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ORIGINAL ARTICLE

Navigating mortality prediction in severe malaria: risk stratification models from the emergency department of coastal India

Short title: Mortality prediction in severe malaria

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ABSTRACT

INTRODUCTION: Malaria, a pervasive infectious disease, remains a critical health concern worldwide, particularly in regions with high transmission rates. This study investigates demographic patterns and prognostic factors influencing outcomes in malaria patients presenting to the emergency department (ED).

MATERIAL AND METHODS: This retrospective cross-sectional study, conducted at ED of South coastal India, from September 1, 2017, to September 1, 2022, analysed data from approximately 12,000 annual visits. Mortality predictors were assessed in malaria-positive patients, including Shock Index (SI), Modified Early Warning Score (MEWS), Sequential Organ Failure Assessment (SOFA), Malaria Severity Index (MSA), Malaria Prognostic Score (MPS), Coma Acidosis Malaria (CAM) score, Respiratory and Bicarbonate-based CAM score (R-CAM and B-CAM), Glasgow Coma Scale (GCS), and GCRBS Score.

RESULT: Analysis of 114 severe malaria cases revealed higher mortality (21.1%) among older rural patients. Non-survivors exhibited elevated pulse rates (139.83 ± 7.43), lower blood pressure (systolic: 62.58 ± 28.27, diastolic: 47.33 ± 20.73), and impaired consciousness (GCS: 6.63 ± 1.69). GCRBS, MSA, and SOFA scores demonstrated exceptional predictive accuracy (AUC = 1.00).

CONCLUSIONS: Identifying crucial mortality predictors like MSA, MPS, CAM, and GCRBS scores in malaria patients can optimize ED management protocols effectively.

KEYWORDS: malaria; prognostic factors; emergency department; GCRBS

INTRODUCTION

Malaria, a potentially life-threatening tropical disease caused by Plasmodium parasites, continues to pose a significant global health challenge [1]. In 2022, the worldwide burden of malaria remained staggering, with an estimated 249 million cases reported across 85 endemic countries and areas. This marked an increase of 5 million cases compared to the previous year, highlighting the persistent threat posed by the disease. Tragically, the mortality rate in the same year stood at 14.3%, underscoring the urgent need for improved prognostic tools and treatment strategies to combat this deadly disease [2].

Within the World Health Organization (WHO) South-East Asia Region, which accounts for about 2% of malaria cases globally, India emerged as a notable hotspot, contributing to 66% of cases in the region. Alongside Indonesia, India accounted for approximately 94% of all malaria-related deaths in the Southeast Asia Region [2]. This disproportionate burden of malaria-

related morbidity and mortality in specific regions, such as Southeast Asia and particularly India, emphasizes the critical need for effective interventions and management strategies [3].

Malaria presents a wide variety of symptoms, ranging from mild to severe, with potentially fatal complications. The disease can be categorized as uncomplicated or severe (complicated), with severe malaria-carrying a high risk of mortality. Major complications of severe malaria include cerebral malaria, severe anaemia, haemoglobinuria, pulmonary oedema acute respiratory distress syndrome (ARDS), acute renal failure, acidosis, and hypoglycaemia[4]. These complications can develop rapidly and progress to death within hours or days, highlighting the importance of prompt and accurate diagnosis and treatment [3].

Prognosticating the outcomes of malaria patients relies heavily on a combination of clinical and laboratory features, aiding in swift triaging and identifying those needing urgent critical care admission. Despite their proven effectiveness in critical care, some scoring systems like MSA (Malaria Score for Adults), MPS (Malaria Prediction Score), SOFA (Sequential Organ Failure Assessment), CAM (Coma Acidosis Malaria score), MEWS (Modified Early Warning Score), and GCRBS (Glasgow Coma Scale, Creatinine, Respiratory rate, Bilirubin, Systolic blood pressure) remain largely unexplored in resource-limited emergency departments (EDs). These scores, leveraging easily accessible clinical parameters and basic lab tests, offer a straightforward means of predicting mortality risk in severe malaria cases. Their simplicity streamlines decision-making without prolonged investigations [5].

While subjective elements in MSA and MPS may introduce observer bias, the quantitative nature of GCRBS and MEWS assessments of all parameters, potentially mitigate such biases. Given malaria's high global incidence, there's a pressing need for improved prognostic tools. This study aims to evaluate mortality predictors and outcomes in malaria patients, focusing on the efficacy of prognostic scoring systems in ED. Insights from this research could inform policy-making, promote standardized scoring system adoption, and enhance patient management protocols in EDs, ultimately improving malaria care.

MATERIAL AND METHODS

Study Design and Setting

The study, a retrospective cross-sectional analysis, gathered data from patients visiting the ED from September 1, 2017, to September 1, 2022. With an average annual visit of 12,000 cases, the authors specifically focused on patients presenting with smear-positive malaria parasites.

Inclusion Criteria

- Patients who were diagnosed as smear-positive for malaria parasite arriving atthe ED.
- Patients of more than or equal to 18 years.

Exclusion Criteria

- Patients less than 18 years.
- Incomplete records.
- Not a confirmed case of malaria.
- Patients with smear positive for malaria along with other tropical fever (e.g. Dengue, chikungunya, etc.).
- Patients partially treated at outside hospitals.
- Pregnant patients.
- Patients leaving against medical advice.
- Patientswho are known cases of chronic kidney disease, cirrhosis of liver disease, respiratory infection, and mental disorder were excluded from this study.

Study protocol

The records of patients who presented to the ED of KS Hegde Medical with fever were analysed and then the patients with smear-positive malaria were included in the study. The patients were assessed and stabilized by the primary survey where airway, breathing, circulation, disability and exposure were evaluated, adjuncts like arterial blood gas analysis (ABG), electrocardiography (ECG), capillary glucose level etc were used and patients were stabilized. For patients with threatened airways, they were intubated by rapid sequence intubation (RSI). Oxygen support to maintain partial pressure of oxygen above 80 mmHg. Mean arterial pressure was maintained above 60 by initial fluid bolus with intravenous (IV) normal saline (NS) at 20mL/kg and

switching over to vasopressor like Nor-epinephrine 0.05–0.1 mcg/kg/min. They were also started on antipyretic measures.

Demographic profile and clinical data along with vitals on arrival to ED were recorded. Basic blood investigations like complete blood count, renal function tests, liver function tests, coagulation profile and fever workup for tropical fever workup (NS1 antigen, widal and IgM for leptospirosis) including peripheral smear for malaria parasite were sent from ED.

For each patient clinical scores like Shock index (SI), mean arterial pressure(MAP), Glasgow coma scale(GCS), MEWS and SOFAwere calculated from the primary survey [6,7].

The severity of malaria upon presentation was evaluated based on several criteria. These included cerebral malaria, characterized by a GCS score of less than 10 or the presence of seizures; severe anaemia, indicated by a haemoglobin level below 5g/dL; jaundice, identified when the total bilirubin level reached or exceeded 3 mg/dL; acute kidney injury, diagnosed with a serum creatinine level surpassing 3 mg/dL; shock, defined by a systolic blood pressure below 90 mmHg despite volume resuscitation or necessitating vasopressor support and pregnancy [4].

Then the six specific prognostic malaria scores were also calculated which are: MSA, MPS, CAM. Respiratory and bicarbonate rate-based CAM score (R-CAM and B-CAM), and GCRBS score, from the investigations sent from the ED on arrival [8–11].

Patients were shifted to ICU or ward, depending on the condition, after initial stabilization. The patients were followed until death or discharge and grouped as non-survivors and survivors respectively.

Outcome

The primary outcome was to assess the predicting factors of mortality and outcome of patients with malaria presenting to the ED. The secondary outcome was to determine the demographic profile of the patients with severe malaria incoastal south India.

Ethical Consideration

The Institutional Ethical Committee Boardprovided the ethical clearance for this study which adhered to the principles of the Declaration of Helsinki concerning ethical principles in medical research.

Statistical analysis

Data analysis was conducted using the computer software SPSS version 23.0. Descriptive statistics were calculated, which include frequencies, percentages, means and standard deviations. Inferential statistics was done for comparison between survivors and non-survivors, using the Mann-Whitney U test, student t-test and Chi-Square/Fisher's Exact test is applied. The association between categorical variables was assessed using the chi-square test. The level of significance for all statistical analyses was set at 5%. Logistic regression analyses were conducted to explore the relationship between variables. The receiver operating characteristic curve (ROC) was employed to determine the optimal cutoff point, providing sensitivity, specificity, and the area under the curve (AUC) and value between 0.9–1 is considered excellent, 0.8–0.9 as excellent, 0.7–0.8 as fair, but 0.6–0.7 and 0.5–0.6 was considered as poor and fail as per academic point system. Statistical significance was defined as a p value ≤ 0.05.

RESULTS

There were a total of 3460 cases of fever with chills of various causes admitted during the study period. Among these,a total of 190 cases were identified as smear-positive for malaria. Among them, a total of76 cases were excluded from the study due to a few reasons: missing data (n=42), leaving against medical advice (n=6), partially treated by an outside hospital (n=14), and patients with co-morbidities (n=12).Two patients were diagnosed with concomitant dengue fever and thus were excluded. After applying the exclusion criteria, a total of 114 cases of malaria remained eligible for analysis.

Among the study group, 90 (78.9%) were survivors and 24 (21.1%) were non-survivors. Analysis revealed stark disparities between survivors and non-survivors across key demographic variables. Among the survivors, males comprised the majority, accounting for 84.6% of cases, while females represented a notable minority at 56.5% among non-survivors. Age-wise, notable distinctions, with a significant proportion of non-survivors falling into older age categories (>60 years), constituting 57.9%. Moreover, residence emerged as a critical factor, with a substantial 88.1% of survivors hailing from urban areas contrasted with 30.9% of non-survivors residing in rural settings (Tab.1).

In comparing clinical parameters, non-survivors of severe malaria exhibited elevated pulse rates (139.83 ± 7.43) and diminished blood pressure metrics including systolic (62.58 ± 28.27) with diastolic (47.33 ± 20.73). They also showed lower mean arterial pressure (52.41 ± 22.94) and oxygen saturation (80.21 ± 4.22), along with elevated respiratory rates (27.96 ± 5.25) and body temperatures (103.13 ± 0.79). Glasgow Coma Scale scores were significantly lower in non-survivors (6.63 ± 1.69), highlighting their impaired consciousness (Tab. 2).

In severe malaria cases, non-survivors showed significantly higher frequencies of Glasgow Coma Scale (GCS) scores <10 (100%), seizures (16.7%), haemoglobin levels <5 g/dL (98.2%), elevated total bilirubin (100%), and creatinine levels >3 mg/dL (91.7% vs. 6.7%) compared to survivors. Additionally, non-survivors had a higher incidence of requiring mechanical ventilation (83.3% vs. 5.6%) and vasopressor support (41.7% vs. 11.1%) (Tab. 3).

In non-survivors of severe malaria compared to survivors, there were significantly lower mean levels of haemoglobin (8.31 g/dL), total leukocyte counts (17,200 cells/mm^3), and platelets (65,500 cells/mm^3), alongside elevated total bilirubin (7.27 mg/dL), serum glutamic oxaloacetic transaminase (SGOT)(129.78 IU/L), serum glutamic pyruvic transaminase (SGPT)(142.5 IU/L), creatinine (3.7 mg/dL), international normalized ratio(INR) (2.70), lactate (6.25 mmol/L), and reduced bicarbonate levels (13.67 mEq/L) (Tab. 4).

In assessing the accuracy of mortality predictors, the area under the ROC curve was utilized. Among them, the GCRBS score stood out with remarkable performance metrics. It demonstrated perfect sensitivity (100%) and specificity (100%), accompanied by an impressive Area under the curve (AUC) of 1.00. Similarly, the MSA and SOFA scores showed outstanding predictive accuracy, with sensitivity and specificity both at 100% and AUCs of 1.00. In contrast, the CAM and BCAM scores displayed limited predictive value, with sensitivities of 97.78% and 100%, respectively, but no specificity (Tab. 5, Fig. 1).

DISCUSSION

Malaria, a mosquito-borne disease, is a significant global health challenge, with India and Indonesia notably contributing to the majority of cases and fatalities within the Southeast Asia Region. Malaria exhibits a wide spectrum of clinical presentations, ranging from mild, uncomplicated cases to severe forms, carrying a notable mortality risk of approximately 14.3%

[2]. In the present study, the elevated mortality rates can be attributed to several factors specific to the coastal region of South India where the research was conducted. This area experiences a higher incidence of malaria due to poor housing conditions and environmental factors. Notably, periods of high temperatures and increased precipitation coincide with a surge in malaria cases, aligning with the breeding patterns of the Anopheles mosquito, the primary vector of malaria. Moreover, inadequate infrastructure and sewage systems in areas prone to heavy rainfall exacerbate the spread of the disease [12].

The present research unequivocally confirms that rural areas exhibit significantly higher mortality rates compared to urban areas, mirroring the findings of a study conducted in Nigeria by Ibinaiye et al. [13], where 61.1% of subjects hailed from rural communities. These results are further supported by a WHO report on malaria in Chhattisgarh, released in April 2023. The absence of comprehensive health education, coupled with the rural population's scepticism towards doctors and modern medicine, undeniably contributes to the surge in cases. Consequently, there is a lack of personal mitigation and prevention techniques, leading to a higher turnover rate of patients presenting late to healthcare facilities, exacerbating their conditions. These findings unequivocally underscore the urgent need for targeted interventions in rural areas to enhance access to healthcare services and curb mortality rates.

This analysis unveiled a significant gender disparity in malaria incidence, with males exhibiting a notably higher prevalence compared to females, as indicated by a male-to-female ratio of 3.9:1, consistent with findings from Abate et al.'s [14] study in Ethiopia in 2021. This discrepancy can be from the greater involvement of males in outdoor activities and occupational settings, leading to increased exposure to mosquito bites, coupled with the financial dependence of women on their male counterparts for healthcare access. However, in urban settings and developed nations, where women's empowerment and financial independence are more pronounced, these gender dynamics may evolve. Additionally, this study highlighted a higher prevalence among individuals aged 21–40 years, a demographic trend consistent with the findings of Abate et al. [14]. This pattern can be attributed to the heightened activity levels typical of this age group, particularly in outdoor settings. Socio-cultural and economic factors play a pivotal role in shaping the demographic profile of vector-borne diseases, underscoring the importance of targeted interventions tailored to specific population groups [15].

Clinical parameters are vital in triaging patients in ED, guiding management strategies and prognosticating outcomes in cases of malaria. However, limited studies have explored the correlation between vital parameters and point-of-care investigations upon arrival with survival outcomes, particularly in ED. A study conducted in Udaipur, Rajasthan by Kumar et al. in 2007 sheds light on this aspect [2].They reported baseline vital parameters including systolic blood pressure (where 6% of patients with BP < 90 mmHg expired and 94% discharged with odds ratio of 12.81) respiratory rate (where in rate <24 per minute had a mortality of 3.77% patients with rate >24 had a mortality of 58.82% with OR of 0.027) and Glasgow Coma Scale (patients with GCS between 3 and 6 had 100% mortality, and a score between 11–15 had 3.63% mortality). The findings of the study are in line with the present where there was higher mortality in patients presenting to ED with tachycardia, hypotension and lower consciousness. Hypotension and shock in malaria may result in tissue hypoperfusion and hypoxia-induced increase in lactate [16].

When comparing severe malaria and mortality rates, significant factors included cerebral malaria (GCS <10), anaemia (Hb <5g/dL), and acute kidney injury (creatinine level >3mg/dL). These findings align with a study by Geleta et al. [17] from Ethiopia, where 17.5% of patients had severe anaemia and among them, 1.7% had cerebral malaria. Notably, the study did not directly compare mortality rates among patients but focused on overall patient characteristics, specifically including children in the analysis.Anaemia in malaria can arise from various factors, including the destruction and reduced production of red blood cells mediated by TNF-alpha, as well as cell lysis during parasite replication, splenic removal, and autoimmune lysis of marked red blood cells [18].Cerebral malaria results from malarial rosettes trapping parasites in brain blood vessels, causing vasodilatation. Intense inflammation, including oxygen free radicals, IFN-gamma, and TNF-alpha, leads to cerebral congestion, reduced blood flow, endothelial cell activation, blood-brain barrier impairment, and cerebral oedema, increasing brain volume [19].

Comparing this study's laboratory parameters with those of a prospective study conducted in Cameroon, Central Africa, byNlinwe et al. [20] in 2018 sheds light on this aspect. Their research focused on baseline lab parameters of patients presenting to the outpatient department with malaria, revealing haemoglobin levels of 11.29 ± 2.50, a total leukocyte count of 7.391 ± 5.24, and platelet counts of 207.4 ± 127.6. Interestingly, the present study's survivor group showed similar findings. The presence of anaemia, leucocytosis, and thrombocytopenia is often linked with mortality. These conditions may arise from factors such as oxidative stress,

splenomegaly, reduced production, or concomitant infections. Anaemia and thrombocytopenia may be secondary to oxidative stress and splenomegaly, while leucocytosis could be due to the redistribution of white blood cells or concurrent infections [21].

Elevated lactate levels in patients correlate with a higher likelihood of negative outcomes, mirroring the findings of Ishioka et al.'s [22] 2020 prospective observational study conducted in Bangladesh. Among the mortality group, lactate levels were recorded at 5.78 ± 1.61, while among survivors, levels were significantly lower at 2.95 ± 0.85. These findings align with the WHO Guidelines for Malaria released in 2021, which designate a plasma lactate level exceeding 5 mmol/L as indicative of severe malaria [23]. Elevated lactate production may be due to the metabolism of *Plasmodium* parasites, and increase anaerobic glycolysis in hypoxic cells and tissues due to parasite sequestration and anaemia. Compromised hepatic and renal lactate clearance which are often associated with underlying liver and kidney conditions, can exacerbate hyperlactatemia [24].

In the emergency department, prognostic indicators for malaria were examined. The MPS conducted by Santos et al.[9] in 2012 in Portugal revealed that survivors had a mean MPS of 1.78 (range: 0.38–4.53) while non-survivors had a mean MPS of 4.68 (range: 4.21–5.20), resulting in a significant palue of 0.008 and an AUC of 0.77 [9]. In the present study, the AUC was perfect, at 1.0 MSA score was extensively researched by Mishra et al. [8] in 2007 in Orissa India showed sensitivity is 89.9%, specificity of 70.6%, and positive predictive value is 94.1% when 5 is taken as the cut-off value.A similar result was found with a better sensitivity and specificity with AUC of 1 for MSA.

Hanson et al. in 2010 delved into the CAM and its associated scores using data from the SEAQUAMAT study [10, 25]. They noted that the CAM score had an AUC of 0.74 (95% CI, 0.67–0.82), while the BCAM score demonstrated an AUC of 0.79 (95% CI, 0.76–0.82), and the RCAM score showed an AUC of 0.68 (95% CI, 0.64–0.71) for predicting mortality [10]. The present analysis revealed a stronger correlation between RCAM and mortality. Notably, measuring base deficits requires access to appropriate laboratory facilities, which typically necessitate minimal maintenance.

The GCRBS score, comprising GCS, creatinine levels, respiratory rate, total bilirubin levels and systolic blood pressure (BP), emerges as a novel prognostic tool in clinical practice.

This study indicates that a GCRBS score of 6 or higher is strongly correlated with elevated mortality, demonstrating exceptional sensitivity and specificity of 100%. This finding aligns with the observations of Mohapatra et al. [11] in Orissa, India, who established a similar threshold with a cutoff score of 5, displaying 85.3% sensitivity and 95.6% specificity. The consistent performance of the score across different studies underscores its potential as an invaluable aid for clinicians, particularly in critical care settings such as the ED, enabling precise prognostication and informed treatment decision-making to optimize patient outcomes.

Several additional factors can influence the severity of malaria, such as climate change, which impacts vector-borne disease transmission, but these were not included in the present study. The rainy season, spanning from June to October, significantly increases the transmission rate of vector-borne diseases. Kabir et al.'s [27] study from Bangladesh observed that the period from July to October is particularly sensitive for dengue cases due to higher relative humidity and lower wind pressure during these months.

This study has some limitations that need to be acknowledged. Primarily, the relatively small sample size and retrospective design introduce inherent biases including selection and information bias. Furthermore, this study was conducted in a tertiary care institute situated in coastal India, potentially limiting the generalizability of the present findings to broader healthcare settings. Additionally, it was not accounted for the specific parasite species and parasitaemia levels, which can significantly influence outcomes. To enhance predictive accuracy, future investigations should incorporate larger datasets, employ more sophisticated modelling techniques, explore novel biomarkers, and utilize advanced data collection methods. Despite these limitations, the present study provides valuable insights into prognostication in the ED for malaria patients, paving the way for further research and refinement of patient care protocols.

CONCLUSIONS

In summary, the present study delves into the nuanced clinical aspects of malaria patients, unveiling key demographic trends, clinical presentations, and predictive markers that influence patient outcomes in the ED. It underscores the pivotal role of identifying crucial mortality predictors like MSA, MPS, CAM and GCRBS scores which exhibit commendable sensitivity, specificity, and accuracy. The integration of these predictive markers into routine ED practices

holds the potential to standardize protocols, particularly in regions burdened by malaria. By doing so, healthcare systems can optimize the management of malaria patients, ensuring prompt and effective interventions that ultimately alleviate the impact of this disease on public health.

Article information and declarations

Data availability statement

The authors agree to the conditions of the publication including the availability of data and materials in this manuscript.

Ethics statement

The study was approved by the Ethical Review Board.Nitte University ethics committee, number: NUSR2-22-019 and date: 28/12/2022). Written or verbal informed consent was not obtained from the patients as it was a retrospective study. The study protocol conforms to the ethical guidelines of the 1975 Declaration of Helsinki as reflected in a priori approval by the institution's human research committee.Written informed consent was not necessary because no patient data has been included in the manuscript.

Author contributions

Conceptualization, methodology and data collection, writing: Original Draft Preparation — MC; formal analysis, investigation, resources, writing:review &editing, supervision —SSVK.

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Conflict of interest

The authors declares that there is no conflict of interest.

Supplementary material

None.

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28. **TABLES AND FIGURES**

Table 1. Demographic profile of malaria patients							
Variable	**Survivors n(n%)**		**Non-survivors n(n%)**			**Total n(n%)**	
Sex							
Male	77(84.6)		14(15.4)			91(179.8)	
Female	13(56.5)		10(43.5)			23(20.2)	
Age							
0–20 years	4(100)		0(0)			4(3.5)	
21–40 years	48(82.8)		10(17.2)			58(50.9)	
41–60 years	30(90.9)		3(9.1)			33(28.9)	
> 60 years	8(42.1)		11(57.9)			19(16.7)	
Residence							
Urban	52(88.1)		7(11.9)			59(51.8)	
Rural	38(69.1)		17(30.9)			55(48.2)	
Variable	**Outcome**	**N**	**Mean ± SD**	**Min**	**Max**	**P-value**	**Median**
Age	Survivors	90	39.34 ± 14.23	18	75	< 0.001*	35.0
	Non-survivors	24	52.58 ± 21.67	25	87		59.0

Table 2. Clinical parameters in malaria on presentation to ED			
Variables	**Survivors (Mean ± Sd)**	**Non-survivors (Mean ± Sd)**	**P-value**
VITALS ON PRESENTATION TO ED			
Pulse Rate (bpm)	90.14 ± 12.63	139.83 ± 7.43	< 0.001*
Systolic BP (mmHg)	111.16 ± 9.89	62.58 ± 28.27	< 0.001*
Diastolic BP (mmHg)	77.03 ± 4.52	47.33 ± 20.73	< 0.001*
SpO2	94.91 ± 4.47	80.21 ± 4.22	< 0.001*
Temperature (^{O}F)	99.85 ± 1.29	103.13 ± 0.79	< 0.001*
Respiratory rate (cpm)	16.82 ± 4.08	27.96 ± 5.25	< 0.001*

Days of hospitalization	4.88 ± 1.45	1.89 ± 0.73	< 0.001
SCORING ON ED PRESENTATION			
MAP	88.40 ± 4.87	52.41 ± 22.94	< 0.001*
Shock Index (SI)	0.79(0.72,0.89)[a]	1.88(1.72,2.11)[a]	< 0.001*
GCS	12.50 ± 1.72	6.63 ± 1.69	< 0.001*
P-value is statistically significant (p < 0.05) [a]Median (Q1,Q3), Mann-Whitney U test is applied			

Table 3. Assessment of severe malaria

Parameters	Survivors n(n %)	Non-survivors n(n %)	P-value
Cerebral malaria	14(15.6)	24(100)	< 0.001*
Seizure	3(3.3)	4(16.7)	0.016*
Severe anemia	0(0)	22(98.2)	0.043*
Jaundice	5(5.6)	24(100)	< 0.001*
Acute kidney injury	6(6.7)	22(91.7)	< 0.001*
Ventilator	5(5.6)	20(83.3)	< 0.001*
Vasopressor	10(11.1)	10(41.7)	< 0.001*
Pregnancy	88(97.8)	23(95.8)	0.597
Metabolic acidosis	7(7.8)	24(100)	< 0.001*
Sinus tachycardia	6(6.7)	24(100)	< 0.001*

Table 4. Lab parameters in malaria

Parameters	Survivors (n = 90) Mean ± SD	Non-survivors (n = 24) Mean ± SD	P-value
Hb	12.89 ± 1.54	8.31 ± 1.48	< 0.001*
TC	7300(6500,8700)[a]	17200(15225,18600)[a]	< 0.001*
Platelets	164000(151500,19800)[a]	65500(31000,87750)[a]	< 0.001*
T. Bilirubin	2.30(2.0,2.5)[a]	7.27(5.34,9.10)[a]	< 0.001*
SGOT	60.61 ± 11.49	129.78 ± 12.39	< 0.001*
SGPT	60(52,70.25)[a]	142.5(132,147.75)[a]	< 0.001*
Glucose	92.40 ± 15.62	80.63 ± 13.20	< 0.001*
Urea	33.7(27.05,40.90)[a]	95(86,104)[a]	< 0.001*

Creatinine	1.9(1.08,2.20)[a]	3.7(3.5,4.24)[a]	< 0.001*
Sodium	137.43 ± 1.75	131.58 ± 4.80	< 0.001*
Potassium	4.01 ± 0.32	4.45 ± 0.58	< 0.001*
Chloride	100.44 ± 3.79	100.17 ± 3.66	0.755
INR	1.20(1.10,1.40)[a]	2.70(2.07,3.30)[a]	< 0.001*
Bicarbonate	23.01 ± 1.93	13.67 ± 2.40	< 0.001*
pH	7.32 ± 0.10	6.91 ± 0.23	< 0.001*
Lactate	1.30(1.0,2.0)[a]	6.25(1.92,9.37)[a]	< 0.001*
*P-value is statistically significant ($p < 0.05$) [a]Median (Q1, Q3), Mann-Whitney U test, p-value			

Table 5. Factors evaluated for mortality predictors in malaria patients

Predictors	Cutoff	Sensitivity	Specificity	AUC	PPV	NPV	Accuracy	P-value
MPS	5	100%	98.89%	1.00	96%	100%	0.99	< 0.001*
MSA	3	100%	100%	1.00	100%	100%	1.00	< 0.001*
CAM	2	97.78%	0	0.36	78.57%	–	0.78	0.055
RCAM	3	100%	84.44%	0.92	63.16%	100%	0.87	0.025*
BCAM	2	100%	0	0.28	78.95%	–	0.78	0.049
GCRBS	6	100%	100%	1.00	100%	100%	1.00	< 0.001*
MEWS	8	91.67%	100%	1.00	100%	97.83%	0.98	< 0.001*
SOFA	9	100%	100%	1.00	100%	1005	1.00	< 0.001*
AUC — area under the curve, PPV — positive predictive value, NPV — negative predictive value								

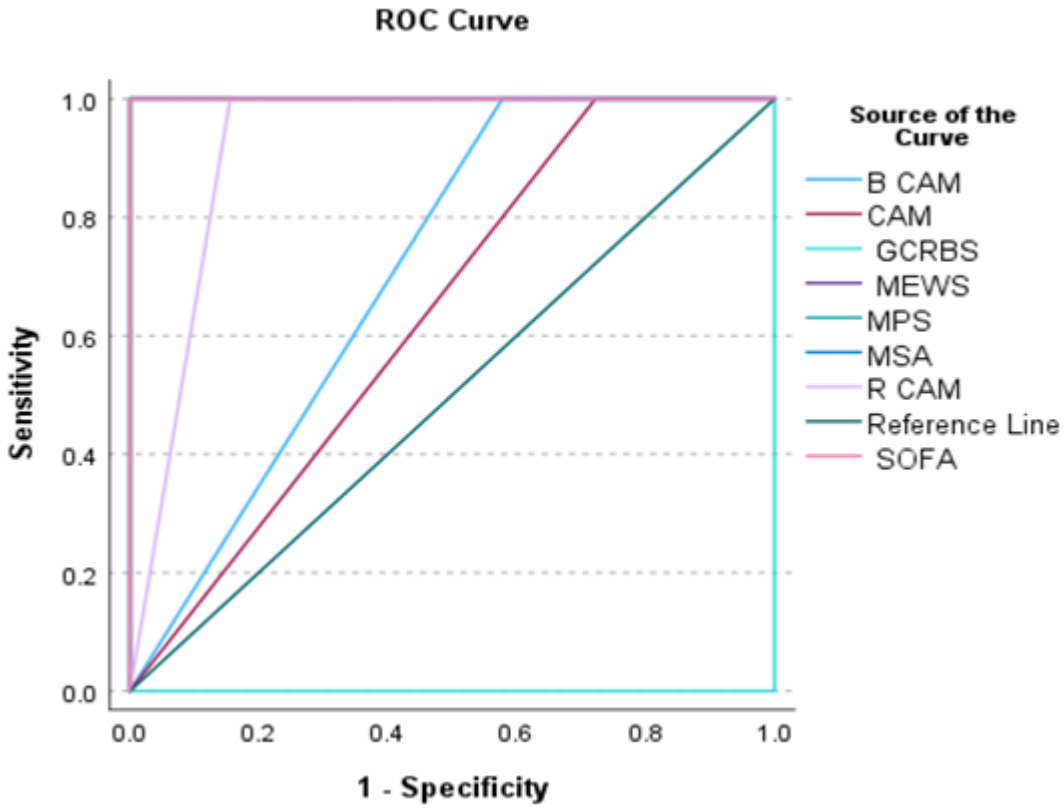

Figure 1. ROC cure for various mortality predictors in patients with malaria