MULTI-FACTORIAL INFLUENCES ON MALARIA TRANSMISSION DYNAMICS IN INDONESIA: INSIGHTS FROM CLIMATE TO COMMUNITY INTERVENTIONS: A Literature Review

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ABSTRACT

Malaria remains a significant public health issue in Indonesia, particularly in regions with high endemicity levels such as Papua and East Nusa Tenggara. Despite the implementation of various control strategies, the spread of this disease continues to be influenced by multiple interrelated factors. This literature review aims to identify and analyze the factors affecting malaria incidence, as well as to evaluate the control strategies implemented across various regions in Indonesia. The method involved reviewing 20 national scientific journals published between 2016 and 2024. The analysis encompassed observational, descriptive, and policy studies that examined the influence of climate, demographics, behavior, environmental conditions, and government policies on malaria incidence.

The results of the literature review indicate that climatic factors such as rainfall and air temperature significantly affect the fluctuation of malaria cases, particularly in wet and humid environments. Demographic factors such as age, low educational attainment, and poor socioeconomic status also significantly contribute to infection risk. Community behavior, residential environmental quality, and population mobility further reinforce transmission chains. On the other hand, intervention strategies such as spatial mapping, mass treatment, mosquito net distribution, and local health cadre engagement have proven effective in several regions including Purbalingga and Papua. The conclusion of this study emphasizes that malaria control in Indonesia requires an integrative approach based on local data, combining epidemiological, climatological, social, and policy dimensions. These findings are expected to serve as a foundation for formulating a more adaptive and contextually appropriate national malaria elimination strategy toward the goal of a malaria-free Indonesia by 2030.

Keywords: Malaria, rainfall, Indonesia.

INTRODUCTION

Malaria remains one of the major communicable diseases and public health concerns in various tropical regions, including Indonesia. This disease is transmitted through the bite of a female *Anopheles* mosquito carrying *Plasmodium* parasites and can lead to death, especially among vulnerable groups such as infants, young children, and pregnant women (Rizki et al., 2024). According to the World Health Organization (WHO), approximately 247 million malaria cases were reported globally in 2021, with a death toll of 619,000 people (WHO, 2023). In Indonesia, although 76% of districts/municipalities were declared malaria-free by mid-2024, significant challenges remain, particularly in eastern regions such as Papua and East Nusa Tenggara (NTT), which account for more than 90% of the national malaria burden (Ministry of Health, 2024). NTT Province, particularly Alor Regency, is among the regions with high malaria morbidity. Moru Health Center in Alor Barat Daya District reported an Annual Parasite Incidence (API) of 16.9% in 2014, far exceeding the national elimination target of less than 1% (Manumpa, 2016). This indicates that malaria prevalence remains relatively high in several areas, especially in the eastern region and other endemic zones (Widyati & Mukono, 2022).

Environmental and climatic factors play a crucial role in the dynamics of malaria transmission. Changes in air temperature, rainfall, humidity, and geographical conditions have been shown to affect the presence and density of mosquito vectors (Mau et al., 2021; Fitriana et al., 2021). Rising temperatures can accelerate the mosquito life cycle and shorten the incubation period of the parasite, while high rainfall creates ideal habitats for mosquito larvae to breed (Wulan et al., 2022; Arisanti & Nurmaliani, 2021). Other suspected influential factors include population density, fishing activity, and uneven distribution of medical personnel (Nurmala, 2017).

A study conducted in Bengkulu revealed a significant relationship between rainfall and malaria incidence, although air temperature did not show a statistically significant

correlation (Wulan et al., 2022). Conversely, research in Ende Regency found a significantly negative relationship between air temperature and malaria cases, emphasizing that the effects of climate are highly contextual and localized (Widyati & Mukono, 2022). Meanwhile, a study in Purbalingga Regency, an area with relatively low endemicity, indicated a declining trend in malaria cases from 2010 to 2019. Case distribution was more concentrated in regions with topographical conditions conducive to *Anopheles* breeding and community behaviors that did not fully support prevention efforts (Sukendar et al., 2021).

In addition to climate factors, behavioral and environmental conditions in communities also contribute to malaria incidence. Risk behaviors such as going outdoors at night without protection, having livestock shelters near homes, not using bed nets, and poor environmental sanitation are critical determinants in the transmission of this disease (Ngongo, 2022; Humaira et al., 2024). Studies in Aceh Province and other regions in Indonesia emphasize the importance of behavioral interventions and environmental control as integral components of sustainable malaria elimination strategies (Humaira et al., 2024). Research in East Sumba Regency, NTT, found that peak biting activity occurred outdoors at night between 18:00 and 01:00, indicating exophilic behavior (Kazwaini & Willa, 2015). In Heram District, Jayapura City, Papua, six types of larval habitats were identified (puddles, ditches, ponds, rivers, tire tracks) distributed across Waena and Yabansai urban villages (Tulak et al., 2018).

As global climate change dynamics become increasingly complex, a deeper understanding of the relationships among climatic variables, human behavior, and malaria incidence is essential. Recent studies suggest that changing climate patterns may expand endemic areas, prolong transmission seasons, and increase the risk of malaria outbreaks in previously unaffected regions (Gotama & Anfa, 2023; Mau et al., 2021).

Therefore, integrating epidemiological, climatic, and

behavioral data is essential in planning mitigation and adaptation programs to address the risks posed by vector-borne diseases such as malaria.

METHOD

This study employed a literature review method by collecting various available references, including research journals, annual reports, books, and malaria data published between 2020 and 2025. The literature review process involved searching, collecting, and analyzing relevant references using accredited journal search engines such as Google Scholar, Garuda, DOAJ, and ScienceDirect. The keywords used for the search included "rainfall," "malaria," and "Indonesia."

RESULTS

Table 1. Results of a literature review

No	Researcher and Year	Research Title	Research Objective	Research Design	Research Findings
1	Arisanti, M. (2020)	Rain Criteria Related to Malaria Incidence in OKU Selatan Regency in 2019	To examine the relationship between rainfall and rainy days with malaria incidence	Quantitative observational with Kruskal-Wallis test	Significant relationship found between rainfall criteria and increased malaria cases (p=0.000)
2	Eliza Eka Nurmala (2017)	Dynamics of Climate Elements (Temperature, Humidity, and Rainfall) and Malaria Incidence in Pandeglang	To examine the relationship between climate elements and malaria incidence in Pandeglang	Ecological time trend study (2005–2010)	No statistically significant relationship found, though the trend was positive
3	Fitriana, I., et al. (2018)	Relationship between Weather and Mosquito Population in Yogyakarta	To investigate the impact of weather on mosquito dynamics	Descriptive analytic	Mosquito population increased during high rainfall and high temperature

No	Researcher and Year	Research Title	Research Objective	Research Design	Research Findings
4	Gotama, A. & Anfa, S. (2023)	Impact of Climate Change on Mosquito-borne Diseases	To review the impact of climate change on malaria and dengue	Systematic review	Global warming is expanding malaria-endemic areas
5	Humaira, S. (2024)	Environment and Behavior Towards Malaria Incidence in Aceh	To analyze environmental and behavioral variables with malaria incidence	Cross-sectional	Resting place variable significant (p=0.053); others not significant
6	Hasyim et al. (2018)	Spatial Modeling of Malaria Cases and Environmental Factors in South Sumatra	To examine spatial relationship between malaria and environmental risk factors	Spatial quantitative using OLS and GWR	Environmental factors (elevation, rainfall, distance to forest) significantly affected malaria incidence
7	Hermayani & Novianty Mansyur (2024)	Literature Review of Risk Factors for Malaria in Children in Endemic Areas	To analyze malaria incidence and risk factors in children in endemic regions	Systematic literature review of 11 articles (2019–2024)	Main risks: poverty, low parental education, poor housing, low net use, and climate
8	Ministry of Health RI (2020)	Technical Guidelines for Malaria Elimination	To provide implementation guidance for malaria elimination in Indonesia	Policy guideline	Focus on surveillance, early diagnosis, and rapid treatment
9	Ministry of Health RI (2024)	Acceleration of Malaria Burden Reduction in High-Endemic Districts in Papua	To describe malaria elimination strategies in Papua	Policy descriptive	86% of national cases come from 14 districts in Papua; strategies: mass treatment, forest malaria cadres, migration surveillance
10	Latuny (2021)	Relationship of Climate Factors with	To identify links between climate and	Descriptive	High humidity and temperature increased

No	Researcher and Year	Research Title	Research Objective	Research Design	Research Findings
		Malaria Incidence in Ambon	malaria incidence		transmission risk
11	Manumpa, S. (2016)	Effect of Demographic Factors and Malaria History in Alor Barat Daya, NTT	To analyze demographic factors and disease history in malaria incidence	Cross-sectional	Significant factors: socio-economic status (p=0.000), education (p=0.001), age (p=0.025)
12	Mau, F. (2020)	Climate Fluctuations and Malaria Incidence in East Sumba	To analyze the relationship between weather and API	Time-series	API fluctuated with rainfall and annual temperature
13	Kazwaini & Willa (2015)	Correlation of Anopheles Density with Rainfall and Vector Status in East Sumba	To correlate Anopheles spp. density with rainfall and malaria vector status	Cross-sectional survey	Rainfall had no direct impact due to permanent habitats. Some species tested positive for P. vivax
14	Ngongo, H. M. (2022)	Behavior and Environmental Conditions and Malaria Incidence	To assess the link between behavior, environment, and malaria	Cross-sectional	Behavioral variables significantly increased malaria risk
15	Tulak et al. (2018)	Spatial Distribution and Characteristics of Positive Anopheles Larvae Habitats Based on Rainfall	To examine habitat characteristics and rainfall's effect on larvae distribution in Jayapura	Field observation with descriptive and statistical analysis	Rainfall significantly affected Anopheles larvae habitat distribution (R^2=0.11–0.77)
16	Rizki, N., et al. (2024)	Environmental Factors Related to	To assess the impact of environmenta	Correlational analytic	Significant: rainfall (p=0.001),

No	Researcher and Year	Research Title	Research Objective	Research Design	Research Findings
		Malaria Incidence in Mentawai	l variables on malaria		temperature (p=0.009), and population density
17	Syahrani et al. (2022)	Inventory of Night-biting Mosquitoes and Bionomics in Sumba	To inventory night-biting mosquito species and their bionomics in Sumba	Longitudinal observation (2015–2018) with HLC method	13 Anopheles and 22 other species found; no significant correlation with rainfall/temperature
18	Sri Sulasmi et al. (2017)	Effect of Rainfall, Humidity, and Temperature on Malaria Prevalence in Tanah Bumbu, South Kalimantan	To assess climate variables' impact on malaria prevalence	Descriptive using 10-year secondary data	Rainfall and humidity affected mosquito density; optimal temperature 26.5–27°C
19	Sukendar & Rejeki (2021)	Malaria Endemicity and Descriptive Epidemiology in Purbalingga	To describe distribution and malaria case trends (2010–2019)	Spatial descriptive	Cases dropped from 952 (2010) to 9 (2019); spatial analysis supports targeted interventions
20	WHO (2014)	World Malaria Report 2014	To report global malaria data	Global descriptive	198 million cases and 584,000 deaths, mostly in Africa and Southeast Asia
21	Widyati (2017)	Air Temperature Relationship with Malaria Cases in Ende	To examine temperature's effect on malaria cases	Descriptive analytic	Significant temperature correlation (p=0.049); avg. 28.9°C with 671 cases
22	Wulan, S., et al. (2022)	Rainfall and Air Temperature in Relation to Malaria in	To assess climate-malaria relationship	Time-series	Rainfall significant (r=-0.173); temperature not significant

No	Researcher and Year	Research Title	Research Objective	Research Design	Research Findings
		Bengkulu City			

DISCUSSION

The review of 20 journals discussing malaria in various regions of Indonesia reveals that the incidence of this disease is not caused by a single factor, but rather by a complex interaction of climatic elements, demographic characteristics, community behaviors, physical environmental conditions, spatial distribution, as well as health policies and intervention programs implemented in different regions. Therefore, this discussion is classified according to the most dominant factors influencing malaria dynamics.

1. Climatic and Weather Factors

Climate is a crucial factor that directly contributes to the life cycle of the Anopheles mosquito as a malaria vector. High rainfall can create stagnant water, serving as a breeding ground for mosquito larvae. Studies by Arisanti & Nurmaliani (2021) in OKU Selatan and Rizki et al. (2024) in the Mentawai Islands show a significant relationship between rainfall intensity and the increase in malaria cases. Furthermore, ambient temperatures within the optimal range (around 26–30°C) are known to accelerate the development of the Plasmodium parasite inside the mosquito, as reported in studies by Widyati & Mukono (2022) and Mau et al. (2021). These studies indicate that climate fluctuations, including changes in temperature and humidity, play a central role in determining the timing and intensity of malaria transmission peaks in a region.

2. Demographic Factors

Demographic characteristics such as age, education level, and socioeconomic status greatly influence individual vulnerability to malaria. Productive age groups, especially adult males working outdoors at night, such as farmers and fishermen, are among the most frequently infected. This is supported by findings from Manumpa (2016) in Alor Barat Daya and Humaira et al. (2024) in Aceh, indicating that low

education and inadequate economic conditions limit access to prevention and treatment facilities and increase exposure risk.

3. Community Behavior

Community behavior plays a key role in breaking the chain of malaria transmission. Lack of awareness regarding prevention, the habit of not using mosquito nets, or engaging in outdoor activities at night contributes to high malaria incidence. Simulations have shown that the use of insecticide-treated nets (ITNs) and indoor residual spraying (IRS) can reduce relapse probability and improve recovery rates (Lusiyana & Ahdika, 2022). The study by Ngongo (2022) emphasizes that unsupportive community behaviors pose significant barriers to control efforts.

4. Physical Environment and Housing Conditions

Environmental conditions surrounding residential areas also significantly influence malaria transmission. Poor sanitation, stagnant water, vegetation, and livestock pens near homes provide ideal breeding grounds for mosquitoes. In addition, open house structures or lack of protective features like window screens and bed nets increase exposure risk. This is demonstrated in the study by Sukendar et al. (2021) in Purbalingga, which found a strong correlation between housing quality and malaria incidence.

5. Spatial and Geographical Factors

Spatial distribution of malaria exhibits certain patterns that can be leveraged for more effective intervention planning. Research in Purbalingga by Sukendar et al. (2021) employed spatial approaches to identify areas with high API levels, which then became intervention priorities. Meanwhile, a study by Ngadino et al. (2024) in Trenggalek, Malang, and Pacitan discovered that An. sundaicus was more common in coastal areas and An. maculatus in rice fields and valleys. Malaria cases were unevenly distributed and linked to population mobility. This highlights the importance of an ecosystem-based approach.

6. Government Policies and Interventions

Various malaria control strategies have been implemented by the government, particularly in high-endemic regions such as Papua. The

Ministry of Health (2024) reports efforts including mass drug administration, distribution of mosquito nets, deployment of forest malaria cadres, and active surveillance among migrating populations as key strategies for elimination. A study by Setianingsih & Sulistyaningrum (2025) showed that these programs reduced the Annual Parasite Incidence (API) by 31.81 per 1000 population. The presence of community health centers significantly decreased malaria incidence, while hospitals had no significant effect. The study concluded that community-based interventions and cross-sectoral coordination are critical to the success of malaria elimination programs in highly endemic areas like Papua.

7. Global Climate Change

The long-term impact of global climate change on vector-borne diseases cannot be ignored. Gotama & Anfa (2023) demonstrated that global warming and climate anomalies could potentially expand malaria-endemic areas into highlands and previously malaria-free regions. These changes demand that health systems be more adaptive and responsive to rapidly changing ecological dynamics.

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CONCLUSION

Based on a review of 34 journals on malaria from various regions in Indonesia, it can be concluded that malaria incidence is driven by complex interactions among climatic, environmental, behavioral, demographic factors, and the effectiveness of government policies and interventions. High rainfall, warm temperatures, and increased humidity have been shown to support the proliferation of Anopheles mosquito vectors. Environmental factors such as stagnant water, vegetation, and substandard housing

also contribute to transmission. Communities with low educational attainment, poor socioeconomic status, and inadequate preventive behavior—such as not using bed nets or spending time outdoors at night—are the most vulnerable.

On the other hand, malaria control and elimination strategies such as bed net distribution, mass drug administration, active surveillance, and public health education have proven effective in several regions. Spatial analysis has also become a vital tool in identifying priority intervention areas. However, geographically challenging and highly mobile regions like Papua still require more context-specific and cross-sectoral strategies. To achieve the national malaria elimination target by 2030, adaptive strategies that incorporate local dynamics, climate change considerations, and sustained community empowerment are essential.

ACKNOWLEDGMENT

We express our sincere gratitude to the lecturers who inspired, guided, and motivated us—Dwi Sarwani Sri Rejeki and Siwi Pratama Mars Wijayanti—as well as the entire academic community of the Faculty of Economics and Business, Universitas Jenderal Soedirman.

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