Malaria Journal

RESEARCH

Open Access

Factors associated with severe malaria-related mortality among hospitalized children under five years of age in Eastern Province of Rwanda: a cross-sectional study using hospital records from 2017 to 2021

Jean Paul Hategekimana[1,2*], Clarisse Marie Claudine Simbi[1], Theoneste Ntakirutimana[1,3] and Laetitia Nyirazinyoye[4]

Abstract

Background Malaria remains a significant concern for children under five in malaria-endemic regions. Rwanda's successful efforts in malaria treatment reduced nationwide cases, but high mortality persists in the Eastern and Southern provinces. This study aimed to investigate the clinical features of severe malaria and to identify the death risk factors among under-five children in Eastern province Hospitals.

Methods This cross-sectional study assessed severe malaria-related mortality and associated factors among children aged under five years in hospitals of Eastern Province, Rwanda, from 2017 to 2021. Data were collected from hospital records, and descriptive statistics and logistic regression were used for data analysis.

Results Factors associated with severe malaria-related mortality included coma (aOR: 10, 95% CI: 1.2–82.5, p = 0.03), Vomiting (aOR: 5.2, 95% CI: 1.0–26.0, p = 0.04), four or more days of illness before consultation (aOR: 30.9, 95% CI: 8.7–109.9, p < 0.01). On the other hand, a low parasitaemia level (aOR: 0.01, 95% CI: 0.0–0.1, p < 0.01).

Conclusion In conclusion, coma, vomiting, and healthcare delays increased mortality in children with severe malaria. Prompt treatment, proper assessments, protocol adherence, and caregiver education on early symptom recognition are crucial for improving outcomes.

Keywords Severe malaria, Mortality, Children under five, Rwanda, Factors, Hospital-based study

*Correspondence:
Jean Paul Hategekimana
hjpahulo@gmail.com
Full list of author information is available at the end of the article

Background

Malaria is endemic and a major cause of death among children in the tropical regions and subtropical regions of the world [1, 2]. Global malaria cases declined from 243 million in 2000 to 230 million in 2015. However, cases increased to 249 million by 2022, with most of the rise coming from World Health Organization (WHO) African countries. Malaria-related deaths fell from 864,000 in 2000 to 576,000 in 2019 but rose again to 608,000 in 2022. Among children under five, malaria mortality decreased from 86.8% in 2000 to 76.0% in 2022. The WHO African region accounted for 93.6% of global cases and 95.4% of deaths, with 78.1% of malaria-related mortality among children under five occurring in 2022 [1].

Today, malaria continues to be a significant threat to public health and remains one of the leading causes of death among children under five years of age in Rwanda [2, 3]. From 2017 to 2022, while malaria cases rose in some WHO African countries, Rwanda reduced its cases from 5.9 million to 1.2 million. [1].

Since 2012, malaria incidence dramatically increased in all 30 districts of Rwanda and tripled increases in the Eastern province, and the prevalence of malaria among children under five years old has increased by 6% from 2010 to 2017 [4, 5].

In Africa 30% of malaria cases among those under five are clinically misdiagnosed for severe malaria where patients present along with other medical conditions usually sepsis this last increases the severity of malaria resulting in increased mortality attributed to severe malaria, and severe malaria predispose to bacterial infection [6].

The WHO defines severe malaria as a multisystem disorder with symptoms including impaired consciousness (coma), metabolic acidosis, hypoglycaemia, severe anaemia (haemoglobin < 5 g/dl), renal impairment or acute kidney injury, jaundice, pulmonary oedema, significant bleeding, shock, jaundice and hyper-parasitaemia [7].

The factors associated with severe malaria-related mortality among those under five were severe anaemia or hypoglycaemia, diarrhoeal disease, cerebral malaria and respiratory infection, lack of health insurance, age of the patient, delayed diagnosis, coma, proximity and access to healthcare services, and weather conditions coma/seizures, hyperlactataemia and hypoglycaemia [6, 8–10]. This study aimed to investigate the clinical features of severe malaria and to identify the death risk factors among under-five children in Eastern province hospitals in Rwanda.

Methods

Study design and study area

This cross-sectional study aimed to assess the factors associated with mortality caused by malaria in children under the age of five who were admitted for severe malaria between January 2017 and December 2021 in the Paediatric wards of nine hospitals located in the Eastern province of Rwanda that include Nyagatare DH in Nyagatare District is located in Northern eastern bordering Uganda and Tanzania in east, Ngarama DH, Kiziguro DH in Gatsibo District, Gahini DH, Rwinkwavu DH in Kayonza District, Kibungo RH in Ngoma District, Kirehe DH in Kirehe District. These hospitals of eastern provinces were reported to have an increased malaria mortality rate among those under five [11]. In Rwanda hospitals, malaria is diagnosed mainly using microscopy and thick smears prepared from peripheral blood. The number and type of parasite seen and developmental stage per 200 WBCs and the semi-quantitative system reporting with cross or plus system is used for reporting malaria parasite density by grading from one (+) up to four (++++) crosses or parasites per microlitre of blood. In this study, one and two crosses, which were equivalent to less than 400 parasites per microlitre of blood, were grouped as low parasitaemia, while three and four crosses, equivalent to 400 or more parasites per microlitre of blood, were grouped as high parasitaemia [12].

In Rwanda, malaria is classified into three categories simple malaria, simple malaria with minor digestive disorders, and severe malaria. Simple malaria is diagnosed using rapid diagnostic tests and treated in the community by the trained community health workers; simple malaria with minor complications is treated at the health center; and the severe malaria cases are referred to the hospital for further management where artesunate is used as first-line treatment [12].

The management of severe malaria is done at the hospital level and anti-malarial administration is initiated only after obtaining a positive result; intravenous artesunate, or quinine in case of contraindication to artemisinin derivatives, is given on admission, and then at 12 h and 24 h for maximum of 7 days; when the patient could take oral medication, the treatment was complemented with oral artemether/lumefantrine (Coartem®) for three consecutive days. In the case of cerebral malaria, lumbar puncture is recommended, and anti-malarial drugs are given along with antibiotics. Patients receive routine checks for hypoglycaemia and anaemia, with additional tests like chest X-rays and lumbar punctures performed as needed. Antibiotics are not routinely used unless there is a co-infection.

Sampling methodology and sample size determination

The sample size was calculated using a single population proportion method, assuming a 50% case fatality rate for maximum representation, with a 95% confidence interval. This resulted in an estimated sample size of 422 patient files, calculated using Kish Leslie's formula (11,12).

A total of 2799 severe malaria cases were recorded in registers and electronic medical records in nine hospitals of the eastern province from 2017 through 2021. To ensure representativeness, each study site was assigned a specific number of participants proportional to the size of the hospital, based on the overall sample size (Table 1). Study participants were systematically selected from hospital registers. For those who met the criteria for severe malaria, their files were retrieved from either physical archives or electronic medical records (EMR). This selection process continued until the sample size was proportionate to each representative hospital.

Data collection

A standardized data abstraction form was developed for this study, and data were collected by trained paediatric nurses from the respective hospitals. Before data collection, these data abstractors underwent a two-day training on the data retrieval and abstraction process, which involved accessing information from both physical archives and electronic medical records. Initially, sociodemographic information—such as age, sex, and insurance status—was collected from the hospital registers for each selected participant. Following this, participant files were retrieved from the hospital archives to gather additional clinical details, including clinical indicators (e.g., respiratory distress, convulsions) and management factors (e.g., blood transfusion, administration of antimalarial drugs, antibiotics provision, lumbar puncture). Where necessary, electronic medical records were used to supplement any missing data from the physical patient files. The inclusion criteria for this study included children aged 2 to 59 months who had positive malaria test results along with severe symptoms. Participants outside of this age range or lacking severe symptoms were excluded from the study. Data were entered using Microsoft Excel version 2016 (Microsoft, USA). All data were reviewed for completeness, consistency, and clarity.

Table 1 Severe malaria cases recorded by hospitals and sample size from each hospital, Eastern province, 2017–2021

Health Facilities	Total severe malaria recorded	Sample size from each hospital
Gahini DH	245	37
Kibungo RH	681	103
Kirehe DH	277	42
Kiziguro DH	129	19
Ngarama DH	103	16
Nyagatare DH	25	4
Nyamata DH	885	133
Rwinkwavu DH	454	68
Total	2799	422

Data analysis procedures

Descriptive statistics were used to summarize the sociodemographic and clinical characteristics, as well as case management data. Frequencies and percentages were presented in tables, while medians, means, and ranges were used for continuous variables. The Chi-squared test was performed to assess associations between independent and dependent variables. Logistic regression analysis was conducted to identify factors associated with severe malaria-related mortality among children. Variables with a p-value < 0.05 in the bivariate analysis were included in the multivariate logistic regression to compute odds ratios (OR) and 95% confidence intervals (CI). A p-value < 0.05 was considered statistically significant. Data analysis was performed using STATA 14 (StataCorp, College Station, USA).

Ethical considerations

The ethical approval (No: CMHS/IRB/119/2023) was granted by the University of Rwanda, College of Medicine, and Health Sciences, and the permission to access patients' files was given by the Hospital administration and the research team ensured adherence to ethical guidelines and standards throughout the study by respecting the privacy and confidentiality of individuals whose data was utilized, managing the secondary data effectively, accurately reporting findings, and appropriately acknowledging the sources. No consent or ascent was required as secondary data were used.

Results

Socio-demographic and clinical characteristics of study participants

A total of 422 participants were included in the study. The socio-demographic and clinical characteristics of study participants are presented in Table 1. The median age of study participants was 24.5 months (IQR: 13–40 months). Half of the participants 50.0% (n = 221) were aged from 2 to 24 months. The majority of study participants were males 53.3% (n = 225). Near all participants used health insurance, 93.1% (n = 393). For clinical characteristics of the participants, the majority of the participants presented with convulsion 66.6% (n = 281). Regarding the number of severe symptoms presented

at once 23.5% (n = 99) were presenting more than three severe symptoms at once. Concerning days with illness before consultation, the participants had a mean duration of illness of 2.5 ± 1.5 days with illness onset before seeking medical care, with a large percentage of the patients 84.7% (n = 353) spending less than three days with illness onset before seeking medical care. Regarding parasitaemia majority of the participants, 74.4% (n = 314) had low parasitaemia. Concerning case management, the majority of the participants were treated using intravenous artesunate complemented with Coartem 86.3% (n = 364). Regarding antibiotic provision, a minority of participants 22.5% (n = 95) were given antibiotics. Furthermore, a very small percentage of the participants' lumbar puncture was performed 2.6% (n = 11). In terms of transfusion, out of 115 anemic participants, nearly all 97.4% (n = 112) were transfused and 2.6% (n = 3) died before transfusion. Considering the time elapsed before blood transfusion the majority of the transfused participants, 55.5% (n = 62) were transfused in less than 3 h after admission. Considering the days of hospital stay, most of the patients were hospitalized for less than one week 87.0% (n = 367) with the median of days of hospital stay being 5 days (range: 0–31 days). Regarding the timing of admission majority of the participants, 71.8% (n = 303) were admitted on weekdays. In terms of seasonality of admission, most of the participants were admitted in the rainy season 60.2% (n = 254) (Table 2).

Table 2 Description of socio-demographic characteristics of children with severe malaria in Hospitals situated in the Eastern Province of Rwanda 2017–2021 (n = 422)

Characteristics	Frequency	Percentage
A. Socio-demographic characteristics		
Age in month		
2–24 months	211	50.0
25–48 months	164	38.9
49–59 months	47	11.1
Sex		
Female	197	46.7
Male	225	53.3
Use of health insurance		
Yes	393	93.1
No	29	6.9
B. Clinical characteristics		
Convulsion		
Yes	281	66.6
No	141	33.4
Coma		
Yes	46	10.9
No	376	89.1
Hypoglycaemia		
Yes	20	4.7
No	402	95.3
Severe anaemia		
Yes	115	27.3
No	307	72.8
Respiratory distress		
Yes	151	35.8
No	271	64.2
Diarrhoea		
Yes	44	10.4
No	378	89.6
Prostration		
Yes	41	9.7
No	381	90.3
Vomiting		
Yes	79	18.7
No	343	81.3
Severe malnutrition		
Yes	13	3.1
No	409	96.9
Renal failure		
Yes	3	0.7
No	419	99.3
Parasitaemia		
High	108	25.6
Low	314	74.4
Number of severe symptoms		
< 3 Symptoms	323	76.5
> 3 Symptoms	99	23.5

Severe malaria treatment outcome among children under five in hospitals situated in the Eastern Province of Rwanda 2017–2021

The proportion of severe malaria-related mortality among children was 12.8% (n = 54) whereas 87.2% (n = 368) had a favourable evolution. Considering the day shift on which death occurred, the majority of the deaths occurred during the night shift 57.0% (n = 31). Considering the time of death after admission, most of the participants 66.7% (n = 36) died within 24 h of admission at the hospital. In terms of disability on discharge, two patients were discharged with renal failure and the patient was discharged with neurological sequelae, specifically seizures and limb rigidity (Table 3).

Analysis of the trend of severe malaria among children under five in Hospitals situated in the Eastern Province of Rwanda 2017–2021

Figure 1 illustrates a sharp decline in severe and uncomplicated malaria cases among children under five in Eastern Province hospitals, in Rwanda, between 2017 and 2021. Severe malaria cases dropped from approximately 1600 in 2017 to near zero by 2021, while uncomplicated

Table 2 (continued)

Characteristics	Frequency	Percentage
Days with illness before the consultation		
< 4 Days	353	84.7
4 Days and more	64	15.4
C. Case management		
Anti-malaria drug taken		
Artesunate + coartem	364	86.3
Artesunate	52	12.3
Quinine	6	1.4
Antibiotic provided		
Yes	95	22.5
No	327	77.5
Lumbar puncture		
Yes	11	2.6
No	411	97.4
Blood transfusion among severe anaemia		
Yes	112	97.4
No	3	2.6
Time before transfusion		
< 3 Hours	62	55.4
> 3 Hours	50	44.6
Days of hospital stay		
< 1 Week	367	87.0
> 1 Week	55	13.0
D. Environmental characteristics		
Parts of |the week		
Weekdays	303	71.8
Weekends	119	28.2
Seasonality		
Dry season	168	39.8
Rainy season	254	60.2

Table 3 Severe malaria treatment outcome among children under five in Hospitals situated in the Eastern Province of Rwanda 2017–2021

Characteristics	Frequency	Percentage (%)
Treatment outcome		
Died	54	12.8
Cured	368	87.2
Shift on which death occurred		
Day	23	43.0
Night	31	57.0
Time of death after admission		
Before 24 h	36	66.7
After 24 h	18	33.3
Discharged with disability		
Yes	3	0.7
No	419	99.3

malaria cases also fell from around 1000 to almost zero during the same period.

Analysis of the trend of severe malaria-related mortality among children under five in hospitals situated in the Eastern Province of Rwanda 2017–2021

Figure 2 shows the trends in all-cause mortality and severe malaria-related mortality among children under five years of age with severe malaria in the Eastern Province, Rwanda, from 2017 to 2021. Both categories experienced a decline over time, with malaria-related mortality showing a steadier decrease. However, there is a noticeable increase in all-cause mortality between 2020 and 2021 (Fig. 3).

On bivariate analysis of the factors associated with severe malaria-related mortality. Among the clinical characteristics analyzed, several factors were found to be significantly associated with mortality risk among children with severe malaria including coma ($p=0.00$), severe anaemia ($p=0.04$), respiratory distress (p-value <0.001), diarrhoea ($p=0.04$) vomiting ($p=0.001$), low-level parasitaemia ($p=0.00$), the patient presenting more than three number of severe symptoms at once ($p=0.001$), illness onset that lasts four days and more without treatment ($p=0.001$), more than 1 week of hospital stay($p=0.04$) (Table 4).

Multivariate analysis of factors associated with mortality among children with severe malaria

Table 5 shows the multivariate analysis of factors associated with mortality among children with severe malaria. This analysis reveals several key factors that were significantly associated with high odds of severe malaria-related mortality among children under five. Notably, children who presented with coma had tenfold increased odds of death compared to those without coma (aOR: 10, 95% CI: 1.2–82.5, $p=0.03$). Vomiting was also associated with significantly higher odds of mortality (aOR: 5.2, 95% CI: 1.0–26.0, $p=0.04$). Furthermore, the timing of seeking medical care was highly significant. Children who had four or more days of illness before consultation had 30.9 times the odds of mortality compared to those who sought care earlier (aOR: 30.9, 95% CI: 8.7–109.9, $p<0.01$). In contrast, low parasitaemia level, severe anaemia, respiratory distress, diarrhoea, the number of severe symptoms, and duration of hospital stay did not show significant associations with mortality in this analysis.

Discussion

Severe malaria is prevalent among young children (1 to 59 months) in East Africa. This study aimed to investigate severe malaria-related mortality and associated factors

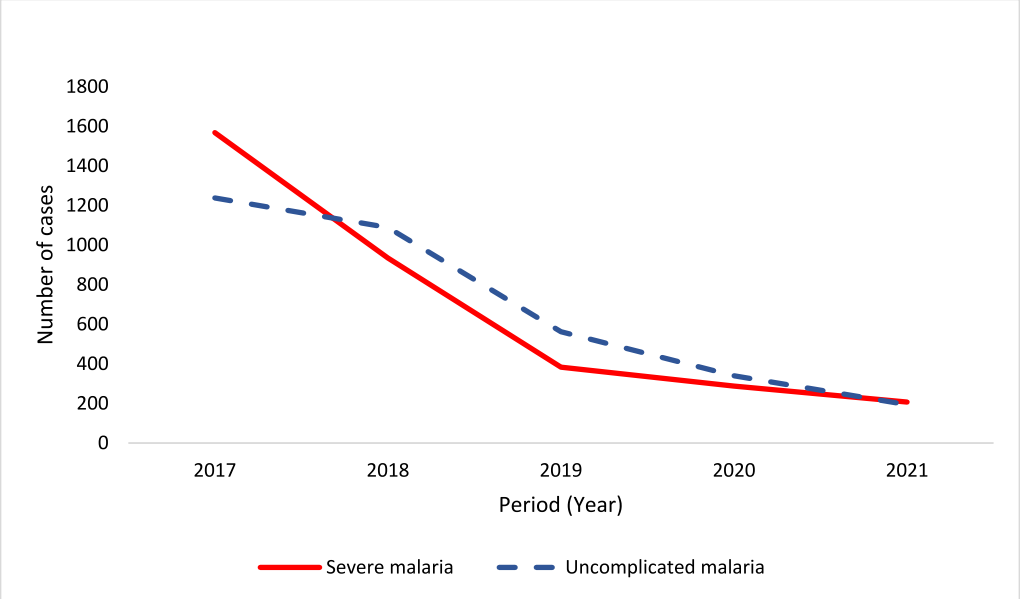

Fig. 1 Trends in severe and uncomplicated malaria cases among children under five in Eastern Province Hospital, Rwanda (2017–2021)

Fig. 2 Map of Eastern Province Hospitals

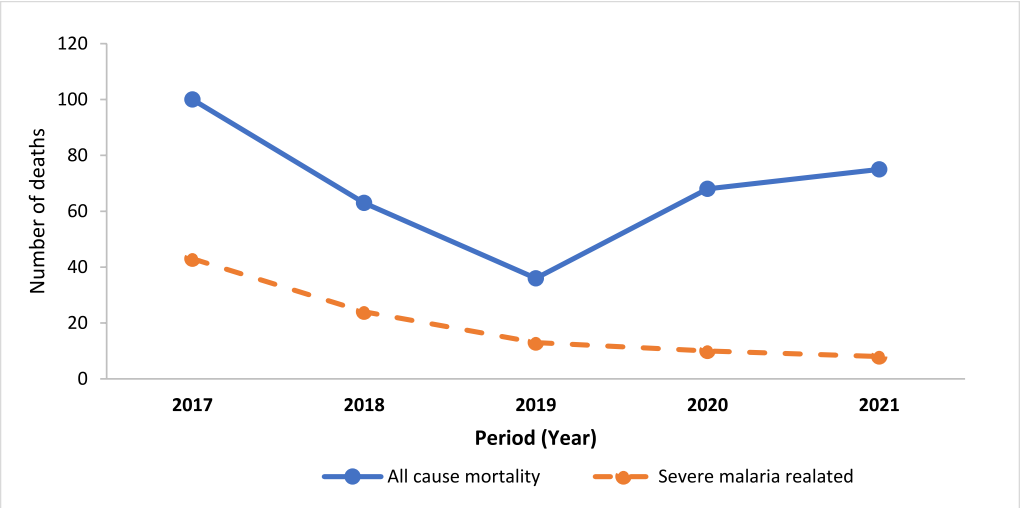

Fig. 3 All-cause mortality and severe malaria-related mortality among children under five years of age with severe malaria from 2017 to 2021, Eastern province hospitals, Rwanda. Bivariate analysis of factors associated with severe malaria-related mortality among under five, Eastern Province Hospitals, Rwanda 2017–2021

in children under five years in hospitals of Eastern Province-Rwanda from 2017 to 2021.

This study found that coma was associated with high odds (OR = 10) of mortality among children aged under five in eastern province hospitals this is similar to findings reported by Sypniewska et al. and Mutombo et al. [13, 14]. However, as other studies suggest, incidental parasitaemia in children with decreased consciousness especially in high transmission areas often leads to misdiagnosis, where cases are diagnosed as cerebral malaria (CM) instead of bacterial meningitis due to limited diagnostic tools [15]. Misclassification can lead to inappropriate treatment, highlighting the need for accurate diagnostics to improve outcomes in malaria-endemic areas. Comprehensive screening, including lumbar punctures, is therefore essential.

This study revealed that vomiting was associated with the odds of death among children under five years old, vomiting was reported among significant symptoms of malaria [16]. The uncontrolled vomiting can lead to hypovolemic shock which is fatal among children when is not corrected immediately [17, 18]. However, vomiting is not solely associated with malaria; other infections, such as viral and bacterial, can also cause vomiting [19]. Moreover, severe malaria heightens the risk of developing bacteraemia, which may frequently go undiagnosed due to overlapping clinical signs with bacterial infections. This misdiagnosis can result in delays in administering antibiotics, ultimately contributing to poorer patient outcomes [20]. Concurrent secondary infections were highlighted as significant factors among the underlying conditions contributing to severe malaria deaths, potentially leading to an overestimation of deaths attributed solely to malaria [21] and this could be the underlying cause which could be clinically poorly explored due to a lack of additional exploratory examinations, including blood culture and other essential laboratory examination [22] hence to the improper treatment of causative agent.

This study found that delays of four days or more significantly increased the odds of death among children under five years old this is similar to findings reported elsewhere [23, 24]. Delays in seeking health care are common among caregivers and parents of children under five years old. This may be due to the use of home medications without prescriptions and consulting traditional healers for children with fever [25, 26]. Timely consultation and prompt initiation of anti-malaria drugs showed a significant reduction in the progression to severe conditions.

Limitations

As this was cross cross-sectional study, it did not identify specific factors associated with a delayed presentation to healthcare facilities. In this study, a sample of 422 severe malaria cases was analysed, which makes up about 15% of the total 2799 cases reported across nine hospitals. While the aim was to capture a representative sample, it is important to note that differences in hospital resources, patient volumes, and adherence to treatment protocols could have influenced the quality of care and outcomes for patients. These variations highlight the need to consider hospital-specific factors when interpreting the findings and discussing their broader implications.

Table 4 Bivariate analysis of factors associated with severe malaria-related mortality among under five, Eastern Province Hospitals, Rwanda 2017–2021

Characteristics	Cured		Died		*p-Value*
	Frequency	Percent	Frequency	Percent	
A. Socio-demographic characteristics					
Age in month					
2–24 Months	182	49.46	29	53.7	
25–48 Months	149	40.49	15	27.8	0.20
49–59 Months	37	10.05	10	18.5	
Sex					
Female	172	46.74	25	46.3	
Male	196	53.26	29	53.7	0.95
Use of health insurance					
No	14	3.8	15	27.8	
Yes	354	96.2	39	72.2	0.00
B. Clinical characteristics					
Convulsion					
No	120	32.61	21	38.9	
Yes	248	67.39	33	61.1	0.36
Coma					
No	343	93.21	33	61.1	
Yes	25	6.79	21	38.9	0.00
Hypoglycemia					
No	353	95.92	49	90.7	
Yes	15	4.08	5	9.3	0.10
Severe Anemia					
No	274	74.46	33	61.1	
Yes	94	25.54	21	38.9	0.04
Respiratory distress					
No	250	67.93	21	38.9	
Yes	118	32.07	33	61.1	0.00
Diarrhoea					
No	334	90.76	44	81.5	
Yes	34	9.24	10	18.5	0.04
Prostration					
No	330	89.67	51	94.4	
Yes	38	10.33	3	5.6	0.28
Vomiting					
No	308	83.7	35	64.8	
Yes	60	16.3	19	35.2	0.00
Renal failure					
No	367	99.73	53	98.2	
Yes	1	0.27	1	1.9	0.17
Severe Malnutrition					
No	358	97.28	51	94.4	
Yes	10	2.72	3	5.6	0.27
Parasitaemia level					
High	57	15.5	51	94.4	
Low	311	84.5	3	5.6	0.00
Number of severe symptoms					
< 3 Symptoms	300	81.52	23	42.6	

Table 4 (continued)

Characteristics	Cured		Died		
	Frequency	Percent	Frequency	Percent	*p-Value*
> 3 Symptoms	68	18.48	31	57.4	0.00
Type of severity					
Cerebral Malaria	233	66.57	28	52.8	
Severe malaria Anemia	72	20.57	7	13.2	
Respiratory distress	23	6.57	4	7.6	
SMA &CM	22	6.29	14	26.4	0.14
Days with illness before the consultation					
< 4 Days	339	92.12	14	28.6	
4 Days and more	29	7.88	35	71.4	0.00
C. Case management					
Anti-malaria drug taken					
Artesunate + coartem	363	98.6	1	1.9	0.60
Artesunate	0	0.0	52	96.3	
Quinine	5	1.4	1	1.9	
Antibiotic provided					
Yes	78	21.2	0	0.0	
No	290	78.8	54	100.0	0.51
Lumbar puncture					
Yes	3	0.8	0	0.0	
No	365	99.2	54	100.0	0.21
Blood transfusion among severe anaemia					
No	0	0.0	3	100	0.07
Yes	94	81.7	18	16.1	
Hour before transfusion					
< 3 Hours	20	76.92	7	58.3	
> 3 Hours	6	23.08	5	41.7	0.25
Days of Hospital stay					
< 1 Week	315	85.8	52	14.2	0.04
> 1 Week	53	96.36	2	3.6	
D. Environmental characteristics					
Parts of |the week					
Weekdays	262	71.2	41	75.9	
Weekends	106	28.8	13	24.1	0.47
Seasonality					
Dry season	141	38.32	27	50.0	
Rainy season	227	61.68	27	50.0	0.10

Conclusion

In conclusion, coma, vomiting, and delays in seeking health care were the main factors linked to higher mortality among children with severe malaria in hospitals in the Eastern Province. These findings highlight the need for prompt treatment, early detection, and close monitoring, especially for cases involving coma. To reduce misdiagnosis of severe malaria, thorough patient assessments are essential, along with strict adherence to protocols that include lumbar punctures and blood cultures to rule out concurrent bacterial infections. Additionally, educational programmes for caregivers are necessary to help them recognize the symptoms of severe malaria early and seek medical care promptly.

Table 5 Multivariate analysis of factors associated with mortality among children with severe malaria among under five, Eastern Province Hospitals, Rwanda 2017–2021

Variables	AOR	P > z	[95% Conf.Interval]
Coma			
No	Ref.		
Yes	10.0	0.03	1.2–82.5
Severe anaemia			
No	Ref.		
Yes	3.1	0.09	0.9–11.1
Respiratory distress			
No	Ref.		
Yes	1.2	0.76	0.3–4.3
Diarrhoea			
No	Ref.		
Yes	1.9	0.51	0.3–12.4
Vomiting			
No	Ref.		
Yes	5.2	0.04	1.0–26.0
Parasitaemia level			
High	Ref.		
Low	0.01	0.08	0.0–0.1
Number of severe symptoms			
< 3 Symptoms	Ref.		
> 3 Symptoms	1.1	0.92	0.2–7.6
Days with illness before the consultation			
< 4 Days	Ref.		
4 Days & more	30.9	0.00	8.7–109.9
Days of hospital stay			
< 1 Week	Ref.		
> 1 Week	0.2	0.24	0.0–2.8

Acknowledgements
The authors thank the eastern province hospitals administration for their invaluable facilitation in access to data. Also thanks goes to AFENET, University of Rwanda, Rwanda Biomedical center.

Author contributions
J.P.H, C.M.C.S and L.N conceptualized the study and designed the methods, J.P.H collected data and analyzed the data, C.M.C.S and L.N supervised the study, T.N. provided substantial contributions to the interpretation of data, All authors contributed equally in drafting, reviewing and approving the final manuscript.

Funding
Not applicable.

Availability of data and materials
Data is provided within the manuscript or supplementary information files upon request.

Declarations

Ethics approval and consent to participate
The studies involving human participants were reviewed and approved by the College of Medicine and Health Sciences, University of Rwanda and the permission to access patients' files was given by the Hospital administration. No consent or ascent was required as we used secondary data.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Author details
[1]Department of Epidemiology and Biostatistics, School of Public Health, University of Rwanda, Kigali, Rwanda. [2]Ministry of Health, Nyagatare District Hospital, Kigali, Rwanda. [3]Department of Environmental Health Sciences, School of Public Health, University of Rwanda RW, Kigali, Rwanda. [4]School of Public Health, College of Medicine and Health Sciences University of Rwanda, Kigali, Rwanda.

Received: 29 August 2024 Accepted: 28 October 2024
Published online: 11 November 2024

References

1. WHO. World Malaria Report 2023. Geneva: World Health Organization. 2023.
2. Gupta N, Hirschhorn LR, Rwabukwisi FC, Drobac P, Sayinzoga F, Mugeni C, et al. Causes of death and predictors of childhood mortality in Rwanda: a matched case-control study using verbal social autopsy. BMC Public Health. 2018;18:1378.
3. DHS. Rwanda Demographic and Health Survey 2019–2020. Final Report, Kigali, 2021.
4. Rudasingwa G, Cho SI. Determinants of the persistence of malaria in Rwanda. Malar J. 2020;19:36.
5. Karema C, Wen S, Sidibe A, Smith JL, Gosling R, Hakizimana E, et al. History of malaria control in Rwanda: implications for future elimination in Rwanda and other malaria-endemic countries. Malar J. 2020;19:356.
6. White NJ. Severe malaria. Malar J. 2022;21:284.
7. WHO. Guidelines for malaria [Internet]. Geneva: World Health Organization; 2023. [cited 2024 Sep 28]. Available from: https://www.who.int/publications/i/item/guidelines-for-malaria.
8. Kogan F. Malaria burden. In: Remote Sensing for Malaria, Chapt 1. Cham: Springer Int Publishing; 2020. https://doi.org/10.1007/978-3-030-46020-4_2.
9. Hakizayezu F, Omolo J, Biracyaza E, Ntaganira J. Treatment outcome and factors associated with mortality due to malaria in Munini District Hospital, Rwanda in 2016–2017: retrospective cross-sectional study. Front Public Health. 2022;10: 898528.
10. Balaji SN, Deshmukh R, Trivedi V. Severe malaria: biology, clinical manifestation, pathogenesis and consequences. J Vector Borne Dis. 2020;57:1–13.
11. Karema C, Aregawi MW, Rukundo A, Kabayiza A, Mulindahabi M, Fall IS, et al. Trends in malaria cases, hospital admissions and deaths following scale-up of anti-malarial interventions, 2000–2010, Rwanda. Malar J. 2012;11:236.
12. Ministry of Health, Rwanda. National Guidelines for the Treatment of Malaria in Rwanda. Kigali, 2013.
13. Sypniewska P, Duda JF, Locatelli I, Althaus CR, Althaus F, Genton B. Clinical and laboratory predictors of death in African children with features of severe malaria: a systematic review and meta-analysis. BMC Med. 2017;15:147.
14. Mutombo AM, Mukuku O, Tshibanda KN, Swana EK, Mukomena E, Ngwej DT, et al. Severe malaria and death risk factors among children under 5 years at Jason Sendwe Hospital in Democratic Republic of Congo. Pan Afr Med J. 2018;29:184.
15. Patel H, Dunican C, Cunnington AJ. Predictors of outcome in childhood *Plasmodium falciparum* malaria. Virulence. 2020;11:199–221.
16. Bria YP, Yeh CH, Bedingfield S. Significant symptoms and nonsymptom-related factors for malaria diagnosis in endemic regions of Indonesia. Int J Infect Dis. 2021;103:194–200.

17. Akkoyun EB, Örsdemir SC, Derinöz O. Sudden unexpected death in a child with vomiting and diarrhea due to intracranial mass lesion. J Pediat Emerg Intensive Care Med. 2017;4:142–5.
18. Taghavi S, Nassar A K, Askari R. Hypovolemic shock. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 [cited 2024 Oct 16]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK513297/.
19. Posovszky C, Buderus S, Classen M, Lawrenz B, Keller KM, Koletzko S. Acute Infectious gastroenteritis in infancy and childhood. Dtsch Ärztebl Int. 2020;117:615.
20. White NJ. Reply to Aung et Al. Clin Infect Dis. 2021;72:536–8.
21. Ogbuanu IU, Otieno K, Varo R, Sow SO, Ojulong J, Duduyemi B, et al. Burden of child mortality from malaria in high endemic areas: results from the CHAMPS network using minimally invasive tissue sampling. J Infect. 2024;88: 106107.
22. Were T, Davenport GC, Hittner JB, Ouma C, Vulule JM, Ong'echa MJ, et al. Bacteremia in Kenyan children presenting with malaria. J Clin Microbiol. 2011;49:671–6.
23. Mutsigiri-Murewanhema F, Mafaune PT, Shambira G, Juru T, Bangure D, Mungati M, et al. Factors associated with severe malaria among children below ten years in Mutasa and Nyanga districts, Zimbabwe, 2014–2015. Pan Afr Med J. 2017;27:23.
24. Peprah NY, Mohammed W, Adu GA, Dadzie D, Oppong S, Barikisu S, et al. Patient socio-demographics and clinical factors associated with malaria mortality: a case-control study in the northern region of Ghana. Malar J. 2024;23:230.
25. Umuhoza C, Karambizi AC, Tuyisenge L, Cartledge P. Caregiver delay in seeking healthcare during the acute phase of pediatric illness, Kigali, Rwanda. Pan Afr Med J. 2018;30:160.
26. Roder-DeWan S, Gupta N, Kagabo DM, Habumugisha L, Nahimana E, Mugeni C, et al. Four delays of child mortality in Rwanda: a mixed methods analysis of verbal social autopsies. BMJ Open. 2019;9: e027435.

Publisher's Note