ENVIRONMENTAL FACTORS TO MALARIA INCIDENCE : A LITERATURE REVIEW

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ABSTRACT

Malaria remains a major public health concern in Indonesia, particularly due to its high mortality rate among children under five, accounting for approximately two-thirds of all cases. The disease is transmitted by female Anopheles mosquitoes, which carry the Plasmodium parasite. In 2019, malaria caused 409,000 deaths globally, with 229 million cases reported, particularly in remote areas with poor access to healthcare, commonly in low-income countries. This literature review highlighted the environmental risk factors contributing to malaria incidence, based on studies from 24 scientific journals using data from the Sinta and Scopus databases. The study identified key environmental factors, including physical, chemical, biological, and socio-cultural elements, with the most significant risk linked to vector breeding sites. Among the reviewed articles, 62.5% (15 out of 24) found a statistically significant association between the presence of mosquito breeding sites and malaria incidence. Additional risk factors included the use of mosquito nets, housing conditions (specifically wall density), and nighttime outdoor activities. Effective malaria control measures require addressing these environmental factors, as they play a crucial role in the disease's transmission. Strategies to disrupt the transmission cycle include eliminating mosquito breeding sites, applying larvicides to stagnant water, cleaning vector resting areas, promoting the use of insecticide-treated nets, and implementing Indoor Residual Spraying (IRS). A community-based, integrated approach to environmental management is essential to reducing malaria transmission and controlling its spread in affected regions.

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INTRODUCTION

Malaria is caused by the Plasmodium parasite carried by anopheles mosquitoes through salivary glands when they bite in search of blood for the maturation of female mosquito eggs. Five types of species infect humans, specifically *Plasmodium ovale*, *Plasmodium malariae*, *Plasmodium falciparum*, *Plasmodium vivax*, and *Plasmodium knowlesi*[1]. Plasmodium lives and multiplies in human red blood cells. *P. falciparum* is highly

feared because it is responsible for 80% morbidity and 90% mortality. *Anopheles* sp. mosquitoes undergo complete metamorphosis in their life cycle from eggs, larvae, pupae, to adults[2].

Malaria's main symptom is fever, which can be periodic depending on the type of the malaria. Other symptoms include headache, nausea, vomiting, diarrhea, aches and muscle pain[3].

According to the WHO assessment of malaria cases in 2022, there are expected to be 249 million cases in 85 countries and regions where malaria is endemic, which is 5 million more cases than in 2021[4].

Eliminating the malaria epidemic is one of the Sustainable Development Goals (SDGs) and a crucial metric that needs to be met by 2030. According to World Malaria Day 2023 in Indonesia, 1,412 deaths from 811,636 new cases of malaria in 2021 occurred in Papua Province, and 89% of malaria cases occurred in the whole country of Indonesia[5]. Malaria causes considerable economic losses, so it is still a problem in Indonesia. Although malaria control efforts have made progress in the past decade, 2022 saw an increase.

Malaria cases in Indonesia increased to 1.6 per 1,000 people in 2022, with a parasite's annual incidence of 1.6 per 1,000 people. API indicators are used to classify malaria endemicity in Indonesia, where eastern Indonesia includes areas with high malaria cases, Kalimantan, Sulawesi, and Sumatra include areas with moderate malaria cases, and Java and Bali include areas with low malaria cases[6].

Environmental factors have a significant impact on malaria transmission. Environmental factors are all external conditions and influences that affect the life and development of organisms such as physical environment such as temperature, humidity, rain, altitude, wind, sunlight, water currents, wall conditions, the presence of wire gauze on house vents, ceilings, and hanging clothes, biological environments such as the presence of standing water, breeding grounds, livestock pens, larva-eating fish, chemical environments such as pH and salinity, as well as socio-cultural environments like the application of mosquito netting, the habit of not wearing long sleeves, the use of insect repellent, various human activities such as dam construction, road construction, mining and the construction of new settlements or transmigration[7]v. This article reviews the environmental factors that can cause malaria, including physical, chemical, biological, social, and cultural environments.

OVERVIEW

The purpose of this literature review was to obtain interesting theoretical studies for future research by systematically identifying and analyzing malaria incidence according to the criteria selected in the topic[8]. The data source used was based on scientific publication literature according to the topic in this study obtain from some publication databases (Sinta and Scopus).

This article reviewed 24 articles that have been filtered and analyzed based on objectives, topic suitability, variables used, and the results of each article. The criteria used in finding the desired article were research on the determinants of malaria incidence, especially environmental factors, and articles published between 2018 and 2022.

This literature review was related to previous research on environmental factors that influence malaria incidence in

Indonesia and other nations. This literature review article's goal was to summarize some of the research that had been conducted on environmental factors and had potentials to examine in detail some environmental factors that affected the incidence of malaria. Based on the collected data, the environmental factors that had the most potential for malaria transmission could be identified so that the control stage could be carried out appropriately according to the target.

According to the data collected from multiple articles, there was a relation between environmental variables and malaria incidence. The environmental factors identified in this review were breeding places, home wall condition, the presence of ceilings, getting used to going out late at night, the presence of wire gauze, bushes, livestock sheds, resting places, the use of mosquito nets, repellent, knowledge, work, treatment, counseling, the presence of puddles, the practice of hanging clothes and going to endemic areas.

The breeding place was the dominant factor that often found from the 24 articles collected. Fifteen articles, the articles number 1, 3, 4, 7, 9, 13, 14, 15, 16, 17, 18, 20, 21, 23 and 24, proved that anopheles mosquito breeding sites had a risk of malaria incidence. The methods used were case-control, with as many as 7 articles, and cross-sectional, with as many as 4, 1, and 1 observational article. Seven articles (number 7,8,12,15,18,21 and 22) stated that the habit of using mosquito nets, home wall condition, and the habit of leaving the house at night were related to malaria. Five articles found that resting places and the existence of livestock sheds were related to the incidence of malaria. There were four articles that found connection between wire gauze's existence and the existence of ceilings and the use of mosquito repellent, and one article found a relationship between malaria and a history of traveling to endemic areas. The articles reviewed are presented in Table 1 :

Table 1. Previous research has been used to categorize the review literature

No.	Researcher/Year	Method	Variable	Result
1	Resiany Nababan &; Sitti Rahmah Umniyati (2018)[9]	Case-control	Physical, biological, and sociocultural environment	The results showed a correlation between Malaria and high incidence. with the breeding habitat of the *Anopheles vector* (p-value 0.02), how well the house's walls are doing (p-value 0.004), the practice of going out at night (p-value 0.01)
2	Rizka, Sofia (2018)[10]	Cross-sectional	Physical environment, biological environment, sociocultural environment, and history of malaria	The study's findings indicated a correlation between the incidence of malaria and the existence of gauze (p-value 0.039), the condition of the house's walls (p-value 0.054), the presence of a ceiling (p-value 0.042), and the presence of shrubs surrounding the house (p-value 0.030).
3	Darmawansyah, Julius Habibi, Ravika Ramlis, Wulandari (2019)[11]	Cross-sectional	The location of breeding, the use of repellent, the pH of the water, ventilation gauze, the presence of animal sheds, and the usage of mosquito nets	The findings indicated a correlation between the prevalence of malaria and breeding pressure, repellant, water pH with (p-value 0.001) and ventilation gauze (p-value 0.016).
4	Laila Isnaeni, Lintang Dian Wuryanto, Ari Udiyono Saraswati, M. Arie (2019)[12]	Case-control	The practice of going outside after dark, using insect repellent, utilizing mosquito nets, breeding grounds, resting locations, livestock pens, and traveling to endemic areas .	The results showed a relationship between the incidence of malaria and the following behaviors: going out at night (p-value 0.000), using mosquito repellent (p-value 0.036), breeding places (p-value 0.000), breeding places separated by distance (p-value 0.011), resting places (p-value 0.003), and livestock sheds (p-value 0.000).
5	Riska, Laode Muh. Sety Siti Rabbani Karimuna (2019)[13]	Cross sectional	The state of the house's exterior, the neighborhood's surroundings, and the conduct of the locals	The study's results showed a correlation between the prevalence of malaria and the physical state of the house (p-value = 0.000).

No.	Researcher/Year	Method	Variable	Result
6	Asep Prastiawan (2019)[1]	Case-control	Population mobility, short duration of stay in malaria-endemic areas, knowledge, attitudes, and actions.	High mobility frequency (p = 0.023), brief stays in malaria-endemic locations (p = 0.014), low knowledge (p = 0.022), and low action (p = 0.010) were found to be correlated with malaria incidence.
7	Nur Hamdani , Kartini, Misrykordiati Mira (2020)[14]	Case-control	The presence of cattle sheds, mosquito breeding grounds, nighttime house departures, and the use of mosquito nets,	The study's results showed a correlation between the prevalence of malaria and the presence of mosquito breeding places (p-value = 0.005), respondents' use of mosquito nets (p-value = 0.032), and respondents' habit of leaving the house at night (p-value = 0.000).
8	Rahayu Lubis, Budi Junarman Sinaga, Erna Mutiara (2020)[15]	Case-control	Use of wire mesh, mosquito nets, geomemographic factors, and prevalence of malaria	The study showed that using wire gauze (OR 2.5) and mosquito nets (OR 2.8) reduced malaria incidence.
9	Hermanto Putra, Muhammad Badiran, Arifah Devi Fitriani (2020)[16]	Case-control	The temperature of the air, puddles, animal cages, lights, house walls, mosquito repellent, nighttime outing habits, therapy, house spraying, and treatment	The study's findings indicated a relationship between waterlogging (p-value 0.001), distance between the house and *breeding place* (p-value 0.001), the presence of animal cages (p-value 0.001), the use of mosquito repellent (p-value 0.014), counseling (p-value 0.042) and treatment (p-value 0.030) with the incidence of malaria.
10	Masrizal, Tria Syananda Putri, Imraatul Hasni (2020)[17]	Case-control	Physical condition of the house, history of visits to malaria-endemic areas, use of repellent, and outdoor activities at night	The study's findings indicated a relationship between the house's physical condition (OR=3.40) with the incidence of malaria
11	Frans Manangsang, Abdul Ganing, Elen R.V. Purba, etc (2021)[18]	Case-control	Pets, puddles, shrubs	The study's findings indicated a relationship between the house being surrounded by shrubs (p-value 0.000) with the prevalence of malaria
12	Haris Ferdinal, Setiawan, Irma Hamisah, etc (2021)[19]	Case-control	occupation, tendencies to leave at night, and use of pesticides, such as mosquito net usage, awareness.	The study's conclusions showed a correlation between the incidence of malaria and work (p-value = 0.034), nightly departure routines (p-value = 0.032), insecticide use (p-value = 0.026), mosquito net use (p-value = 0.014), and knowledge (p-value = 0.034).

No.	Researcher/Year	Method	Variable	Result
13	Renold Markus Mofu (2022)[20]	Case-control	The following factors may be present: standing water, bushes, mosquito larvae, the use of mosquito repellent, the habit of opening the house door at night or going outside at night, nutritional status, the use of long clothes, the use of mosquito nets at night, and the use of mosquito nets while sleeping.	The study's results showed a correlation between the incidence of malaria and the following factors: standing water, bushes, mosquito larvae, use of mosquito repellent, nighttime outdoor activities, nighttime home door opening, nutritional status, and wearing long clothing.
14	Sitti Madayanti, Mursid Raharjo, Hary Purwanto (2022)[21]	Case control	The physical state of the house includes breeding places, the density of the walls and ceiling, the existence of gauze on the ventilation system, relaxation areas throughout the house, and anti-malaria measures.	The study's conclusions showed a correlation between the frequency of malaria and the density of the house's walls (p-value 0.018), the existence of the ceiling (p-value 0.010), the gauze-covered ventilation system (p-value 0.000), the presence of breeding areas (p-value 0.037), resting places (p-value 0.001), and actions (p-value 0.000).
15.	Yana Afrina, Mursid raharjo (2020)[22]	Case control	The state of the ceilings, walls, shrubs, puddles, and cow sheds; stepping outside at night; hanging clothes; using mosquito nets; using repellent regularly;	The study's results showed a correlation between the prevalence of malaria and the state of walls, ceilings, puddles, and shrubs, stepping outside at night, hanging clothes, and using mosquito nets and repellent.
16	Teuku Maulana, Said Devi Elvin, Sofyan Sufri(2022)[23]	Cross-sectional	physical characteristics of habitat (water temperature, brood area, water depth, lighting, water clarity, and water flow), biological characteristics (aquatic vegetation, fauna, *Anopheles* larvae), and chemical characteristics (water pH and salinity)	The results of the study showed a correlation between the occurrence of malaria and the biological environment (p = 0.021), physical environment (p = 0.0001), and chemical environment (p = 0.011).
18	Fitni Hidayati, Mursid Raharjo, Martini martini (2022)[24]	Case-control	The state of the house's walls, the existence of wire gauze, the home's ceiling, the bushes, and the cow sheds	The study's findings indicated a relationship between wire gauze (p-value 0.001), house ceiling (p-value 0.001), bushes (p-value 0.001), livestock sheds (p-value 0.002), and breeding places (0.001) with the incidence of malaria
19	Istiana Istiana, Usman Hadi, Yoes Prijatna Dachlan, etc (2021)[25]	Cross sectional	Malaria prevalence, social and environmental factors	The results of the study showed a correlation between the frequency of malaria and the state of the wall (p = 0.048), the plastic roof (p = 0.015), and the distance between the home and the cattle shed (p = 0.015).

No.	Researcher/Year	Method	Variable	Result
20	Watmanlusy,E. (2019)[26]	Cross sectional	Air temperature, humidity, density of *Anopheles*, distance Breeding places	The influence of air temperature (p = 0.022), humidity (p = 0.003), Anopheles *density (p = 0.001), and* breeding places distance (0.000) with malaria incidence.
21	Hamre, Karen E.S. Dismer, Amber M. Rogier, etc (2022)[27]	Observational Cross sectional	Prevalence of malaria Risk factors related to individuals, households, and environments. Using mosquito nets, having a wealthy home, and being higher up is protective.	Weighted malaria prevalence was low (0.56%; 95% CI: 0.45-0.70%). In 1,134 people, serological evidence of exposure was recently found. The likelihood of malaria is increased by fever, age greater than five, living in a home with subpar wall materials, and being farther from roadways. However, the usage of mosquito nets, household prosperity, and elevation are protective factors.
22	Musoke, David Miiro, George Ndejjo, Rawlance Karani, etc (2018)[28]	Cross sectional	Use of mosquito nets, environmental risk factors	Increases in participant education levels, including primary (aPR = 1.27 [95% CI: 1.00-1.60]), secondary (usual level) (aPR = 1.47 [95% CI: 1.16-1.85]), advanced/tertiary (aPR = 1.55 [95% CI: 1.19-2.01]), and higher household income (aPR = 1.09 [95% CI: 1.00-1.20]), were associated with increased household use of mosquito nets. Furthermore, people without jobs were less likely to use mosquito nets in their homes (aPR = 0.83 [95% CI: 0.70-0.98]). 42 (5.8%) of the homes had gone through the IRS in the preceding 12 months, and 220 (43.2%) of the homes had closed their windows before 6 p.m.
23	Okunlola, Oluyemi A. Oyeyemi, Oyetunde T. (2019)[29]	Assess the correlation between space and time, cross-sectional	Malaria incidence and risk variables related to the environment (higher temperatures, droughts, rainfall, and closeness to water in the SEM)	In the OLS model, annual rainfall, precipitation, and proximity to water showed substantial positive relationships (P < 0.01) with malaria incidence rates, while drought had a negative association (P < 0.001) with malaria incidence.
24	Bhondoekhan, Fiona R.P. Searle, Kelly M. Hamapumbu, Harry Lubinda, etc (2020)[30]	Case control	Parasite prevalence of malaria, aparasitemic inhabitants, environmental risk factors	The adjusted OR for the distance to the home index for every 50 μm was 1.24 (95% CI 0.98-1.58), and for the closeness to third-order flows A and fifth order, it was 2.97 (95% CI 1.04-8.42) and 2.30 (95% CI 1.04-5.09), respectively.

The more mosquito breeding sites, the easier it is for mosquitoes to breed, and the higher the mosquito density. Thus, mosquito breeding habitats must be eradicated as a major step with several control activities. In addition to including fish in mosquito breeding habitats such as ponds, public awareness is very important in protecting the environment and controlling malaria. The closer to mosquito breeding sites, the higher the transmission of malaria, so it can be used as a basis for setting screening targets[30].

CONCLUSION

One element that may have an impact on the increase in malaria cases is the environment. Low environmental quality can accelerate malaria transmission and increase the spread of Anopheles vectors. Malaria will continue to rise if the transmission chain remains unbroken.

One important step is to break the chain of malaria transmission by controlling environmental factors. Environmental factors that must be controlled include physical, chemical, biological, social and cultural environments. Activities carried out in order to control malaria require cooperation from the health sectors as well as from the community. Forms of control activities that can be carried out are eradicating breeding habitats, *Anopheles* vector rest areas, the use of mosquito nets, implementing Indoor Residual Spraying (IRS), and other activities that can encourage breaking the chain of malaria transmission.

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CONFLICT OF INTEREST

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AUTHOR CONTRIBUTION

All authors have contributed to all process in this research, including preparation, data gathering and analysis, drafting and approval for publication of this manuscript.

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