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Malaria-Associated Anaemia: A Cross-Sectional Study in Mau Bokul Village, East Sumba

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Abstract: Malaria remains a major public health challenge in eastern Indonesian and anaemia is a principal haematological complication with notable clinical and functional consequences. Community-based data quantifying malaria-associated anaemia in East Sumba are scarce. This study aimed to determine the prevalence of anaemia associated with malaria and to evaluate the association between malaria infection and anaemia among residents of Mau Bokul Village, East Sumba. An analytical cross-sectional survey was conducted on 98 community participants recruited by consecutive sampling during June–July 2025. Malaria diagnosis was established by microscopy of Giemsa 3%-stained thick blood films and haemoglobin (Hb) was quantified using a point-of-care digital meter (Easy Touch GCHb). Fisher's Exact Test analyzed the association between malaria and anaemia with significance set at ($p < 0.05$). The results are indicate malaria prevalence was 8.2% (8/98), and anaemia prevalence was 34.7% (34/98). All malaria-positive individuals were anaemic. The association between malaria and anaemia was statistically significant ($p < 0.001$).

Keywords: Anemia, *Plasmodium*, Hemoglobin, Malaria, Mau Bokul Village Pandawai District East Sumba Regency.

Introduction

Malaria remains a disproportionate burden for vulnerable populations in endemic areas, including eastern Indonesia, where Plasmodium falciparum and Plasmodium vivax are the main causative agents driving morbidity and mortality (World Health Organization, 2023; 2024). Anaemia is a major haematological complication of malaria, resulting from multifactorial pathophysiological processes including intravascular and extravascular haemolysis of parasitized erythrocytes (White, 2018), splenic clearance of non-parasitized erythrocytes, cytokine-mediated suppression of erythropoiesis with dyserythropoiesis, and hepcidin-driven iron sequestration limiting erythroid production (Penha-Gonçalves & Carlos, 2019; Spottiswoode, et al., 2017; Phyo, et al., 2022; Desmansyah, et al., 2015).

Sumba Island, particularly East Sumba Regency, still has a significant malaria burden. Pandawai District is one of the areas with high cases, particularly Mau Bokul Village. In 2023, 81 malaria cases were recorded in this village, but in 2024, this number decreased to 29 cases (WHO, 2024). The high malaria burden in this area has the potential to worsen general public health and increase the risk of complications from malaria (Cibulskis et al., 2016). Mau Bokul Village is an agricultural area with an environment that supports the proliferation of Anopheles, thus increasing the risk of exposure for the community, the majority of whom work as farmers (Ministry of Health of the Republic of Indonesia, 2023; BPS, 2016).

In Indonesia, both P. falciparum and P. vivax exhibit a broad clinical spectrum, with P. vivax increasingly recognized as a cause of severe malaria and anaemia, complicated by antimalarial resistance and treatment constraints related to glucose-6-phosphate dehydrogenase (G6PD) deficiency (Dini, et al., 2020; Watson, et al., 2018; Guntur, et al., 2021; Almeida, et al., 2021; Llanos-Cuentas, et al., 2019; Jiero & Pasaribu, 2021; (Dayananda, et al., 2018; Yilma, 2024; Kim, et al., 2021). Despite this, community-based data quantifying malaria-associated anaemia in East Sumba remain limited, necessitating this study to inform local clinical and public health strategies.

Material and Method

Study Design

This observational analytical cross-sectional study was conducted in Mau Bokul Village, Pandawai Subdistrict, East Sumba, Indonesia, during June–July 2025. The independent variable was malaria, while the dependent variable anaemia. Ethical approval was obtained from the Universitas Nusa Cendana ethics committee (27.1/UN15.21/KEPK-FKKH/2025), and all procedures adhered to ethical principles for research involving humans.

Population and Sample

Ninety-eight residents in sampling location (Figure 1) which is Mau Bokul Village, Pandawai Subdistrict, East Sumba, Indonesia were enrolled using consecutive sampling based on attendance and willingness.

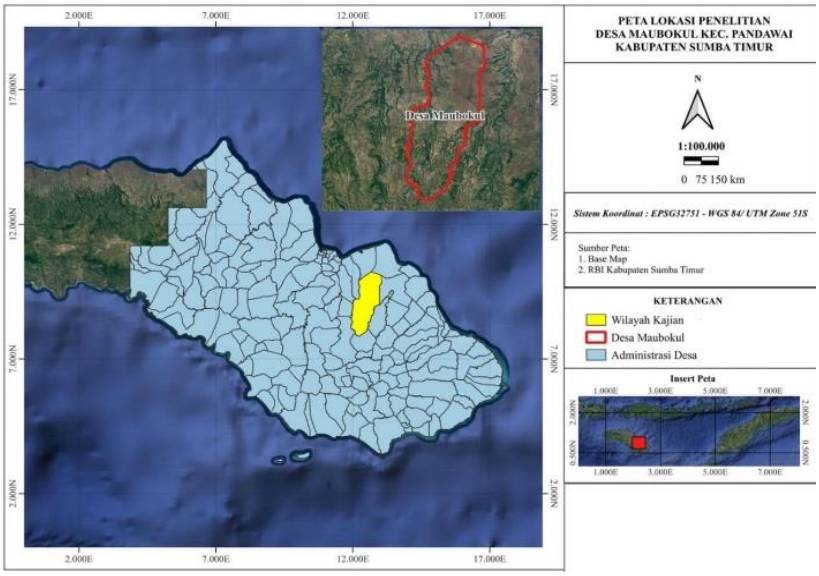

Figure 1. Sampling location: Mau Bokul Village on Sumba Island, Indonesia

A sampling technique was employed to recruit participants using a consort diagram (Figure 2). Inclusion criteria were residence in Mau Bokul for at least six months, self-reported malaria symptoms, and written informed consent. Exclusion criteria included acute conditions or therapies interfering with laboratory assessment.

Data Collection

Capillary finger-prick blood specimens were collected aseptically are used to diagnose malaria and anaemia. Malaria diagnosis was performed via thick blood films and stained with 3% Giemsa following field standards, and slides were examined by trained microscopists under light microscopy. In keeping with best-practice guidance for field microscopy and rapid diagnostic testing, internal quality assurance procedures were applied (slide cleaning, stain lot control, and rereading of a subset of slides) to minimise misclassification (Yusuf, et al., 2022). Haemoglobin concentration was measured using the Easy Touch GCHb point-of-care device. Given the performance variability of point-of-care Hb meters in endemic settings, we adhered to device calibration and capillary sampling protocols to improve accuracy, consistent with validation evidence for Hb meters used in tropical field conditions (Lailla, et al., 2021). No Plasmodium species identification or parasite density quantification was performed. Anaemia was defined by operational Hb thresholds used in local health services.

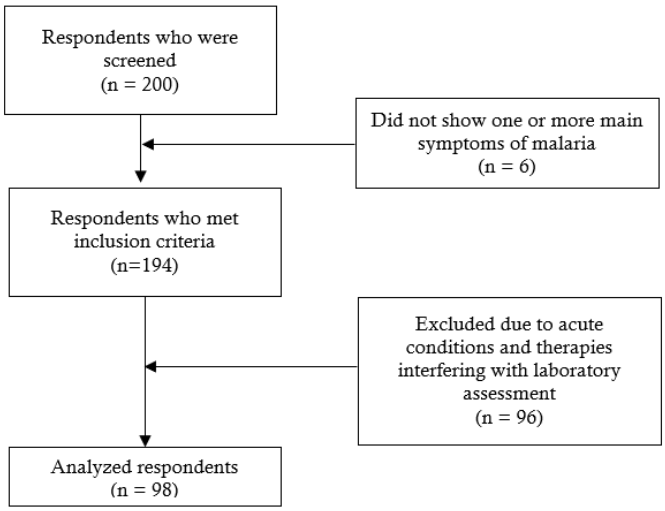

Figure 2. Consort diagram of this study

Data Analysis

Statistical analysis employed frequency distributions and Fisher's Exact Test to evaluate the association between malaria status and anaemia, with significance at ($p < 0.05$). To complement significance testing, this study reported effect sizes as risk ratio (RR) with 95% confidence intervals (CIs) and risk difference (RD) with 95% CIs to convey relative and absolute risk used SPSS version 30.0.

Result and Discussion

Table 1 shows the study included 98 participants, predominantly female (67.35%) with the largest age groups were ≥15 years (69.4%). Table 2 shows malaria was detected in 8 participants (8.2%), all of whom were anaemic. Anaemia was present in 34 participants (34.7%) overall. Among malaria-negative participants, 26/90 (26.5%) were anaemic. Fisher's Exact Test demonstrated a highly significant association between malaria infection and anaemia ($p < 0.001$). Participants with malaria had a 3.46-fold higher risk of anaemia (RR 3.46; 95% CI 2.51–4.79), with an absolute risk increase of 71.1% (RD 0.711; 95% CI 0.286–0.795).

Table 1. Characteristics of the respondent

Variable		Respondent	
		n	%
Gender	Male	32	32.65
	Female	66	67.35
Age	1-4	5	5.1
	5-11	20	20.4
	12-14	5	5.1
	≥15	68	69.4

Table 2. Association between malaria and anaemia

		Anaemic Status				RR (95% CI)	RD (95% CI)	P value
		Anaemic		Non-anaemic				
		N	%	N	%			
Malaria	**Positive**	8	8.2	0	0	3.46 (2.51-4.79)	0.711 (0.286-0.795)	<0.001
	Negative	26	26.5	64	65.3			
	Total	**34**	**34.7**	**64**	**65.3**			

Disscussion

This community-based survey confirms a strong association between malaria infection and anaemia, with universal anaemia among microscopy-positive cases and a statistically significant relationship ($p < 0.001$). The findings are consistent with contemporary understanding of malaria-induced anaemia, which integrates haemolysis of parasitized erythrocytes, splenic removal of non-parasitized but altered erythrocytes, inflammatory suppression of erythropoiesis, and iron sequestration mediated by hepcidin that limits erythroid output (Penha-Gonçalves & Carlos, 2019; Spottiswoode, et al., 2017; Phyo, et al., 2022; Desmansyah, et al., 2015).

In heterogeneous transmission settings of eastern Indonesia, P. vivax substantially contributes to morbidity including severe anaemia while programmatic challenges persist around safe radical cure in populations with G6PD deficiency (Dini, et al., 2020; Almeida, et al., 2021; Llanos-Cuentas, et al., 2019; Jiero & Pasaribu, 2021; Dayananda, et al., 2018; Yilma, 2024). The observed malaria prevalence of 8.2% and anaemia prevalence of 34.7% indicate a clinically relevant dual burden in this rural community. Regional syntheses and national reviews suggest that ecological, occupational, and housing factors may increase nocturnal vector exposure and recurrent infections, contributing to chronic or subclinical anaemia (Guntur, et al., 2021; Kim, et al., 2021; World Health Organization, 2024). At a global scale, cartographic and burden assessments further underscore the continued relevance of P. vivax in sustaining anaemia in endemic communities (Battle et al., 2019; Dayananda, et al., 2018). This study also found that malaria cases were more common among women and individuals over 15 years old. This is likely due to their more frequent outdoor activities, such as washing clothes and fetching water from the river in the late afternoon and evening, when Anopheles mosquito activity is higher. Adults may have an increased malaria risk due to outdoor domestic activities without adequate self-protection (Syukur & Winarti, 2024).

Programmatically, integrating haemoglobin screening within malaria case management, ensuring species-appropriate therapy, and expanding access to point-of-care G6PD testing can help mitigate relapse-driven cumulative anaemia burden in P. vivax–endemic areas (Howes et al., 2021; Llanos-Cuentas et al., 2019; Recht et al., 2018; World Health Organization, 2023, 2024). Strengthening the diagnostic pathway—combining quality-assured microscopy or RDTs with validated point-of-care haemoglobin meters—can improve case detection and anaemia management at the primary care level (Yusuf, et al., 2022; Lailla, et al., 2021).

Strengths of this study include community-based sampling and the combined use of standardised microscopy and point-of-care haemoglobin quantification. Limitations include the cross-sectional design (limiting causal inference), small numbers of malaria-positive cases, absence of species identification and parasite density, and lack of inflammatory or erythropoietic biomarkers. Future research should adopt longitudinal designs with species confirmation and parasite quantification, and incorporate biomarker panels (e.g., inflammatory indices, iron status/hepcidin) while adjusting for nutritional and infectious confounders to clarify pathways and optimise interventions (Safeukui, et al., 2015; Battle et al., 2019; Dayananda, et al., 2018).

Conclusion

Malaria infection was strongly associated with anaemia among residents of Mau Bokul Village, East Sumba, with universal anaemia among microscopy-positive cases and a significant statistical association. Integrating Hb screening, species-appropriate treatment, and anaemia management into malaria control at the primary care level is warranted in endemic settings. Future research using longitudinal designs and comprehensive confounder assessment is recommended to elucidate causal mechanisms and optimize targeted interventions.

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