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The Relationship between Preventive Behavior and Environment with Malaria in Indonesia: Meta-Analysis Study

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ABSTRACT

Background: Malaria infection is caused among others by behavioral and environmental factors around the house. **Method:** The PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analyses) method was used to select articles according to the criteria set by the researcher, and the meta-analysis was a follow-up analysis to determine the difference in the mean of selected articles in the PRISMA protocol. This article analyzes the relationship between preventive behavior factors and the home environment on malaria incidence with a meta-analytic. Study approach—search articles through three electronic journal portal websites with keywords, namely malaria, environment, and Indonesia. The criteria for the article are the time of publication (1 January 2020 to 3 March 2021), preventive behavior, home environment, original research, and case-control study design. Analysis using software Review Manager 5.4. **Findings:** The results of the literature search using the PRISMA protocol obtained four articles. The results of the analysis showed a positive relationship to malaria, namely variables leaving the house at night ($p < 0.0001$), ventilation of mosquito net houses ($p = 0.01$), and puddles of water in the environment around the house ($p = 0.05$). The results showed that the latest malaria research in Indonesia related to preventive behavior and home environmental factors is still minimal. The results of the study can be used as input for policymakers in controlling malaria.

KEYWORDS: malaria; prevention behavior; environment; house condition; meta-analysis.

1. Introduction

Malaria continues to affect both global health and lives, especially in Indonesia. Malaria is caused by the Anopheles mosquito and a Plasmodium parasite vector. It is particularly lethal in high-risk populations, such as newborns, babies, women of childbearing age, and women during pregnancy. Malaria has a negative effect on human capital and can cause anemia.[1,2]

The occurrence of malaria infection is caused by several factors, including distinguishing factors (including age, gender, ethnicity), behavioral factors (including the habit of using mosquito repellents, the habit of going out at night, the use of mosquito nets) [3,4], health service factors (includes: counseling, spraying, treatment), other factors (including vector, immunity, nutritional status, mosquito density, and wind), environmental risk factors for seasonal conditions, physical environmental factors outside the home and inside the house (including the distance between the house and the breeding place [3,5],

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temperature, sunlight, humidity, lighting, rest areas, puddles, house walls, ventilation, use of wire netting, and house floors), chemical, environmental factors (including freshwater, brackish water, and saltwater), factors biological environment (including the presence of large animal cages). Handling malaria in an endemic area requires a multi- faceted approach, including by looking at the population's environmental and socio-economic conditions.[3–7]

Ensure the equitable access to malaria prevention, diagnosis and treatment; transforming malaria control into a central intervention.The development of the global malaria strategy needs the participation of many sectors.[8] One method of fighting malaria in Indonesia is carried out with ACT, spraying of house walls, and distribution of nets. Challenges in the implementation of malaria programs are a result of less community awareness, regular changes in weather, and a lack of infrastructure and resources in many areas (provinces such as Papua and NTT).[8,9]

The number of malaria cases has been estimated to be 299 million with an estimated mortality of over 409,000. Orphan children between the ages of 5 and 15 years old are the largest malaria targets in the world and contribute 67% (or around 274,000) of the total deaths from the disease (F 67% of the total amount of children who contract the disease).[10] In Indonesia, three provinces have very high Annual Parasite Incidence (API), namely Papua Province, West Papua, and East Nusa Tenggara, with API figures of 64.03; 7.38; and 2.37 per 1,000 population, respectively. Meanwhile, the number of cities/regencies with high endemicity is 23 districts/cities (4.3%) throughout Indonesia.[11]

Several studies have shown a link between environmental factors and preventive behavior with the incidence of malaria. Research in Ethiopia has shown that risk factors associated with malaria include household pets, the use of long-lasting insecticide-treated nets (LLIN), and house conditions.[12] The use of insecticide-treated bed nets (ITN) and indoor residual spraying (IRS) was an effective measure to reduce mosquito populations and bites in Zimbabwe, Uganda, Congo, although it was not associated with malaria.[13–15]

According to the above, this context, this article will employ a meta-analysis approach to talking about the relationship between preventive factors and malaria incidence in Indonesia.

2. Methods

This study used a meta-analysis approach based on the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) protocol with identification, screening, eligibility, and included stages.[17,18] Literature search was carried out on three electronic journal portal websites, namely Google Scholar, PLOS ONE, and PubMed with keywords: malaria, environment, and Indonesia.

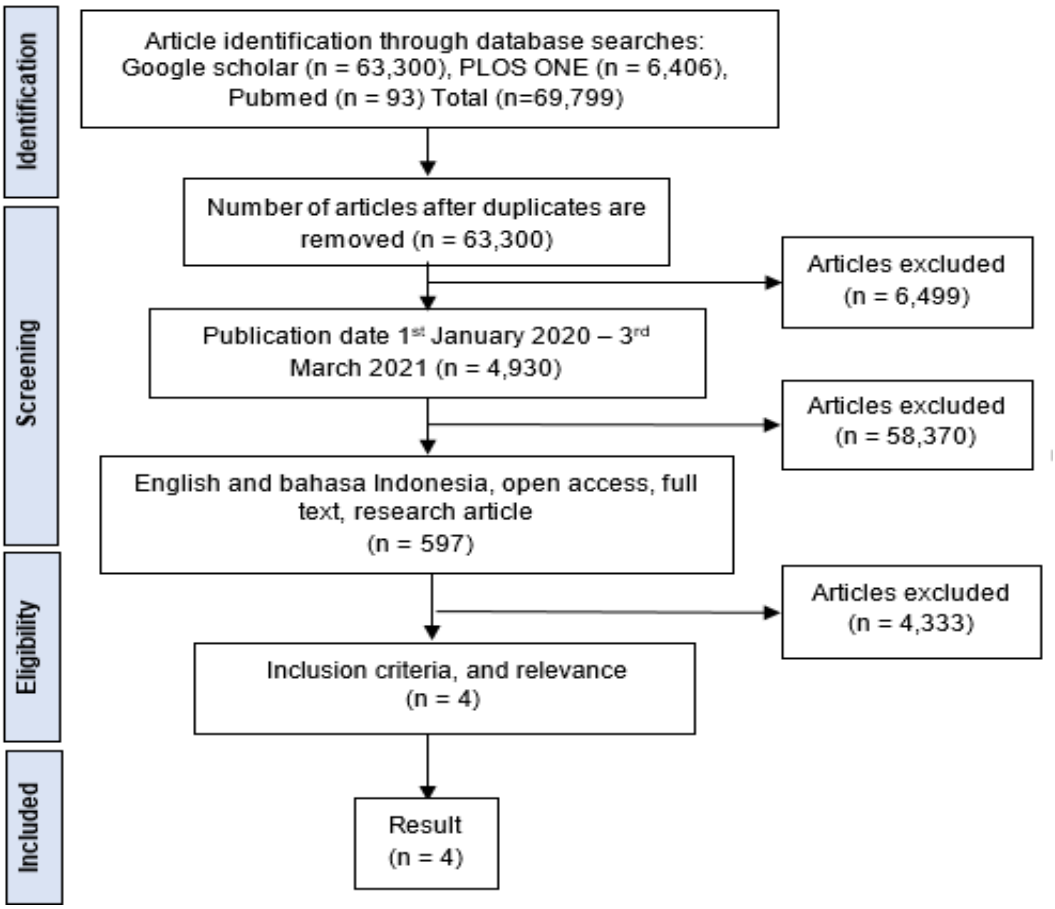

Fig 1. The flow of the literature search is based on the PRISMA protocol

In the identification stage, 69,799 articles were obtained. The first screening stage is carried out using Mendeley software (check for duplicates feature). There are 6,499 duplicate articles. In the second screening stage, by limiting the publication date of articles (1 January 2020 to 3 March 2021), the result is that 58,370 articles were issued. The third screening stage is articles using English or Indonesian, open access, full text, and research articles, and the result is that 4,333 articles were issued. The eligibility stage is carried out according to the inclusion criteria: case-control study design, Indonesian research locations, original research articles using quantitative analysis, valid research articles, and articles analyzing preventive behavior and environmental factors. Obtained four articles that meet the inclusion criteria. The flow of the literature search based on the PRISMA protocol can be seen in Figure 1.

Analysis to calculate the weighted weight and combined effect of the influence of the preventive behavior and environmental variables on malaria using Review Manager 5.4 software. The analysis was carried out on the Odds Ratio data from each research article to determine the variation between studies (Heterogeneity) and the mean difference statistical test of the meta-analysis results (Test for overall effect)

3. Results and Discussion

The name of the researcher, the year, the title, the location of the study, and the number of respondents from the four search results articles using the PRISMA protocol used in this meta-analysis study can be seen in Table 1.

Table 1. Articles by locations, research area, and number of respondents

Article code	Researcher Name	Research Year	Research title	Research area	Number of respondents
P-1	Sutriyawan [18]	2021	Case-Control Analysis of Malaria Incidence in Sukamerindu Health Center Bengkulu City, Indonesia	Kota Bengkulu, Indonesia	300
P-2	Putri [19]	2020	Analysis of Environmental Risk Factors and Treatment Efforts Malaria Import Patients in Puskesmas in the Work Area of District Health Center of Segeri, Pangkep Regency 2019.	Baring, Kec. Segeri, Kab. Pangkajene, Sulawesi selatan	80
P-3	Sulistyawati [20]	2020	Potential Risk Factor for Malaria Infection in Banjarnegara, Indonesia: A Matched Case-control Study	Banjarmangu, Banjarnegara, Indonesia	34
P-4	Sulistyawati [21]	2020	Malaria Risk Factors in Banjarnegara, Indonesia: A Matched Case-Control Study	Banjarmangu, Banjarnegara, Indonesia	50

P: Article code

Table 2. Articles absed on research variables and odds ratio (OR) value

Article code	Variable	Bed nets OR (95% CI)	Mosquito repellent OR (95% CI)	House ventilation nets OR (95% CI)	Stagnant water in the home environment OR (95% CI)	Cattle in the home environment OR (95% CI)	Going out at night OR (95% CI)
P-1	Environmental and society behaviors factor	4.011 (2.480-6.487)	2.250 (1.418-3.572)	2.588 (1.625-4.122)	1.758 (1.113-2.778)		
P-2	Environmental risk factors	2.538 (1.023-6.298)					2.786 (1.125-6.899)
P-3	Environmental and individual factors	7.80 (2.64-23.03)		4.66 (1.54-14.14)		1.12 (0.43-2.91)	3.87 (1.41-10.65)
P-4	Environmental and human behaviour factors	2.087 (1.148–3.795)	1.278 (0.421-3.881)	3.907 (0.647–24.452)	1.862 (0.954-3.633)	1.490 (0.874-2.541)	

P: Article code, OR: Odds Ratio, CI: Confidence Interval

Table 3. Result of the analysis of the relationship between preventive behavior and the incidence of malaria

Article code	Variable	Case	Total	Weight	OR (Random, 95% CI)	Analysis results
			Using bed nets			
P-1	Yes No	103 47	150	28,2%	4,80 (2,95-7,82)	Heterogenity: Tau^2= 1,25
P-2	Yes No	27 13	40	25,1%	4,31 (1,69-11,00)	Chi^2= 22,05 I^2= 86%
P-3	Yes No	26 8	34	23,5%	10,56(3,44-32,39)	df= 3 P < 0,0001
P-4	Yes No	9 16	25	23,2%	0,32 (0,10-1,00)	Test for overall effect: Z= 1,80 (P=0,07)
			Use of mosquito repellents			
P-1	Yes No	91 59	150	48,6%	2,38 (1,50-3,78)	Heterogenity: Tau^2= 17,39 Chi^2= 31,44 I^2= 91% df= 1 P < 0,00001
P-4	Yes No	2 23	25	51,4%	0,01 (0,00-0,06)	Test for overall effect: Z= 0,64 (P= 0,52)
			Going out at night			
P-2	Yes No	26 13	40	55,9%	3,86 (1,53-9,75)	Heterogenity: Chi^2= 0,32 df= 1 (P = 0,57) I^2= 0%
P-3	Yes No	24 10	34	44,1%	5,76 (2,03-16,35)	Test for overall effect: Z= 4,32 (P < 0,0001)

P: Article code, OR: Odds Ratio, CI: Confidence Interval
Heterogeneity: variations between studies
Tau^2: Heterogeneity with units according to substance
Chi^2: Heterogeneity values statistically,
I^2: Heterogeneity in percent
Test for overall effect: The statistical test of the mean difference in the meta-analysis results.

Table 2 shows the research variables of the four articles used in the meta-analysis. There are variables using mosquito nets (P-1, P-2, P-3, P-4), use of mosquito repellents (P-1, P-2), the presence of home ventilation nets (P-1, P-3, P-4), standing water in the home environment (P-1, P-4), Cattle in the home environment (P-3, P-4) and behavior going out at night (P-2, P-3). Not all articles examine the same variables. The four researchers studied only the mosquito net variable.

The results of the analysis in table 3 are for p and I^2 values for the variable use of bed nets (P <0.0001, I2 = 86%) and the use of mosquito repellents (P <0.00001, I^2 = 91%). Small p-value and large I^2 indicate that the heterogeneity between studies is significant so that the analysis model used is the random effect model.

The results of the analysis differ from the variables on the behavior of going out at night. The results of the analysis P = 0.57 and I^2 = 0% indicate that the heterogeneity between studies is small, so that the analysis model used is the fix effect model.

Meanwhile, from the test for overall effect in table 3, the P values for the variable use of mosquito nets and mosquito repellents are 0.07 and 0.52. P value> 0.05 indicates no significant relationship between the variable use of mosquito nets and mosquito repellents and malaria incidence. Meanwhile, the variable of behavior outside the house at night (P <0.05) shows a significant relationship with malaria.

Table 4. Relationship between the home environment and the incidence of malaria

Article code	Variable	Case	Total	Weight	OR (Random, 95% CI)	Analysis results
Using house ventilation nets						
P-1	Yes	58	150	38,5%	0,40 (0,25-0,63)	Heterogenity: TaU^2= 4,10 Chi^2= 23,21 df= 2 (P < 0,00001) I^2= 91% Test for overall: effect Z = 2,45 (P = 0,01)
	No	92				
P-3	Yes	6	34	35,6%	0,05 (0,01-0,16)	
	No	28				
P-4	Yes	1	25	25,9%	0,00 (0,00-0,03)	
	No	24				
Presence of stagnant water in the home environment						
P-1	Yes	88	150	62,1%	2,01 (1,27-3,19)	Heterogenity: TaU^2= 0,48 Chi^2= 3,13 df= 1 (P = 0,08) I^2= 68% Test for overall: effect Z = 2,00 (P = 0,05)
	No	62				
P-4	Yes	18	25	37,9%	6,61 (1,92-22,73)	
	No	7				
Presence of cattle in the home environment						
P-3	Yes	17	34	52,9%	1,00 (0,39-2,59)	Heterogenity: TaU^2= 0,83 Chi^2= 3,77 df= 1 (P = 0,05) I^2= 73% Test for overall: effect Z= 0,94 (P= 0,35)
	No	17				
P-4	Yes	17	25	47,1%	4,52 (1,38-14,82)	
	No	8				

P: Article code, OR: Odds Ratio, CI: Confidence Interval
Heterogeneity: variations between studies
$Tau^{2:}$ Heterogeneity with units according to substance
Chi^2: Heterogeneity values statistically,
I^2: Heterogeneity in percent
Test for overall effect: The statistical test of the mean difference in the meta-analysis results.

The results of the analysis in table 4 for P and I^2 values for environmental variables around the house which include: there is a home ventilation network (P <0.00001, I^2 = 91%), there is a pool of water (P = 0.08, I2 = 68 %), and there are cattle sheds (P = 0.05, I^2 = 73%) indicating that the heterogeneity between studies on these three variables is significant so that the analysis model used is the random effect model.

Meanwhile, from the test for overall effect in table 4, the P-value results for the home ventilation network variables, standing water, and livestock drums are 0.01; 0.05; and 0.35. The P-value indicates that the two variables, namely the home ventilation network and standing water, have a significant relationship with malaria incidence. Meanwhile, the livestock drum variable shows no significant relationship with malaria.

3.1 Preventive behavior factors in the incidence of malaria

The analysis results in table 3 show that there is no significant difference in the variable use of bed nets (P <0.05) with the incidence of malaria. Based on the four studies tested, three studies showed higher malaria rates in the group using bed nets. There are different results in the study of Kesterman et al. Finding the effectiveness of using bed nets against malaria incidence.[22] The same was found in the study of Rodriguez et al. in Papua New Guinea; Researchers distributed bed nets gradually and found a reduction in malaria

incidence in the short term by up to 57%.[23] The ineffective use of bed nets in this study may be related to the poor condition of the bed nets, such as holes so that mosquitoes can still enter the bed nets.[20] The incidence of malaria can be increased again due to decreased endurance obtained in the population, the quality of outdoor mosquito nets, and an earlier shift in mosquito bite time.[24,25]

Changes in the timing of mosquitoes to biting indicate that vector control interventions can lead to different adaptation responses and possible variability in Genetics among vector populations. Follow-up research on the Mekong River There is no evidence that widespread distribution of mosquito repellents increases malaria incidence in endemic areas.[26] Goodyer et al. find various doses of the active substance in mosquito repellents on the market. This has a direct effect on the effectiveness of repelling mosquitoes.[27]

3.2 Environmental factors in the incidence of malaria

The results of the analysis in Table 4 shows that the environmental variables in the use of home ventilation nets have significant differences in the group using the home ventilation net compared to the group that does not use the home ventilation net. There were similar results in the three studies, where the incidence of malaria was higher in the group that did not use a home ventilation net in studies P-1, P-3, and in studies P-4. In line with the research results of Engka et al., Mustafa et al., and Nababan et al., Delil et al. showed a relation between the use of home ventilation nets and the risk of malaria incidence.[28–30]

The group variable there was a puddle in the home environment has a significant difference. There were the same results in both studies. Malaria incident was higher in the group where there was a puddle in the home environment, in study P-1 and P-4. This study was seen to reveal that there was a higher prevalence of malaria in a family where there was a puddle than in the environment without one.[32] According to the study by Imakwu et al., the prevalence of malaria in the group where there is no puddle is higher than where there is stagnant water.[33] Onyiah et al. stated that the group with no puddle in the home environment was 87.4% greater than the group with a puddle in the home environment 12.6%.[34]

4. Conclusions

The meta-analysis study review results showed a significant positive relationship between nighttime discharge variables, house ventilation networks, and standing water around the home environment to the incidence of malaria.

Suggestions for research with the following meta-analysis approach are to expand further the variables related to malaria as well as to expand the year of publication so that it is hoped that the results can illustrate the research map on malaria risk factors in Indonesia.

Author Contribution

All author contributed fully to the writing of this article.

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The author declare no conflict of interest.

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