

ENVIRONMENTAL QUALITY FACTORS AND DENSITY OF ANOPHELES LARVAE AGAINST MALARIA ENDEMICITY IN INDONESIA. A SYSTEMATIC REVIEW

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ABSTRACT

Malaria is still a serious problem of health in tropical and subtropical climates. The potential for malaria has become a global concern with increasing morbidity and mortality rates. Millions of people die every year, and 80% of them occur in children. Indonesia is included in the highest level of malaria excess in the world, after India in 2020. In 2021, malaria in Indonesia reached 94,610 cases. Of 34 provinces in Indonesia, 31 provinces still have confirmed cases of malaria. Malaria is caused by the female Anopheles mosquito containing plasmodium. Anopheles mosquitoes have preferred behavior in the process of breeding, resting, and biting, according to the environmental conditions of their habitat. Therefore, this literature discusses several environmental quality factors (temperature, humidity, rainfall, wall conditions, gauze wire on ventilation, ceiling of the house, presence of bushes, and presence of standing water) and the density of Anopheles larvae on the incidence of malaria. This research was conducted in the form of a literature review using the Sinta database as reference material. Based on a study of 16 scientific journals, there were 11 scientific journals regarding significant risk factors for the incidence of malaria and 5 journals regarding Anopheles larvae density.

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INTRODUCTION

The Millennium Development Goals (MDGs) are health development programs to improve the degree of health in the world. The programs in health development are to tackle malaria by establishing global partnerships.¹ Malaria is a type of infectious disease that has existed since 30 million years ago and still survives today known as an ancient disease. In health, malaria is still a serious problem to overcome by breaking the chain of transmission. Malaria is generally found in tropical and subtropical

climates in accordance with its breeding habitat.²

Transmission of malaria through the bite of a female Anopheles mosquito vector is infected with the plasmodium parasite and has the ability to divide asexually in the human body and sexually on the mosquito body. Types of plasmodium are found based on the disease for instance tropical malaria is caused by *Plasmodium falciparum*, Tertiana malaria is caused by *Plasmodium vivax*, quartiana malaria is caused by *Plasmodium malariae*, and malaria ovale is caused by *Plasmodium ovale*.³

Anopheles mosquitoes undergo perfect metamorphosis in growth and development with cycles in the form of eggs, larvae, pupae, and adult mosquitoes. Female mosquitoes can secrete their eggs up to 100 eggs and become larvae for about 1-2 days. The larvae undergo skin turnover up to four times and become pupae about 5-14 days in the water based on environmental temperature. The pupae develop into adult mosquitoes for 2-3 days. Adult female anopheles is able to live 1-2 weeks according to environmental qualities that are very influential on the breeding of anopheles mosquitoes that can cause malaria.

Based on the report of malaria cases in the world which was released on December 06, 2021 by the *World Health Organization* (WHO), there were 241 million cases of malaria in 2020 with a total of 627,000 deaths in the world. This case increased from 2019 with a total of 229 million cases and the number of deaths of 409,000 people.⁴

Based on Ministry of Health data, malaria in Indonesia in 2021 reached 94,610 cases. Malaria pain rate based on API (*Annual Parrasite Incidence*) in Indonesia per 1000 population in 2020 was 0.94%. Of the 34 provinces in Indonesia, 31 provinces still confirmed malaria pain per 1000 population.⁵

Malaria is an aspect of the MDGs to reduce the spread and overcome the risk of malaria.⁶ Malaria elimination is one of WHO's programs in malaria control with various approaches taken, including holistic approach, IVM (*Integrated Vector Management*), and integrated vector control. Vector control in an integrated manner with several technical approach strategies and cross-sector cooperation.

Malaria endemic areas are usually clustered and the action is only affected by

vektor and plasmodium, but is also influenced by breeding sites and resting sites which are environmental factors as mosquito habitat sites. Both of these components must also be controlled, because it greatly affects the ups and downs of malaria incidence.⁷

Based on Hendrik L. Blum's theory, there are several factors in improving the degree of health, namely: environment, behavior, health care, and heredity. The environment plays an important role among three other factors. Environmental factors are as a transmission medium pathogenesis or the process of disease.

Contextually, malaria's determinant factors are physical, biological, chemical, social and behavioral environments. The physical environment is always related to the climatic state of a local. Climate is the average weather with the quantity of variation in statistics over a given period of time. The climatic variables are light, air temperature, humidity, rainfall, etc. The biological environment is a vehicle for the development of mosquitoes. Lush plants will block the entry of the sun into the surface of the soil, so it experiences high humidity. In addition, larvae can also live on plants such as algae and aquatic plants. Others are used for a ringing place.⁸

This paper reviews articles about environmental quality factors that cause malaria, including temperature, humidity, rainfall, wall conditions, ceilings, the presence of bushes and sewers. In addition, this paper also examines the density of Anopheles larvae against the occurrence of malaria based on previous research.

MATERIALS AND METHODS

The method in this study was scoping review to identify the literature thoroughly, obtained from various sources

according to the research topic and significant data from the results of previous research. This literature review has done

and further is grouped based on related variables, such as temperature, humidity, rainfall, wall conditions, gauze wire on ventilation, ceiling of the house, presence of bushes, presence of standing water, and density of Anopheles larvae. The samples obtained in

stages in the selection of types of literature with the traditional review method

this study were based on the Ministry of Research database that met the criteria as follows: based on indexed syntax (Sinta 2-5), published within the last six years, and there were variables related to risk factors for malaria and anopheles larva density

RESULTS

Table 1. Categories in the review literature based on previous research

Authors	Method	Variable	Result
Fadjar Harry, Suharyo Hadisaputro, Ari Suwondo (2016)	Case control	The state of the walls of the house, the presence of ceilings, the presence of bushes, the presence of sewers	There is a significant result between the presence of a ceiling of the house ($p = 0.003$), and the presence of gutters around the environment (p value = 0.002) with the incidence of malaria. ⁸
Efraim Watmanlusu Mursid Raharjo, Nurjazuli (2019)	Cross sectional	Temperature, humidity, and the density of <i>Anopheles</i> sp mosquitoes	The results showed an association of malaria incidence with: Air temperature ($p=0.022$), humidity ($p=0.003$). ⁹
Fridolina Mau Mulatsih (2018)	Secondary data	Rainfall, temperature	There are significant results between <i>Plasmodium falciparum</i> infection and rainfall ($p<0.05$). ¹⁰
Deviani Utami, Tusy Triwahyuni, Yelin Julita (2018)	Case control	The presence of bushes in the environment / near the house, there are puddles / trenches,	The association of malaria incidence with the presence of bushes ($p=0.000$), and puddles/ditches ($p=0.000$). ¹¹
Irwandi Rachman, Princess Sahara, Anggi Alanuari, Suhermanto (2017)	Case control	Temperature, humidity, and The use of mosquito nets	The results showed a relationship between temperature ($p = 0.022$), Humidity (0.006, Mosquito net use (0.016) with the incidence of malaria. ¹²
Afra Wayranu, Againono, Marsum (2016)	Case control	The presence of ventilation, the presence of gauze wire, the presence of ceilings, the presence of bushes, trenches / sewers, puddles, the state of the walls,	The results of the study found a relationship against the occurrence of malaria: the presence of wires gauze ($p = 0.011$) puddles (0.014), the presence of bushes (0.011). ¹³
Resiany Nababan and Siti Rahmah (2017)	Case control	Temperatures, humidity, rainfall, the presence of breeding habitats, the presence of livestock, breeding site distance, the state of the walls of the house, the habit of going out at night, the presence of mosquito nets,	There is a relationship between malaria based on factors: breeding habitat ($p = 0.02$), wall condition ($p=0.004$). ¹⁴
Desi Tri Puspaningrum, Mursid Raharjo, Nurjazuli (2016)	Case control	The presence of standing water, the presence of cash wire, the state of the walls of the house	The existence of gauze wire, the condition of the walls of the house ($p = 0.0001$), the presence of standing water (0.022) with the incidence of malaria. ¹⁵
Rizka Sofia (2018)	Cross sectional	The presence of gauze wire in the vents, the state of the walls of the house, the presence of ceilings, the presence of bushes	The relationship between the presence of gauze wire in ventilation ($p = 0.012$), the state of the walls of the house (0.004), the presence of a ceiling (0.048), and the presence of bushes (0.001) with the incidence of malaria. ¹⁶
Ahmad Faizal Rangkuti, Sulistiyani, Nur Endah (2017)	Case control	There is a puddle	There is a significant association between standing water ($p = 0.033$) and malaria. ¹⁷

Riska Laode (2019)	Cross sectional	Physical condition of the house, environment and community behaviour with events malaria	There is a signification between the physical factors of the house to the occurrence of malaria ($p = 0.000$). ¹⁸
Suci Lestari, Adrial, Rosfita Rasyid (2016)	Descriptive surveys	Density of Anopheles larvae and breeding place	<i>Found anopheles</i> larvae in the pond of the former fish cage, with the density of: 27.93 larvae/dipper. ¹⁹
Giril Metasari, Yunita Windusari, (2019)	Descriptive surveys	Density of Anopheles larvae and Breeding place	Found larvae in rice fields with density 2.4 larvae/dipper. ²⁰
Helena, Ndiki, Apris, Rebekah Limbu (2020)	Descriptive surveys	density of Anopheles larvae and Breeding place	<i>Anopheles</i> larvae are found in rice fields with density (12 larvae / dipper), average river estuaries (9 larvae / dipper), and average lagoons (5 larvae / dipper). ²¹
Amlarrasit, M Adi Wijaya, Awalul fatiqin (2018)	Cross sectional	density of Anopheles larvae	<i>Anopheles</i> larvae are found in swamps with density (100 larvae), in pond (210 larvae). ²²
Mardilah, Shahribulan, Slamet Santosa, and Israhid (2021)	Descriptive surveys	Larval density	Based on the results of the study found larvae in the west (179 larvae / 50 dipper), in the east (4 larvae/50 dipper). ²³

DISCUSSION

Environmental Quality Factors

Environmental quality greatly affects the proliferation of malaria vector. The environmental quality factors that are more dominant in this study are the physical environment including: temperature, humidity, rainfall, the condition of the walls, and ceiling of the house, gauze wire and puddles. The biological environment is like the diversity of bushes.

Temperature

Mosquito vectors are a class of insects that have metabolism and vital cycles that can be influenced by temperature. Most of the insects, including mosquito vectors, cannot regulate their own body temperature at a high temperature range. Whereas, at low temperatures vectors can survive, but their metabolism will drop.

Temperature can affect the breeding of parasite plasmodium in the body of mosquitoes up to 7-14 days faster than usual. The results of Efraim Watmanlusy's article (2019) with air temperature

($p=0.003$) and Irwandi Rachman's research found that air temperature ($p=0.022$) had a significant relationship with the incidence of malaria. The way to minimize the occurrence of malaria is to protect from mosquito bites by using mosquito nets while sleeping and using long-sleeved clothes.¹⁷

Humidity

In the growth, spread, and age of mosquitoes, there are factors that influence as a barrier related to the respiratory system of the mosquitoes have, that is humidity. Mosquitoes are very susceptible to humidity, especially at humidity with a low climate. During the day, mosquitoes rest in humid and relatively cold places, while in the afternoon mosquitoes will reactivate because the temperature begins to decrease and humidity is high. Mosquitoes that are endophilic in nature will rest in the house in the dry season with appropriate moisture. Meanwhile, mosquitoes that are exophilic will rest in the holes in the soil with appropriate moisture.

Humidity is the presence of moisture content in the air by units of percent. Mosquitoes with high humidity (above 60%) will be easier to experience malaria transmission. The suitability of moisture, coolness and comfort of Anopheles provokes an increase in malaria. This is in accordance with the results of the research of Efraim Watmanlusu (2019) with humidity ($p=0.003$) and Irwandi Rachman's research obtained humidity ($p=0.022$) which showed a relationship between humidity and the occurrence of malaria.²⁴

Rainfall

Rainfall greatly contributes to vector habitats and is influenced by the amount of rainfall, the frequency of rainy days, the state of geography, and the physical properties of rainwater reservoirs as mosquito's breeding sites. If there is continuous heavy rainfall, the vector population will decrease due to the pouring/washing of vector habitats. Meanwhile, at a moderate rainfall frequency with relatively long irradiation, it will result in mosquito density because it can cause vector breeding sites. In accordance with the results of the study of Fridolina Mau (2018) there is a relationship between rainfall ($p<0.05$) and the incidence of malaria. Therefore, people must pay more attention to their environment in order to break the chain of transmission and breeding of Anopheles vectors.¹⁴

Wall Condition

The condition of the walls of houses with a semi-permanent category has a higher risk of contracting malaria. The walls of the house are hollow as access to the exit and entry of mosquitoes into the house, thereby increasing the risk of malaria. Wooden and bamboo house walls

can pose a risk of malaria than houses with brick construction. The distance between the wood there is a gap so that it can be an opportunity for mosquitoes to enter the house.

This statement is supported by the research of Nababan (2017) that there is a significant relationship between the condition of the wall ($p=0.004$) and the incidence of malaria. The results of other studies on the relationship of wall conditions that are significant with malaria incidence are a study by Puspaningrum (2016) with wall conditions ($p=0.0001$) and a study by Sofia (2016) has a significant relationship between wall conditions ($p=0.004$) and malaria incidence.

Ceiling of the house

Anopheles mosquitoes have a behavior of biting humans in the near-night to the near-morning. Anopheles mosquitoes like to go through places that are dim or have less light intensity. A house that does not have a ceiling in it can be a way in and out for mosquitoes, and can even be used as a place for mosquitoes to perch. The greater the chance of mosquitoes coming in and out of the house, the greater the chance of mosquitoes biting humans so that the higher the risk of the malaria. The ceiling is the upper interior surface that is directly related in the room made of wood, eternit ceiling or woven bamboo. If inside the house does not have a ceiling, it will make it easier for mosquitoes to enter and carry out activities in the house at night, so that it becomes a great opportunity for the occurrence of malaria.⁵ This situation corresponds to the results of a study by Fadjar Harry (2016) which showed significant results between the ceilings of houses and malaria ($p=0.003$).

Gauze wire on ventilation

Mosquitoes will be very easy to get into the house if gauze wire is not installed on the ventilation, since there is no barrier for mosquitoes to enter the house from the ventilation, so that the risk of malaria becomes high. Wayranu's research (2016) showed a relationship between the presence of gauze wire ($p=0.011$) with the incidence of malaria. A study by Sofia (2018) also shows the presence of relationship between a gauze wire ventilation and malaria ($p=0.012$).

The presence of bushes

The biological environment plays a pivotal role in making the soil fertile and the air fresh. However, the lack of maintenance will cause nesting sites so that they can cause diseases, one of which is malaria. The presence of bushes can block the sun's activities from emitting its rays until it can penetrate the ground surface. This results in high levels of humidity. This situation makes an Anopheles mosquito more comfortable to make it a rest, so that the number of mosquito populations around the house increases, so as to increase the chances of malaria.¹¹

A study by Sofia (2018) also shows the presence of relationship between a gauze wire ventilation and malaria ($p=0.012$).

Utami's research (2018) showed a relationship between the presence of bushes (p value= 0.000) with the incidence of malaria. A study by Sofia (2018) also shows the presence of relationship between a presence of bushes ($p=0.001$) with the incidence of malaria.

The presence of standing water

The presence of stagnant water in the home environment will be a breeding

ground for mosquitoes. Female mosquitoes usually lay their eggs in stagnant water, then turn into larvae, and become adult mosquitoes in ten days. The types of puddles found were sewers, sunken soil surfaces, swamps, streams and also empty ponds.¹³ Sewers with water flow conditions that do not always flow at any time result in a small puddle in the channel, so the Anopheles cycle can occur in the puddles.

The results of Wayranu's study (2016) regarding the presence of standing water ($p=0.014$) and research result by Rangkuti (2017) showed a significant relationship between waterlogging ($p=0.033$) and the incidence of malaria.

The density of Anopheles larvae

The density of Anopheles larvae can lead to the transmission of malarial diseases. The more larvae are found, the easier it is for the spread of malaria to occur. Larvae that later develop into female Anopheles mosquitoes are capable of becoming malaria vectors for humans.¹⁴

The increasing population of Anopheles may increase the risk of malaria transmission in humans. The density of Anopheles is related to breeding places around the home environment.¹⁵ Anopheles larvae breed in stagnant water, such as in clear water that is in direct contact with the soil and is not polluted much including ponds, swamps, rice fields, river estuaries, irrigation canals, and freshwater puddles.¹⁶ The density of a vector can determine the degree of effectiveness of the host with vector. If the density of Anopheles vector continues to increase, it will affect the incidence of malaria.²⁷

The results of Lestari's research (2016) found Anopheles larvae in ponds of former fish cages with a density (27.93 larvae/dipper). In accordance with the

results of the research by Metasari (2019) larvae were found in rice fields with a density (2.4 larvae/dipper). The results of Helena's research (2020) found Anopheles larvae in rice fields with a density (12 larvae/cidukan), river estuaries (9 larvae/cidukan), and lagoon (5 larvae/cidukan). The results of Mardilah's research (2021) were found larvae in west delta with a density (179 larvae/dipper) and in east delta were found density of larvae (4 larvae/50 dipper).

CONCLUSION

Environmental quality factors that cause malaria disease are physical factors, including the presence of ceiling, temperature, humidity, rainfall, and the state of the walls; and biological factors, including the presence of bushes and puddles/sewers. In addition to the environmental factors, mosquito density also affects the occurrence of malaria. The more mosquito containers are found, the more mosquito populations bite humans, causing malaria. Anopheles larvae are found in ponds of unused fish cages, rice fields, river estuaries, and lagoons. To reduce the incidence of malaria, it is expected that there is cross-sectoral cooperation between technicians and the community to break the chain of transmission of the disease vector. To deal with the incidence of malaria, this issue must be handled not only on the case, but also the vector. Aspects of malaria control should focus in all aspects, such as physical environment, chemistry, biology, socio-culture, and behavior.

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CONFLICT OF INTEREST

All Authors have no 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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