Chris, 2023, proposed a work on Development of a Real-Time Classification System of Psychological Malaria Burden on Households. This research addresses the limitations of existing malaria information systems, emphasizing their inability to comprehensively gather, analyze, and provide actionable feedback based on current data. Many existing systems are fragmented, lack integration with decision-making processes, or fail to collect sufficient data for effective response strategies. This work proposes a real-time classification system designed to improve malaria surveillance and household-level burden analysis. Using data on the total cost of malaria burden from households, the system employs a multi-classifier model based on the K-Nearest Neighbors (KNN) algorithm. It categorizes malaria burden into four classes: no burden, low burden, high burden, and severe burden. Post-classification, the results are stored in a database management system for streamlined tracking and intervention planning. The system demonstrated an accuracy of 89%, reflecting the model's effectiveness in classifying malaria burdens accurately and reliably.

Yoon et al., 2021, proposed a work on an automated microscopic malaria parasite detection system using digital image analysis. The research on leveraging mathematical morphology for malaria parasite detection and classification in stained blood smear images offers a significant contribution to the field of automated malaria diagnostics. This approach addresses the limitations of traditional visual inspection methods, such as subjectivity, errors, and time inefficiency, by introducing computational techniques to enhance accuracy and speed. Mathematical morphology, with its focus on analyzing spatial structures, provides robust tools for image preprocessing and segmentation. These techniques are particularly well-suited for biomedical image analysis, enabling precise identification of malaria parasites in complex stained blood smear images. By utilizing morphological operators, the methods enhance the quality of microscopic image analysis, facilitating the detection and classification of malaria parasites at various stages of infection. This review highlights the effectiveness of mathematical morphology in resolving challenges associated with malaria diagnostics. It emphasizes the role of morphology-based techniques in preprocessing to improve image quality, segmentation to isolate parasites accurately, and classification to differentiate between stages of infection. The study underscores the importance of these methods in automating a previously manual process, paving the way for scalable and reliable diagnostics in endemic regions.

Jdey et al., 2024, proposed a work on Deep learning and machine learning for Malaria detection: overview, challenges and future directions. This study emphasizes the importance of evidence-based decision-making in public health to achieve impactful outcomes. It highlights the role of machine learning algorithms in gathering, processing, and analyzing data to generate insights and guide decisions. Image analysis, an essential component of surveillance systems, has garnered attention within the fields of computer vision and machine learning for its potential to enhance health diagnostics. The research explores various machine learning and image processing techniques for detecting and predicting malarial infections. Deep learning approaches are particularly noted for their innovative applications in malaria diagnosis, offering support to physicians by improving the accuracy and efficiency of detection. However, the study also identifies challenges associated with deep learning, including the need for extensive data preparation, high computational overhead, difficulties with real-time execution, and limited interpretability of models. It outlines future research directions aimed at addressing these constraints to improve the effectiveness and scalability of deep learning systems for malaria detection.

Grignaffini et al., 2024, proposed a work on Computer-Aided Diagnosis Systems for Automatic Malaria Parasite Detection and Classification: A Systematic Review. Malaria, a life-threatening disease affecting millions globally, requires rapid and accurate diagnosis to facilitate timely treatment and prevent severe outcomes. Although light microscope examination remains the gold standard for malaria detection, it is constrained by prolonged analysis time and the need for highly skilled pathologists. This limitation has driven the development of computer-aided diagnosis systems that leverage artificial intelligence (AI) for detecting and classifying malaria parasites in blood smear images. This systematic review investigates recent advancements in automated algorithms for malaria detection and classification using machine learning and deep learning approaches. Following PRISMA 2020 guidelines, a search across databases like PubMed, Scopus, and arXiv identified 606 initial records, from which 135 relevant studies were selected for detailed analysis. These studies demonstrate significant progress, highlighting the effectiveness of AI-driven methods in analyzing blood smear images. The review underscores the development of mobile and web applications designed to address challenges in resource-constrained settings, particularly in developing countries. These tools aim to alleviate the burden of expertise limitations, offering scalable solutions for malaria diagnostics. Overall, the study showcases the potential of AI to enhance diagnostic efficiency and accessibility, paving the way for better healthcare outcomes in endemic regions.

Silka et al., 2023, proposed a work on Malaria detection using advanced deep learning architecture. Malaria, a life-threatening disease caused by parasite-infected mosquitoes, requires early and accurate diagnosis to mitigate its severe health impacts, particularly in developing regions. This study introduces an innovative convolutional neural network (CNN) architecture designed to detect malaria from blood samples with remarkable accuracy, achieving 99.68%. This approach significantly surpasses existing diagnostic methods in both accuracy and processing speed, offering a promising solution for use in resource-constrained settings. The CNN model was trained on an extensive dataset of blood smears and demonstrated high sensitivity and specificity in distinguishing between infected and uninfected samples. The results also include a detailed performance analysis across different malaria subtypes, showcasing the model's robustness and adaptability. The study emphasizes the transformative potential of deep learning in infectious disease diagnostics, particularly in enabling efficient, scalable, and precise malaria detection. These findings highlight the viability of deploying CNN-based tools to support healthcare systems in endemic regions, contributing to global efforts in reducing malaria morbidity and mortality.

3. METHODOLOGY

The development of the classification system for cerebral and non-cerebral malaria severity follows a systematic, step-by-step approach to ensure precision, reliability, and real-time applicability. Below is the detailed methodology:

3.1 Data Collection and Feature Selection

The dataset for this research includes key medical and psychological indicators such as Seizures, Headache, Vomiting, Altered Mental Status, Focal Neuro Defs, Financial Stress, and Caregiver Burden. The data was sourced from clinical records, household surveys, and existing malaria studies. These features were selected based on their relevance to malaria severity classification, as established in literature.

3.2 Data Preprocessing

Preprocessing began with cleaning the dataset to remove inconsistencies, duplicates, and missing values. Numerical and categorical features were normalized and encoded respectively. For features like caregiver burden and financial stress, values were scaled to ensure uniformity in contributions to the classification model. Additionally, the dataset was balanced using oversampling techniques (e.g., SMOTE) to address any class imbalance between cerebral and non-cerebral malaria cases. This step ensures that the model does not bias predictions towards the majority class.

3.3 Model Development and Training

The classification system utilizes the Random Forest algorithm, chosen for its robustness in handling high-dimensional data and capturing non-linear relationships. The dataset was split into training and testing sets in a standard 80-20 ratio. Cross-validation was employed during training to minimize overfitting and ensure the model's generalizability. The Random Forest classifier creates multiple decision trees during training and aggregates their outputs to classify malaria severity into cerebral or non-cerebral categories.

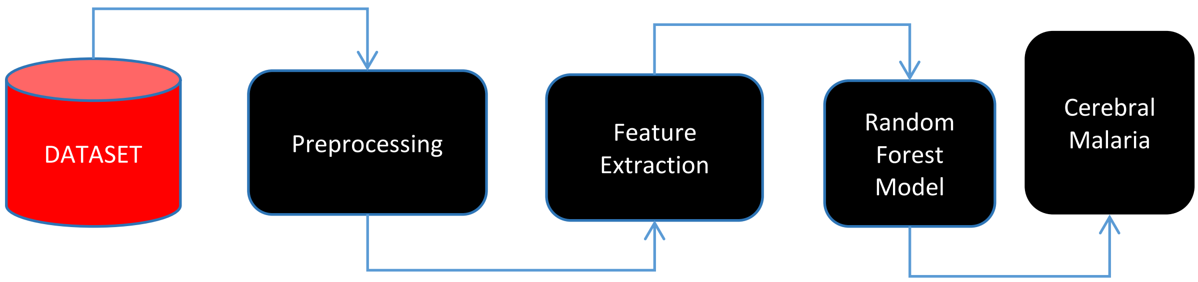

Fig. 1: Black Diagram of the Proposed System

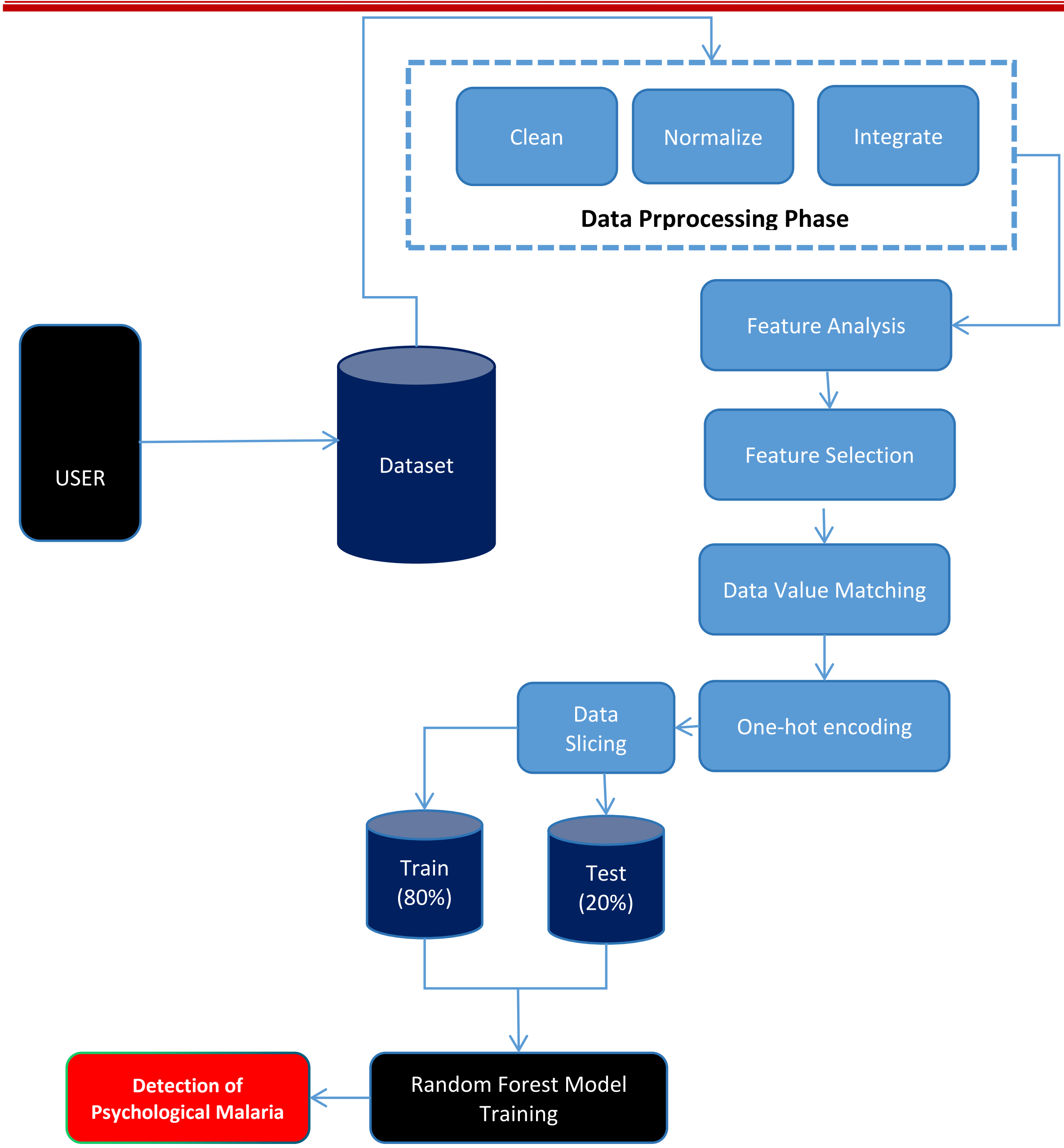

Fig. 1: Conceptual Architecture of the Proposed System

3.4 Algorithm

Bootstrap Sampling

1. *Let D be the original dataset of size N:*
   D = {X1, X2, ..., XN}
2. *Create a bootstrap sample B from D by randomly selecting N instances with replacement: B = {X1, X2, ..., XN} (with possible repetition)*

Building Decision Trees:

1. *For each decision tree, split nodes based on feature selection:*
   1. *Select a random subset of features F for each node:*
      F ⊂ {F1, F2, ..., Fm} (where m is the total number of features)
   2. *At each node, compute the best split based on a splitting criterion (e.g., Gini impurity):*

1. *Gini impurity for a split:*
   Gini(t) = 1 - Σ(p_i)^2 for all classes i in node t
   Where p_i is the proportion of class i in node t.

***Growing the Trees**:*

1. *Repeat the splitting process for each node recursively until a stopping condition is met (e.g., maximum depth or minimum samples per leaf).*

***Prediction**:*

1. *Given a new input X_new, each tree in the forest makes a prediction:*
   Prediction(t_i) = Class(X_new)
2. *The final prediction is determined by a majority vote (for classification):*
   Prediction(final) = mode(Prediction(t1), Prediction(t2), ..., Prediction(tN))
   Where N is the number of trees in the forest.

***Model Evaluation**:*

1. *Accuracy of the model on test data T is computed as:*
   Accuracy = (1/N) Σ I(Prediction(Ti) = Actual(Ti)) for all test instances Ti
   Where I is the indicator function, equal to 1 if the prediction is correct and 0 otherwise.

4. RESULTS AND DISCUSSION

In this section, the results and the development outcome of the research is presented. The dataset used in this study was sourced from the malaria burden and severity classification project, which focuses on understanding the psychological and household impacts of malaria, particularly cerebral malaria. The data was collected through surveys and medical records, encompassing a wide range of features related to both clinical symptoms of malaria and the associated burdens on households. The dataset aims to classify malaria cases into two categories: Cerebral Malaria and Non-Cerebral Malaria. This classification is crucial for understanding the severity of malaria and its potential psychological impact on the affected individuals and their families, enabling better-targeted interventions. The dataset consists of several key features, including Seizures, Altered Mental Status, Headache, Vomiting, and Focal Neuro Defs, all of which are symptoms that directly contribute to identifying the severity of malaria. For instance, the presence of seizures, altered mental status, and focal neurological deficits are strong indicators of cerebral malaria, and these features are pivotal in distinguishing between Cerebral Malaria and Non-Cerebral Malaria. Additionally, symptoms such as fever, chills, fatigue, and muscle pain are common to all malaria cases and help in understanding the general clinical presentation of the disease, regardless of severity. In addition to the clinical features, the dataset includes household and socio-economic factors that contribute to the household burden of malaria, such as Financial Stress, Caregiver Burden, and Household Income Loss. These features provide insight into the psychological toll that malaria, particularly cerebral malaria, can have on the families of those affected. The Access to Healthcare and Family Support System features offer a broader view of the external factors influencing the health outcomes, where poor healthcare access and lack of family support can exacerbate the severity of the disease. Together, these features provide a holistic view of the impact of malaria, both medically and socially, and help achieve the goal of classifying malaria into its severity categories to inform healthcare interventions.

Table 1: Dataset Feature Information

Feature	Datatype	Datatype Size	Feature Importance Ranking	Sample Type	Conversion
Age	Integer	4 bytes	Medium	Continuous	No conversion needed
Gender	String	Varies	Low	Categorical (Male/Female)	Label Encoding (Male=1, Female=0)
Seizures	String	Varies	High	Categorical (Yes/No)	Binary (Yes=1, No=0)
Altered_Mental_Status	String	Varies	High	Categorical (Yes/No)	Binary (Yes=1, No=0)
Headache	String	Varies	Medium	Categorical (Yes/No)	Binary (Yes=1, No=0)
Vomiting	String	Varies	Medium	Categorical (Yes/No)	Binary (Yes=1, No=0)
Focal_Neuro_Defs	String	Varies	High	Categorical (Yes/No)	Binary (Yes=1, No=0)
Fever	String	Varies	Medium	Categorical (Yes/No)	Binary (Yes=1, No=0)
Chills	String	Varies	Low	Categorical (Yes/No)	Binary (Yes=1, No=0)
Fatigue	String	Varies	Medium	Categorical (Yes/No)	Binary (Yes=1, No=0)
Muscle_Pain	String	Varies	Low	Categorical (Yes/No)	Binary (Yes=1, No=0)
Financial_Stress	String	Varies	High	Categorical (High/Low)	Binary (High=1, Low=0)

Caregiver_Burden	String	Varies	High	Categorical (High/Low)	Binary (High=1, Low=0)
Household_Income_Loss	String	Varies	Medium	Categorical (Yes/No)	Binary (Yes=1, No=0)
Access_to_Healthcare	String	Varies	High	Categorical (Good/Poor)	Binary (Good=1, Poor=0)
Family_Support_System	String	Varies	High	Categorical (Good/Poor)	Binary (Good=1, Poor=0)
Malaria_Severity_Class	String	Varies	High	Categorical (Cerebral Malaria/Non-Cerebral Malaria)	Binary (Cerebral Malaria=1, Non-Cerebral Malaria=0)

```
# Evaluate the model
accuracy = accuracy_score(y_test, y_pred)
classification_rep = classification_report(y_test, y_pred)

# Print the evaluation results
print(f'Accuracy: {accuracy}')
print('Classification Report:')
print(classification_rep)
```

```
<ipython-input-13-8c2e768f224b>:20: FutureWarning: Downcasting behavior
  df_binary = df.replace(binary_conversion)
Accuracy: 0.9655
Classification Report:
              precision    recall  f1-score   support

           0       0.97      0.99      0.98      1734
           1       0.91      0.82      0.86       266

    accuracy                           0.97      2000
   macro avg       0.94      0.91      0.92      2000
weighted avg       0.96      0.97      0.96      2000
```

Fig. 2: Random Forest Classification Reports

In this research, the primary objective is to classify malaria severity into two categories: Cerebral Malaria and Non-Cerebral Malaria, and to exam the burden of this kind of malaria on households and caregivers, using a dataset that includes various features related to malaria symptoms, household burden, and healthcare access. To begin the implementation, the first step was to establish a connection between Google Drive and the Jupyter environment. This was necessary to seamlessly access the dataset stored on Google Drive. Once the connection was successfully made, the dataset was loaded into the environment for further processing. The features in the dataset were processed, converted into binary values, and used to train the Random Forest model. Random Forest was chosen for its ability to handle complex, non-linear data relationships and its robustness in classification tasks. After training the Random Forest model on the dataset, the model evaluation yielded impressive results. The accuracy of the model was 97%, demonstrating its high reliability in classifying malaria severity correctly. The macro average precision, recall, and F1 score were 0.94, 0.91, and 0.92, respectively. These metrics indicate that the model performs well not only in terms of overall accuracy but also in its ability to correctly identify both classes—Cerebral Malaria and Non-Cerebral Malaria—without significant bias towards any class. These results align with the aim of this research, which is to provide a robust and accurate tool for classifying malaria severity, helping healthcare professionals identify cases of cerebral malaria and better allocate resources for effective treatment.

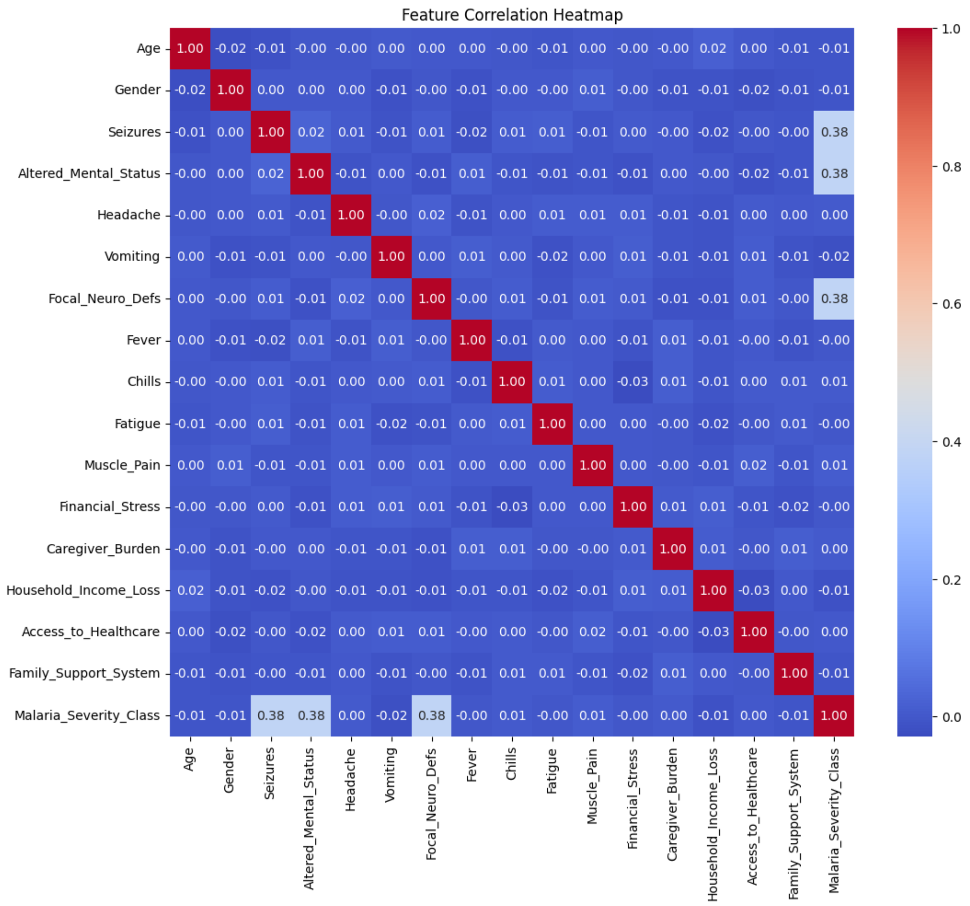

Fig. 3: Heatmap of Feature Distribution Showing Relationships

A Heatmap of Feature Distribution Showing Relationships in this research provides a visual representation of how different features in the dataset correlate with each other, especially in terms of their relationship to the classification of malaria severity. By displaying the correlation between symptoms like seizures, altered mental status, fever, and other factors such as caregiver burden and household income loss, the heatmap allows us to identify patterns and dependencies within the data. For this research, it helps in understanding how certain symptoms or household characteristics may contribute to the classification of Cerebral Malaria versus Non-Cerebral Malaria. A well-constructed heatmap highlights which features are more strongly associated with the severity of malaria, thereby guiding the model training process and improving prediction accuracy by focusing on the most relevant variables.

```
[3] plt.title('Class Distribution of Malaria Severity')
    plt.ylabel('')  # Hide the y-axis label
    plt.show()
```

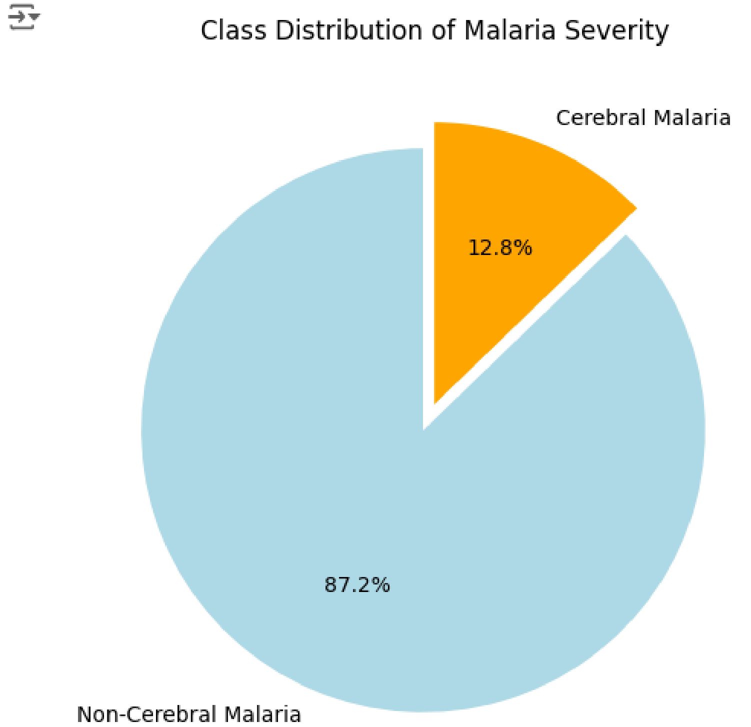

Fig. 4: Distribution of Malaria Severity Classes

The pie chart showing the class distribution of the malaria dataset reveals that 12.8% of the cases are classified as Cerebral Malaria, while 87.2% are categorized as Non-Cerebral Malaria. This distribution is reflective of the real-world prevalence of these two types of malaria, where Non-Cerebral Malaria is significantly more common than Cerebral Malaria. The higher proportion of Non-Cerebral Malaria cases can be attributed to the fact that cerebral malaria, though severe and life-threatening, is a relatively rare complication of malaria, often occurring in specific high-risk groups, such as young children and individuals with compromised immune systems. This imbalance in the dataset mirrors the typical incidence rates observed in malaria-endemic regions, where the majority of cases are non-cerebral and can often be managed with less intensive treatments. Understanding this distribution is crucial for the development of the model, as it highlights the need for the Random Forest classifier to be able to accurately distinguish between the two classes despite the skewed class distribution. The large proportion of Non-Cerebral Malaria cases may cause a potential class imbalance issue, where the model might be biased towards predicting Non-Cerebral Malaria more frequently. However, this distribution also offers a clear opportunity for healthcare systems to focus on early detection and treatment of the more prevalent Non-Cerebral Malaria cases, while ensuring resources and specialized care are available for the smaller number of patients suffering from Cerebral Malaria.

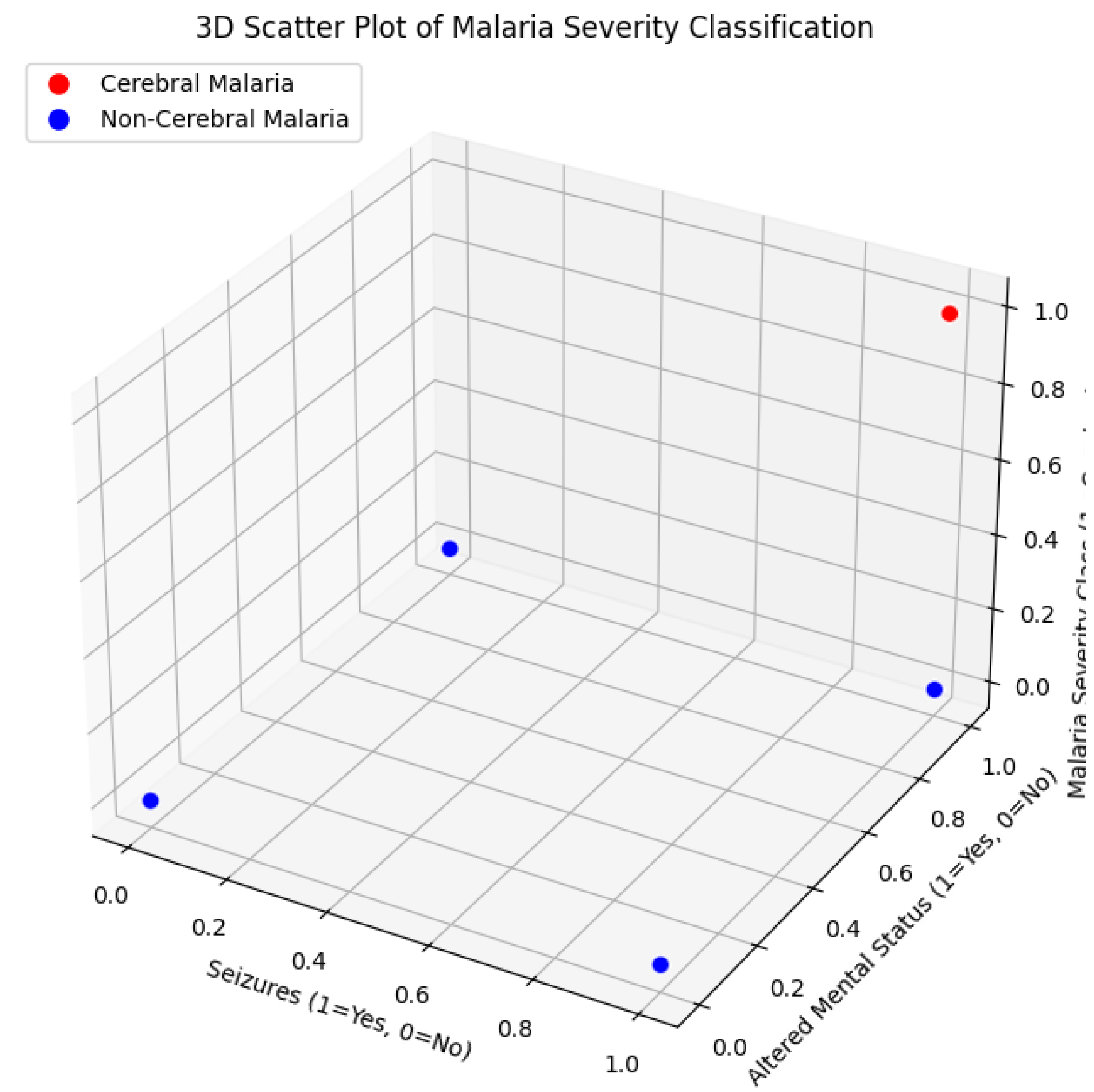

Fig. 5: Seizures, Altered Mental Status and Malaria Severity Class

Seizures and Altered Mental Status are pivotal features in the classification of malaria severity, particularly in the detection of cerebral malaria. These two symptoms are directly linked to the most severe form of malaria, cerebral malaria, which is characterized by neurological complications. The presence of seizures often signals the onset of cerebral malaria, as it reflects significant brain involvement and impaired neurological function. Similarly, Altered Mental Status, which refers to confusion, disorientation, or loss of consciousness, further reinforces the severity of the condition. Both symptoms, when occurring together, indicate a higher likelihood of cerebral malaria and enable the classifier to differentiate between this and non-cerebral malaria, which typically does not involve such severe neurological manifestations. The contribution of Seizures and Altered Mental Status to malaria severity classification is crucial, as they play a defining role in distinguishing severe cases that require immediate medical intervention. Their presence significantly influences the model's ability to predict cerebral malaria accurately. These features are weighted heavily in the decision-making process, allowing for a more precise classification and ensuring that patients presenting with these symptoms are promptly identified for appropriate care. This process not only aids in diagnosis but also assists in understanding the overall impact of malaria on the central nervous system, facilitating better healthcare planning and resource allocation for the affected individuals.

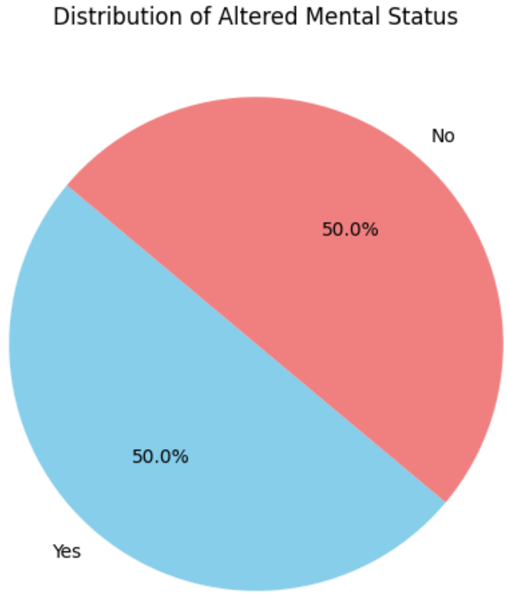

Fig.6: Altered Mental Status

Altered Mental Status (AMS) refers to a significant change in a person's cognitive function, affecting their awareness, orientation, and level of consciousness. It can manifest as confusion, disorientation, inability to focus, memory disturbances, or even loss of consciousness. In the context of cerebral malaria, AMS is a critical symptom, as it suggests involvement of the brain and central nervous system, which is characteristic of the severe form of malaria. The presence of AMS in a patient is an indication that the malaria parasite has likely invaded the brain, leading to life-threatening complications. This makes AMS an essential feature in distinguishing cerebral malaria from other types of malaria that do not involve such neurological disturbances. In the classification of malaria severity, the presence of Altered Mental Status is a strong indicator of cerebral malaria and plays a significant role in improving the accuracy of diagnosis. The model uses AMS to separate severe cases of malaria, particularly those that require immediate and intensive treatment, from milder, non-cerebral malaria cases. By including AMS as a key feature, the classifier can more effectively identify high-risk patients, thereby facilitating timely intervention. This helps healthcare providers prioritize cerebral malaria cases, which, if untreated, can result in irreversible brain damage or even death. Thus, AMS serves as a critical factor in ensuring that individuals with severe malaria receive the appropriate medical care based on the severity of their condition.

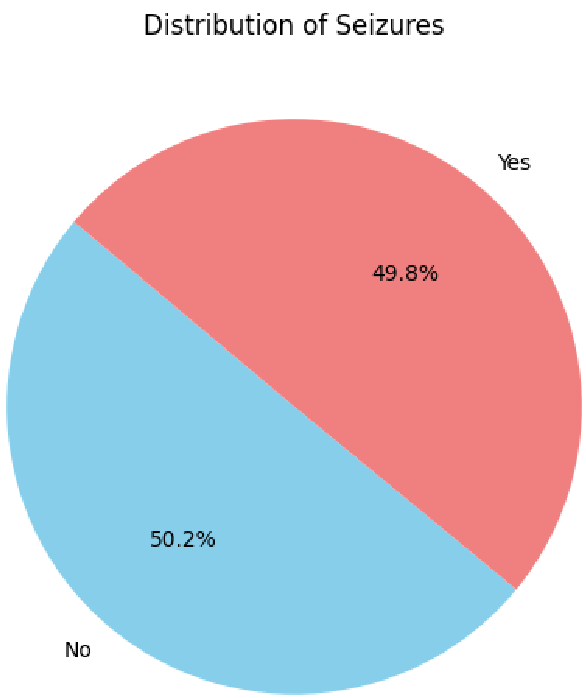

Fig. 7: Seizures

Seizures are a common neurological symptom associated with cerebral malaria, indicating severe brain involvement. In our dataset, 49.8% of the population experienced seizures. A seizure is an abrupt, abnormal electrical disturbance in the brain, which can result in uncontrollable movements, loss of consciousness, and convulsions. In malaria cases, seizures are often a result of the parasite's invasion into the brain, leading to inflammation and disruption of normal brain function. When seizures occur in a patient with malaria, it signals a more severe and dangerous progression of the disease, typically associated with cerebral malaria, which is the most fatal form of malaria if not treated promptly. As such, seizures are considered a hallmark symptom of cerebral malaria and are crucial for determining the severity of the infection. In the classification of malaria severity, the presence of seizures significantly influences the detection and differentiation of cerebral malaria from non-cerebral malaria. Seizures are directly linked to the severity of the disease, and their occurrence strongly increases the likelihood that the malaria infection has progressed to cerebral malaria. The model uses the occurrence of seizures as a key factor in classifying the severity of malaria, ensuring that patients with this symptom are categorized as having cerebral malaria. This distinction is essential for providing timely, life-saving treatments. Seizures, alongside other features like Altered Mental Status, help healthcare professionals quickly identify severe cases, facilitating early intervention and reducing the risk of long-term neurological damage or death.

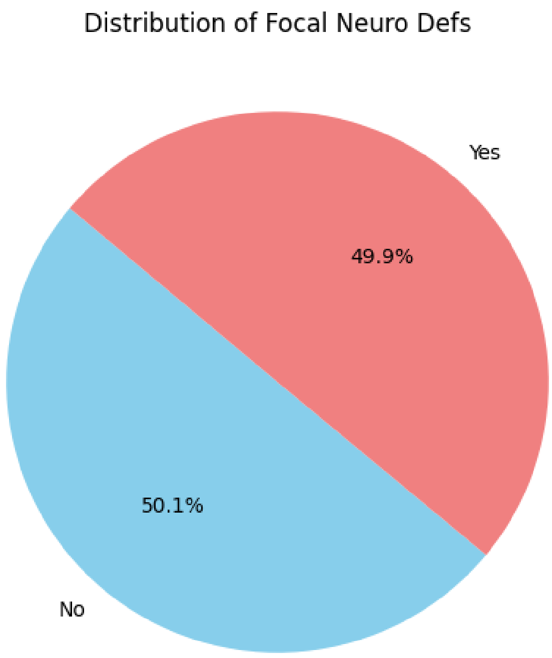

Fig. 8: Focal Neuro Defs

Focal neurological deficits (Focal Neuro Defs) refer to impairments in specific areas of brain function that are localized to a particular region of the brain. Our population had 49.9% of people with focal neuro deficits. These deficits can manifest as weakness or paralysis in specific parts of the body, difficulty speaking, vision problems, or changes in sensation. In the context of cerebral malaria, focal neurological deficits are caused by the brain's response to the malaria parasite, leading to swelling and disruption in the affected brain regions. These neurological abnormalities are critical indicators of severe malaria, as they reflect direct damage to the brain, which can lead to long-term consequences if not promptly addressed. The presence of focal neuro deficits plays a significant role in the classification of malaria severity, particularly in differentiating between cerebral and non-cerebral malaria. When focal neurological deficits are observed, it often indicates that the malaria infection has caused severe complications, requiring immediate and aggressive treatment. The model used in this research incorporates the presence of these deficits to improve the accuracy of cerebral malaria classification. By considering focal neuro deficits as an important feature, the system can better identify cases of cerebral malaria and prioritize them for more intensive care. This enhances the ability to assess the full extent of malaria's impact on patients and helps healthcare providers respond effectively to prevent long-term neurological damage.

CONCLSUION

This research effectively addressed the challenge of malaria severity classification by employing machine learning techniques, particularly the Random Forest algorithm, to distinguish between cerebral and non-cerebral malaria type. The model was trained on a comprehensive dataset that included critical clinical symptoms, socio-economic factors, and demographic information, allowing for a nuanced approach to predicting malaria severity. By leveraging symptoms such as seizures, altered mental status, headache, vomiting, and focal neurological deficits, the model demonstrated strong performance, achieving an accuracy of 97%. This high accuracy highlights the model’s potential for enhancing diagnostic processes, enabling healthcare providers to swiftly identify cerebral malaria, which is often associated with higher mortality and morbidity rates. The research also reveals the broader implications of malaria severity on households and caregivers. Malaria, particularly cerebral malaria, imposes significant socio-economic burdens on families, leading to financial stress, household income loss, and caregiving challenges. The study illustrated how these factors compound the severity of the disease, creating a vicious cycle of health and economic adversity. Caregivers, often at the frontlines of malaria management, face substantial physical, emotional, and financial strain, which can hinder their capacity to provide optimal care. The findings from this work suggest that a more integrated approach, combining medical diagnostics with socio-economic support systems, is critical in mitigating the burden of malaria on both patients and their families. By providing accurate severity classification, this model can serve as a tool for improving healthcare delivery, optimizing resource allocation, and ultimately alleviating the multi-faceted burden malaria imposes on affected communities.

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