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REVIEW

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# Stroke incidence, presentation, and outcomes in malaria: a review of current evidence

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## Abstract

Malaria, a global health challenge, remains a leading cause of morbidity and mortality, particularly in sub-Saharan Africa, Southeast Asia, and South America. While traditionally associated with fever and systemic complications, the neurological impact of malaria, including stroke, has become a significant concern. This review aims to examine the incidence, clinical presentation, and outcomes of stroke in individuals with malaria, highlighting the role of malaria in both ischaemic and haemorrhagic strokes. A literature search identified nine studies published between 1999 and 2024, comprising case reports and case series involving malaria-related strokes in patients aged 2 to 47 years. Most cases involved *Plasmodium falciparum,* with a notable association between this parasite and haemorrhagic strokes. *Plasmodium vivax,* while less commonly implicated, was associated with ischaemic strokes, especially in younger patients. Diagnostic challenges, including misdiagnosis, were frequently encountered due to the overlap of neurological symptoms with cerebral malaria, emphasizing the need for a high index of suspicion. The pathophysiology of malaria-related strokes is multifactorial, with both mechanical obstruction of cerebral vessels and hypercoagulable states contributing to stroke development. Treatment generally involves a combination of anti-malarial therapy and supportive care, including management of complications such as raised intracranial pressure or seizures. Outcomes vary, with ischaemic stroke patients showing better recovery than those with haemorrhagic strokes. However, mortality remains high, particularly in cases with severe complications like cerebral venous thrombosis. Early diagnosis and intervention are crucial for improving survival and minimizing long-term neurological impairment. Further research is needed to refine diagnostic approaches, elucidate the underlying mechanisms, and optimize management strategies for stroke in patients with malaria.

**Keywords** Malaria, Stroke, Ischemic stroke, Hemorrhagic stroke, Plasmodium falciparum, Plasmodium vivax

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## Background

Malaria remains a major global health concern, with an estimated 263 million cases and 597 000 deaths reported in 2023, predominantly in sub-Saharan Africa, Southeast Asia, and South America [1]. This is an increase of 11 million cases above 2022 global estimates and a rise in incidence from 58.6 cases per 1000 population at risk in 2022 [1]. Despite significant advances in malaria control, the disease continues to disproportionately affect vulnerable populations, including children under five and pregnant women [2]. While malaria is primarily known for its febrile illness and systemic complications, its neurological manifestations, particularly cerebral malaria, pose a significant burden, often resulting in long-term disability or death [3]. Stroke, on the other hand, is one of the leading causes of morbidity and mortality worldwide, with a growing incidence in low- and middle-income countries (LMICs), including malaria-endemic regions [4]. Traditionally, the increasing burden of stroke in these settings has been attributed to the rise in non-communicable diseases (NCDs) such as hypertension, diabetes, and dyslipidaemia [5]. However, emerging evidence suggests that infectious diseases, including malaria, can also play a pivotal role in stroke pathogenesis, particularly in younger individuals without traditional vascular risk factors [6].

Despite growing recognition of malaria's neurological impact, the true burden of stroke in malaria-endemic regions remains underreported. The lack of neuroimaging facilities, limited access to specialized stroke care, and overlapping clinical presentations between cerebral malaria and stroke contribute to diagnostic challenges [7]. This diagnostic ambiguity often results in misclassification, which delays appropriate interventions and leads to worse clinical outcomes [7]. Understanding the epidemiology, clinical presentation, and consequences of stroke in malaria patients is critical for improving early recognition and management. While cerebral malaria has been extensively studied, there is a need to explore further the incidence of ischaemic and haemorrhagic strokes in patients with malaria, particularly in adults who do not fit the classical profile for cerebral malaria.

Given the potential interplay between malaria and stroke, there is an urgent need for targeted research to characterize stroke subtypes, risk factors, and prognostic outcomes in malaria-infected patients. Addressing this knowledge gap can inform public health strategies that integrate stroke prevention and management into malaria-endemic settings. Moreover, recognizing the vascular implications of malaria contributes to a broader understanding of infection-associated strokes and their long-term sequelae. This paper examines the incidence, clinical presentation, and outcomes of stroke in malaria.

### Methodology

This narrative review evaluates evidence on the incidence, clinical presentation, and outcomes of stroke in individuals infected with malaria.

### Search strategy

A literature search was conducted in PubMed/MEDLINE, Scopus, Web of Science, Embase, African Journals Online (AJOL), and the Cochrane Library, covering studies from database inception to December 31, 2024. Gray literature was identified through Google Scholar, WHO Malaria Reports, and regional stroke registries (e.g., African Stroke Organization). Search terms included: ("Malaria"OR"Cerebral Malaria"OR"Plasmodium falciparum"OR"Plasmodium vivax"OR"Severe Malaria") AND ("Stroke"OR"Ischemic Stroke"OR"Hemorrhagic Stroke"OR"Cerebrovascular Disease") AND ("Incidence"OR"Epidemiology"OR"Clinical Presentation"OR"Outcomes"). To minimize selection bias, manual searches of reference lists from relevant articles, systematic reviews, and meta-analyses were performed. Duplicate records were removed using EndNote (version X9).

### Eligibility criteria

Studies were included if they met the following criteria:

Population: Patients with confirmed malaria infection (*P. falciparum*, *P. vivax*, *Plasmodium ovale*, or *Plasmodium malariae*).
Study focus: Reported data on stroke incidence, clinical features, risk factors, or outcomes in malaria patients.
Study design: Original peer-reviewed studies (e.g., case reports, case series, cohort studies, cross-sectional studies).
Outcome measures: Reported at least one of stroke incidence, subtype (ischaemic vs. haemorrhagic), neurological deficits, mortality, or long-term disability.
Language: English-language publications.

Exclusion criteria included:

Studies on animal models or in vitro research.
Non-peer-reviewed articles (editorials, conference abstracts).
Studies lacking stroke-specific data or confirmation of malaria.

### Study selection

Two independent reviewers (NA, AEB) screened records in two stages: (1) title and abstract screening to exclude irrelevant studies, and (2) full-text review to confirm eligibility. Discrepancies were resolved through discussion or consultation with a third reviewer (EK). The study selection process is summarized in a PRISMA flow diagram (Fig. 1).

### Data extraction

Data were extracted independently by two reviewers (NA, GO) using a standardized form. Discrepancies were resolved through consensus.

### Quality assessment

Study quality was assessed using the Joanna Briggs Institute (JBI) critical appraisal tools, tailored to study designs

**Table 1** Risk of Bias Assessment of Included Studies

| Study | Clear Patient Description | Diagnostic Clarity | Treatment Description | Outcome Reporting | Confounding Factors | Overall Risk of Bias | Comments |
|---|---|---|---|---|---|---|---|
| Leopoldino et al. (1999) | Yes | Yes | Yes | Yes | No | Moderate | Clear description of MCA stroke with imaging; no comorbidities reported, limiting confounder assessment |
| Kaushik et al. (2009) | Yes | Yes | Yes | Yes | No | Low | Detailed case with imaging-confirmed vertebrobasilar stroke, antiplatelet use, and follow-up; comorbidities not reported |
| Jatav et al. (2014) | Yes | Yes | Yes | Yes | No | Moderate | Frontal lobe infarct well-described with outcomes; no mention of comorbidities or imaging details |
| Gediya et al. (2017) | Yes | Yes | Yes | Yes | No | Moderate | Clear *P. vivax* stroke case with recovery; no comorbidities or detailed imaging reported |
| Kochar et al. (2017) | Yes | Yes | Yes | Yes | No | Moderate | Acute infarct in young patient well-documented; lacks comorbidity data and imaging specifics |
| Shewiyo et al. (2019) | Yes | Yes | Yes | Yes | No | Low | CT-confirmed basal/thalamus stroke, detailed treatment and recovery; no comorbidities reported |
| Butt & Ahmed (2022) | Yes | Yes | Yes | Yes | Yes | Low | AKI and polyneuropathy reported, MCA thrombosis confirmed; comprehensive case with follow-up |
| Krishnan et al. (2004) | Yes | Yes | Yes | Yes | No | Moderate | CVT in three cases described, but no specific venous territories or comorbidities reported |
| Birhanu et al. (2024) | Yes | Yes | Yes | Yes | No | Moderate | Hemorrhagic stroke with imaging, but no unique findings or comorbidities reported |

Assessed using Joanna Briggs Institute (JBI) Critical Appraisal Checklists for Case Reports and Case Series. Domains: (1) Clear Patient Description (demographics, clinical history); (2) Diagnostic Clarity (stroke confirmation via imaging/clinical criteria); (3) Treatment Description (interventions specified); (4) Outcome Reporting (outcomes and follow-up clarity); (5) Confounding Factors (comorbidities reported). Overall Risk of Bias: Low (all domains met), Moderate (minor gaps, e.g., no comorbidities), High (significant gaps). Most studies are case reports, limiting confounder assessment

(e.g., case reports, case series). Two reviewers (NA, ICA) independently evaluated risk of bias, focusing on selection bias, reporting clarity, and outcome measurement. Table 1.

### Data synthesis

Due to heterogeneity in study designs and outcomes, a narrative synthesis was conducted to summarize the incidence of stroke, clinical presentations, comorbidities, treatments, and outcomes.

## Results

This review includes a total of nine studies [8–16] published between 1999 and 2024. The studies consisted of case reports and case series, with ages ranging from 2 to 47 years (Table 2). In all the studies, malaria was diagnosed based on clinical presentation and laboratory confirmation, typically through blood smears or rapid diagnostic tests. Stroke cases were diagnosed through a combination of clinical assessments and neuroimaging techniques, such as CT scans and MRI, which identified infarcts or hemorrhages. The treatment protocols across the studies were largely consistent, with anti-malarial therapy as the cornerstone. Quinines were the most used anti-malarial agents, often in combination with other drugs like doxycycline, sulfadoxine/pyrimethamine, or clindamycin. Supportive care, including fluid management and antipyretics, was also widely implemented.

### Malaria species

*Plasmodium falciparum* was frequently associated with hemorrhagic strokes [8–10]. The severity of these complications highlights the heightened risk of stroke in individuals infected with *P. falciparum*. In contrast, *P. vivax*, although less commonly associated with stroke, has been implicated in ischaemic strokes, particularly among younger patients [11–13]. While *P. vivax* malaria is generally considered less severe than *P. falciparum*, these findings suggest that even non-falciparum malaria can lead to significant neurological consequences, including ischaemic infarcts.

### Age and demographics

The age range of patients affected by stroke due to malaria spans a wide spectrum. The youngest reported case involved a 2-year-old child from East Africa [14], highlighting that even very young children can experience stroke as a complication of malaria. On the other end of the spectrum, the oldest reported patient was a 47-year-old male [10], demonstrating that stroke complications related to malaria are not limited to any specific age group, with individuals of varying ages being susceptible. Regarding gender, no clear predominance was observed in the studies reviewed. However, the sample sizes were generally small, which limits the ability to draw definitive conclusions about gender-specific risks and trends.

### Clinical presentation

Patients with malaria-related stroke commonly present with a range of symptoms, including fever, headache, altered sensorium, and various neurological deficits. Hemiparesis or hemiplegia was observed in several cases [8, 14, 15]. In addition to motor deficits, specific neurological manifestations such as cranial nerve palsies [10, 11] and signs of cerebellar dysfunction were also documented [12]. Seizures [16] and signs of increased intracranial pressure [9] were additional clinical features that contributed to the complexity of the patients'presentations, further complicating their management and prognosis.

### Stroke types

Malaria-related strokes predominantly include two types: ischaemic and haemorrhagic strokes. Ischaemic strokes were observed in both *P. falciparum* and *P. vivax* infections, affecting various cerebral artery territories, as seen in multiple cases [10, 13, 16]. On the other hand, haemorrhagic strokes were more commonly associated with *P. falciparum* infections, with cerebral parenchymal haemorrhage [8] and venous infarcts due to thrombosis [15] frequently reported. These severe complications highlight the significant impact of malaria on cerebral vasculature, resulting in both ischaemic and haemorrhagic events in affected patients.

Among the included studies reporting ischemic strokes (n = 6), infarcts commonly involved the middle cerebral artery (MCA) territory [15, 16] and frontal lobe [12] in the anterior circulation, and the vertebrobasilar territory [13] in the posterior circulation. The MCA was the most frequently reported territory, potentially due to mechanical obstruction by parasitized red blood cells (RBCs). No studies explicitly reported angiographic findings (vessel cut-offs), though Butt & Ahmed [15] noted intra-arterial thrombosis in the MCA, suggesting a mechanical aetiology.

One study [8] reported a right cerebral parenchymal hsemorrhage associated with *P. falciparum* malaria, but no unique imaging findings (specific patterns or locations) were described beyond the haemorrhage's location and associated hemiparesis. One study [9] reported cerebral venous thrombosis (CVT) in three adults

**Table 2** Study Characteristics

| | Authors | Year | Number participants | Age (Years) | Case Description | Clinical Findings | Diagnosis | Treatment | Outcome |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Leopoldino JF, Fukujima MM, Gabbai AA | 1999 | 1 | 28 | Case of malaria with stroke in the middle cerebral artery territory | Fever, headache, weakness, neurological sequelae, no encephalitis | Stroke (middle cerebral artery) | Supportive care, quinine | No encephalitis, mechanical theory applicable |
| 2 | Kaushik RM, Kaushik R, Varma A, et al | 2009 | 1 | 47 | male with fever, vomiting, hoarseness, dysphagia, and altered sensorium | Left lateral medullary syndrome, left cerebellar dysfunction | Cerebral malaria with ischemic stroke in vertebrobasilar territory | Quinine, doxycycline, sulfadoxine/pyrimethamine, aspirin, clopidogrel | Gradual neurological improvement, discharged after 15 days |
| 3 | Birhanu AM, Kebede MA, et al | 2024 | 1 | 26 | male with fever, headache, vomiting, and loss of consciousness | Right cerebral parenchymal hemorrhage, left hemiparesis | Hemorrhagic stroke associated with P. falciparum malaria | Antimalarial treatment, supportive care | Recovery from hemiparesis, neurological improvement |
| 4 | Butt N, Ahmed E | 2022 | 1 | 18 | Complicated case of acute kidney injury with polyneuropathy and thrombosis | Axonal/sensory neuropathy, intra-arterial thrombosis in middle cerebral artery | Malaria with neurological manifestations including polyneuropathy and stroke | Prompt antimalarial therapy, supportive care | Recovery of renal function and motor/sensory functions |
| 5 | Shewiyo EJ, Nyalile KB, et al | 2019 | 1 | 2 | boy with convulsions, fever, left hemiplegia, right hemiparesis | Hyperparasitemia, CT hypoperfusion in basal and thalamus regions | Cerebral malaria with stroke | Artesunate injections, IV antibiotics, sodium valproate, physiotherapy | Full neurological recovery after 10 days |
| 6 | Gediya NU, Marvaniya MK, et al | 2017 | 1 | 16 | female with fever, altered sensorium, and left-sided weakness | Left hemiparesis, left upper motor neuron facial palsy | Stroke associated with P. vivax malaria | Antimalarial therapy, supportive care | Full recovery, no complications |
| 7 | Krishnan A, Karnad DR, Limaye U, Siddharth W | 2004 | 3 | 45, 48, 35 | Three adults with falciparum malaria developed cerebral venous thrombosis | Fever, altered consciousness, focal neurological deficits | Cerebral venous thrombosis in severe malaria | Antimalarial therapy, anticoagulation | Recovery with no major sequelae |
| 8 | Jatav OP, Singhal A, Singh AP | 2014 | 1 | 30 | female with P. vivax infection and a frontal lobe infarct | Fever, headache, neurological sequelae | Frontal lobe infarct due to P. vivax malaria | Quinine, supportive care | Neurological improvement after antimalarial therapy |
| 9 | Kochar SK, Kamath SD, Toshan N, Singhal Y, Kochar A | 2017 | 1 | 16 | male developed an acute cerebral infarct during P. vivax malaria | Left-sided weakness, facial palsy, and altered consciousness | Acute cerebral infarct in P. vivax malaria | Quinine, supportive care | Full recovery with no complications |

with falciparum malaria, but specific venous territories (e.g., superior sagittal sinus, transverse sinus) were not detailed. Clinical presentations included focal neurological deficits and altered consciousness, consistent with CVT's typical manifestations.

#### Diagnostic challenges

Misdiagnosis remains a significant challenge in the management of malaria-related strokes. Several cases were initially misdiagnosed or not considered for stroke, leading to delayed interventions. For example, in one case [13], a patient with malaria-related stroke was initially treated for meningitis due to similar clinical features, delaying the correct diagnosis and appropriate treatment. The importance of considering stroke in the differential diagnosis for malaria patients, particularly those presenting with neurological symptoms, is critical to ensuring prompt and effective management.

#### Pathophysiological mechanisms

The pathophysiology of malaria-related strokes involves multiple mechanisms that contribute to cerebrovascular complications. One prominent theory suggests that mechanical obstruction of cerebral vessels by infected red blood cells plays a key role in the development of stroke [9]. This mechanism is supported by cases where stroke was attributed to such obstructions, which hinder blood flow and lead to ischaemia in the affected cerebral regions [16]. The aggregation of parasitized red blood cells in small vessels can lead to local ischaemia, thereby exacerbating neurological deficits. In addition to mechanical blockage, the inflammatory responses and potential hypercoagulable states associated with severe malaria are also implicated in stroke development. For instance, cases of cerebral venous thrombosis have been linked to these hypercoagulable conditions, with inflammatory mediators contributing to vessel damage and thrombosis [9]. This suggests that the pathogenesis of stroke in malaria is multifaceted, involving both direct mechanical obstruction and a systemic hypercoagulable state, which together increase the risk of cerebrovascular complications.

#### Treatment and management

The treatment and management of malaria-related strokes generally follow a multi-pronged approach, focusing on both the underlying malaria infection and the neurological complications that arise. Artesunate injections were a common initial treatment across all studies, highlighting their essential role in both managing the malaria infection and potentially reducing stroke severity. Artesunate, as a first-line anti-malarial, is particularly effective in treating severe forms of malaria, including cerebral malaria, and may also help mitigate the neurological impact of malaria-induced strokes [13, 14]. Prompt initiation of anti-malarial therapy is crucial in reducing parasitaemia and preventing further brain vascular damage. In addition to anti-malarial therapy, supportive care is a crucial component in managing these complex cases. This includes the administration of antibiotics to treat potential secondary infections, which are common in patients with severe malaria [10]. For cases involving cerebral venous thrombosis or other thrombotic complications, anticoagulation therapy may be considered to prevent further clot formation and improve cerebral circulation [9]. Symptomatic treatments for managing fever, seizures, and increased intracranial pressure are also essential in stabilizing the patient and improving overall outcomes.

#### Outcomes

The outcomes of stroke in malaria patients vary widely depending on the severity of the infection, the type of stroke, and the timing of intervention. Many patients demonstrated significant neurological improvement with timely and appropriate treatment. Younger patients, in particular, often experienced favourable outcomes, with some achieving full recovery, especially when interventions such as anti-malarial therapy and supportive care were administered early [11]. Early recognition and management of stroke symptoms were key factors contributing to better recovery. The overall prognosis for patients with ischaemic strokes was more favourable than for those with haemorrhagic strokes, as the latter were more prone to complications such as raised intracranial pressure and extensive parenchymal damage. However, mortality rates were notably high in cases with severe complications, particularly those involving cerebral venous thrombosis. In these instances, even with aggressive treatment, the risk of death remained high, with the most severe cases resulting in fatal outcomes due to increased intracranial pressure or other complications [9].

## Discussion

This review synthesized the current evidence on the incidence, clinical presentation, and outcomes of stroke in patients with malaria. Malaria is widely recognized for its acute febrile manifestations and the risk of organ dysfunction in severe cases, but the neurological sequelae, particularly stroke, are less frequently emphasized in clinical practice [17]. This review emphasizes the need for heightened awareness among healthcare providers in malaria-endemic regions, particularly when neurological symptoms such as hemiparesis, seizures, or altered consciousness occur in patients with a history of malaria.

While stroke is not a hallmark feature of malaria, its occurrence suggests that the infection such as malaria has the potential to cause profound vascular damage to the brain [18].

The heterogeneity in stroke presentations—ranging from ischemic strokes caused by microvascular occlusions to haemorrhagic strokes and cerebral venous thrombosis—further complicates clinical management. The fact that falciparum malaria is more frequently linked to haemorrhagic strokes and cerebral venous thrombosis supports the notion that different *Plasmodium* species exert distinct pathophysiological effects on the cerebrovascular system [19]. The implication here is that a detailed approach to diagnosis and treatment is necessary, considering both the type of malaria and the likely mechanism of stroke. Moreover, the high incidence of stroke in younger patients infected with *P. vivax* challenges the assumption that this species is benign in comparison to *P. falciparum.* It suggests that clinicians should maintain a high index of suspicion for neurological involvement, even in patients with less severe forms of malaria. This is particularly important in paediatric populations, where neurological complications of malaria are often underreported [20].

A significant takeaway from this review is the recurring issue of delayed diagnosis or misdiagnosis of stroke in malaria patients. In endemic areas, where malaria is more common than stroke, neurological symptoms such as hemiparesis or altered consciousness may be wrongly attributed to malaria encephalopathy or other causes, delaying critical interventions like neuroimaging and thrombolytic therapy. This highlights a broader diagnostic challenge in regions with limited healthcare resources, where malaria overshadows other potentially life-threatening conditions, including stroke. The potential for misdiagnosis highlights the need for improved diagnostic protocols and a more systematic approach to patient evaluation. Incorporating rapid neuroimaging techniques, such as CT or MRI scans, into routine diagnostic pathways for malaria patients presenting with neurological symptoms could enhance the early detection of strokes and inform more informed treatment decisions. Furthermore, clinicians should be trained to consider stroke in the differential diagnosis for any malaria patient exhibiting focal neurological deficits. The overlap of malaria and stroke symptoms also suggests that the pathophysiology of malaria-related stroke could be more complex than previously thought. Malaria exacerbates pre-existing vascular vulnerabilities, such as endothelial dysfunction, which predispose specific individuals to stroke [21]. This raises the question of whether malaria is a contributing factor in the development of stroke in patients with underlying risk factors, such as hypertension or diabetes, even in the absence of overt cerebrovascular disease.

The pathophysiology of stroke in malaria is complex and multifactorial. Traditionally, the focus has been on the mechanical obstruction of cerebral vessels by infected red blood cells, a hallmark of *Plasmodium falciparum* infections [22]. While this theory is well-supported by the findings of several studies [22, 23], our review also highlighted the potential role of inflammatory responses, endothelial damage, and hypercoagulability in driving stroke development. Endothelial damage, driven by the sequestration of the *Plasmodium* parasite, promotes microvascular occlusion and thrombosis, as parasitized RBCs adhere to the vascular endothelium, impairing cerebral blood flow [22]. These mechanisms, coupled with the release of inflammatory cytokines and hypercoagulability, show a complex interaction among the parasite, the immune system, and the vasculature. Given the role of endothelial damage and thrombosis in ischaemic stroke, antiplatelet therapy could mitigate these effects. However, among the six studies reporting ischaemic strokes in this review, only one [10] documented the use of aspirin and clopidogrel in a case of vertebrobasilar territory stroke, with the patient showing gradual neurological improvement. The limited use of antiplatelets likely reflects clinical caution due to bleeding risks in malaria, such as thrombocytopenia or cerebral haemorrhage [8], or a prioritization of anti-malarial and supportive therapies. This scarcity highlights a research gap, as the efficacy and safety of antiplatelets in malaria-associated ischemic stroke remain underexplored, warranting further investigation to balance antithrombotic benefits against haemorrhagic risks. Cerebral venous thrombosis, which was particularly common in *P. falciparum* infections, illustrates the importance of the hypercoagulable state induced by malaria. Inflammatory mediators released during malaria infection may trigger clot formation, which, when compounded by mechanical obstruction, can lead to severe neurological outcomes. This suggests that stroke in malaria is not simply a mechanical phenomenon but also a consequence of the body's immune response to the infection. The interplay between these mechanisms warrants further exploration, as understanding these processes could help identify novel therapeutic targets to reduce stroke risk in patients with malaria. Furthermore, the fact that even *P. vivax,* traditionally considered less virulent, can cause ischaemic strokes suggests that the pathogenesis of stroke in malaria is not solely determined by the severity of the parasitic infection but also by the host's immune response and underlying vascular health. This finding calls for a more

holistic understanding of how malaria interacts with host biology to produce neurological damage.

The management of stroke in malaria patients involves a combination of anti-malarial therapy, symptomatic management, and supportive care. Artemisinin-based therapies, such as artesunate, are the cornerstone of treatment for severe malaria and have shown some potential in mitigating stroke severity [24]. However, there is limited evidence on how effectively these therapies specifically address stroke-related pathology. In severe cases of haemorrhagic stroke or cerebral venous thrombosis, additional interventions such as anticoagulation or thrombolysis may be required, though these must be balanced against the risk of bleeding, especially in patients with coagulopathy. Anti-malarial treatment should be administered as early as possible to reduce the parasite burden and prevent further vascular damage. However, this must be complemented by targeted neuroprotective therapies, particularly in patients with severe neurological complications.

Research into adjunctive therapies for malaria-associated stroke is still limited, and future clinical trials are needed to evaluate the efficacy of neuroprotective agents or other supportive measures that could improve outcomes in these patients. The management of stroke in the context of malaria also highlights the importance of timely intervention. The high mortality associated with delayed diagnosis and treatment underscores the need for rapid recognition of stroke symptoms in malaria patients. In addition, addressing the broader healthcare infrastructure challenges, such as access to imaging and specialized care, is essential for improving patient outcomes in malaria-endemic regions.

Several gaps exist in the current understanding of malaria-related stroke, warranting further investigation. First, longitudinal studies are needed to explore the long-term neurological outcomes of stroke in malaria survivors, particularly in children and young adults. These studies could provide insights into the potential for cognitive or functional impairments following a malaria-associated stroke, which is critical for patient rehabilitation and care planning. Moreover, more research is needed to understand the relative contributions of different *Plasmodium* species to stroke risk. While *P. falciparum* is more commonly associated with severe strokes, *P. vivax* and other species may contribute to neurological damage in ways that have not yet been fully elucidated. Investigating the molecular mechanisms underlying stroke in *P. vivax* infections could uncover new therapeutic avenues for stroke prevention and management. The development of evidence-based guidelines for the diagnosis and management of stroke in malaria patients, particularly in resource-limited settings, could improve clinical outcomes. This would include standardized protocols for the use of neuroimaging, stroke scoring systems, and specific therapeutic interventions that account for the unique challenges of managing stroke in malaria-endemic areas.

### Limitations and strengths of review

This review conducted a literature search across multiple databases, enhancing the reliability of the evidence collected and ensuring a comprehensive assessment of existing studies. It highlighted the significant relationship between malaria and stroke, which is often overlooked, thereby contributing to a deeper understanding of the neurological consequences of malaria. However, this review has some limitations. The variability in study design, especially involvement of case reports and case series, which inherently lack the rigor of randomized controlled trials, may affect the reliability of the conclusions drawn.

## Conclusion

This review highlights the significant but underrecognized relationship between malaria and stroke, particularly in malaria-endemic regions where the burden of both diseases is high. Stroke, both ischaemic and haemorrhagic, is a serious complication of malaria, with *P. falciparum* more frequently associated with haemorrhagic strokes, and *P. vivax* contributing to ischemic events. The clinical presentation of malaria-related strokes often overlaps with symptoms of cerebral malaria, which can result in diagnostic challenges and delayed intervention. Early detection and timely management, including prompt initiation of anti-malarial therapy and supportive care, are critical in improving patient outcomes. The findings show the importance of raising awareness among healthcare providers to consider stroke as a potential complication in malaria patients, particularly in those presenting with neurological symptoms. Further research is needed to fully elucidate the underlying pathophysiological mechanisms, risk factors, and long-term outcomes of stroke in malaria patients. Future research could employ case–control studies, multi-center observational studies, or stroke registries to differentiate stroke subtypes, explore age and gender differences, and assess long-term neurological consequences. Integrating stroke prevention and management strategies into malaria control programmes could enhance patient outcomes and reduce the long-term burden of both diseases in malaria-endemic settings.

#### Abbreviations

CT Computed Tomography

| | |
|---|---|
| MRI | Magnetic Resonance Imaging |
| CVA | Cerebrovascular Accident |
| IS | Ischaemic Stroke |
| HS | Haemorrhagic Stroke |
| CM | Cerebral Malaria |
| ICU | Intensive Care Unit |
| CSF | Cerebrospinal Fluid |
| IV | Intravenous |
| TBI | Traumatic Brain Injury |
| DVT | Deep Venous Thrombosis |
| TACI | Total Anterior Circulation Infarct |
| MCA | Middle Cerebral Artery |
| ICA | Internal Carotid Artery |
| ECG | Electrocardiogram |
| PE | Pulmonary Embolism |
| CTA | Computed Tomography Angiography |
| FBC | Full Blood Count |
| PCR | Polymerase Chain Reaction |
| JH | Jaundice and Hepatomegaly |
| SIRS | Systemic Inflammatory Response Syndrome |

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NA conceptualised the study; all authors were involved in the literature review; EK extracted the data from the reviewed studies; All authors wrote the final and first drafts. All authors read and approved the final manuscript.

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**Code availability**
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## Declarations

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Not applicable.

**Consent for publication**
Not applicable.

**Competing interests**
The authors declare no competing interests.

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