Malaria among mine workers in Tanjung Agung Muara Enim District, South Sumatra, Indonesia: an analysis of environmental risk factors.

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Abstract. Malaria is still a public health concern in Tanjung Agung, Muara Enim District, South Sumatra, Indonesia, although the third SDG aims to eliminate the disease by 2030. This study aimed to identify the environmental factors that put mining workers at a higher risk of malaria. It was a cross-sectional study. The study included 92 selected participants. Bivariate analysis revealed a correlation between malaria and mosquito mosquito breeding (p-value = 0.039), mosquito resting sites (p-value = 0.018), and house wall conditions (p-value = 0.028). Multivariate analysis revealed that a housewall was the most significant risk factor, with PR = 0.267, 95% confidence interval (0.089-0.797), and p-value = 0.006. Understanding the interactions between the mosquito resting behaviour patterns of malaria mosquitoes is essential for planning adequate vector control. As demonstrated by these results, malaria elimination requires reducing mosquito resting malaria vectors.

Keyword: Malaria, Mine Workers, Environmental Risk Factors

1. Introduction

Muara Enim, South Sumatra, Indonesia, is still a malaria-endemic region [1],[2],[3],[4],[5],[6]. Mineral mining, plantations, agriculture and fisheries are suitable nesting sites for the *Anopheles* mosquito: Ponds, rice fields, ditches and former open-cast mines. These conditions are the trigger for malaria in Muara Enim. *Anopheles* habitats include irrigation canals, rice fields, watercourses in rice fields, fish ponds, buffalo ponds, swamps and lakes.

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Anopheles barbisrostris, An. kochi, An. barbumbrosus, An. tesselatus, An. umbrosus, An. nigerrimus, An. subpictus, and An. maculatus was captured [7]. Malaria transmission occurs in small-scale mining in the gold, rubber, and oil palm industries, putting workers at risk for malaria [8]. Malaria is more prevalent in artisanal mining communities than non-artisanal areas [9]. As a risk group, it is essential to study malaria transmission, commonly found in artisanal or small-scale miner (ASM) communities [9]. The small-scale mining area is risky for malaria transmission[10]. Another research has collected data analysing housing as a risk factor for malaria. This study examined roof type, wall type, floor type, closed or open eaves, ceiling presence or absence, house height, and modern or traditional dwelling [11]. It is essential to know where vectors rest so that strategies to eliminate them can be implemented [12]. So malaria transmission in miners is interesting to investigate in Tanjung Agung Muara Enim District, South Sumatra, Indonesia

2. Materials and Methods

The cross-sectional survey was conducted in June and July 2022. Using a purposive method, the investigator chose three villages following Tanjung Lalang, Tanjung Agung, and Penyandingan in Tanjung Agung Sub-District, Muara Enim District. The respondents are illegal artisanal miners who have resided in these areas for over six months. Variables studied include the presence of mosquito breeding and mosquito resting sites and the condition of the domestic environment. The sample size was calculated using the sampling formula to test the two proportions hypothesis. Table 1 shows the number of samples.

$$n = \frac{\left(Z_{1-\frac{a}{2}} \sqrt{2P\,(1-P)} + Z_{1-\beta} \sqrt{P_1(1-P_1) + P_2(1-P_2)} \right)^2}{(P_1 - P_2)^2}$$

Researchers used a cross-sectional study including 92 study participants in the study area. A logistic regression model is used to investigate the risk factors related to malaria occurrence. The dependent variable is malaria. The disease definition is a microscopy-based diagnosis reported in the Muara Enim Malaria Surveillance Information System (SISMAL). The diagnosis is based on the disease being detected by microscopic examination by health professionals and then documented or registered in SISMAL. Before a questionnaire was used for data collection, its validity and reliability were investigated. The independent variables of this study were the environmental conditions, mosquito mosquito breeding and mosquito resting places. The home environment includes the walls, ceiling and floor.

3. Results and Discussion

Each variable in the study was evaluated using univariate and bivariate analysis. The variables include mosquito breeding, mosquito resting sites and home environment. Table 2 shows the univariate and bivariate analyses.

Table 1. Univariate and bivariate analysis based on environmental risk factors of participants (n=92)

Research variables	n=92	95% CI (lb-ub)a	PR; 95% CI (lb-ub)b	P-value
Malaria				
No	84.78			
Yes	15.22	0.08-0.24		
Mosquito breeding				
No risk	39.13			
At risk	60.87	0.50-0.70	0.038 (1.13-2.02)	0.039
Mosquito resting				
No risk	34.78			
At risk	65.22	0.54-0.74	0.018 (1.22-1.94)	0.018
House wall				
Eligible	38.04			
Not Eligible	61.96	0.51-0.71	0.028 (0.26-1.10)	0.028
Ceiling				
Eligible	54.35			
Not Eligible	45.65	0.35-0.56	0.819 (0.48-1.77)	0.820
Floor				
Eligible	34.78			
Not eligible	65.22	0.54-0.74	0.056 (0.33-1.15)	0.056

lb Lower 95% confidence boundary of cell percentage, ub Upper 95% confidence boundary of cell percentage
[a]95% CI of percentage in univariate analysis
[b]95% CI of percentage in bivariate analysis

Based on the availability of mosquito breeding sites, more mining employees in Tanjung Agung Sub-district were at risk (60.87%) than those who were not (39.13%). Based on the availability of mosquito resting places, more mining workers were at risk (65.22%) than those not (34.78%). Based on the condition of house walls, more miners did not meet the criteria (61.96%) than those who did (38.04%). More miners have unqualified house skylights (45.6%) than qualified (54.35). Regarding house floor conditions, more miners do not meet the standards (65.22%) than meet them (34.78%). Bivariate analysis showed an association between the presence of a mosquito breeding place (p-value 0.039), mosquito resting site (p-value 0.018) and house walls (p-value 0.028) and malaria among miners in the study site.

Table 2. Factors associated with malaria prevalence in the low endemic area (n=92)

Research variables	PR crude (95% CI)a	P-value	PR adjusted (95% CI)b	P-value
House wall				
Eligible				
Not eligible	0.028 (0.26-1.10)	0.028	0.267 (0.089-0.797)	0.018

Ref.: The reference category is represented in the contrast matrix as a row of one
[a]Crude prevalence ratio (PR)
[b]Adjusted prevalence ratio (APR)

Multivariate analysis showed that an adequate house wall was the most significant risk factor, with a PR =0.267, 95% CI (0.089-0.797), and a p-value of 0.006. Figures 1, 2 and 3 show the house environment and mosquito breeding and mosquito resting sites.

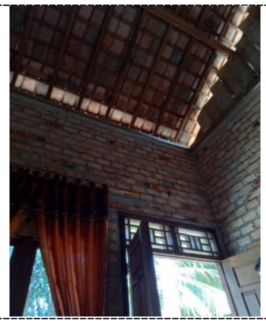

Figure 1. The home's environment

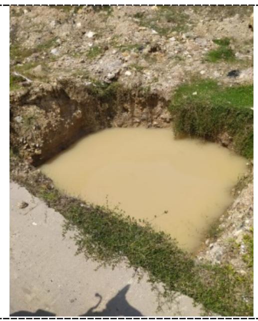

Figure 2. Mosquito mosquito breeding

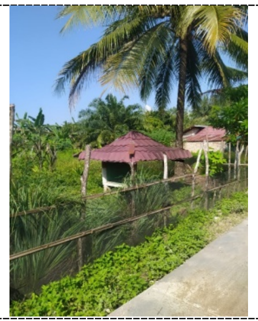

Figure 3. Mosquito resting sites

In low-transmission settings, housing improvements can provide similar protection to vector control strategies. Malaria risk is influenced by mosquito entry and indoor residence. Besides, malaria vector management requires knowledge of *Anopheles* mosquito resting sites[13]. Living in the highest quality housing reduces the number of vectors [14]. Understanding the feeding and mosquito resting habits and transmission potential of adult vectors in an area is critical for properly planning and implementing improved vector control strategies which is part of Integrated vector management and helps eliminate malaria by 2030 [15]. Knowing adult vector feeding and mosquito resting habits helps control them [16]. Malaria surveillance and control rarely include collection of outdoor mosquito resting *Anopheles* mosquitoes, partly due to the lack of standardised collection equipment [17]. Knowledge of the mosquito resting sites and blood sources of *Anopheles* minimus is essential for implementing vector control measures [18]. Structural changes can reduce rural malaria transmission. In western Kenya's rice irrigation area, home renovation with locally available insecticide-treated blankets and small ITNs can reduce malaria vector and parasite exposure [19]. Malaria transmission depends on indoor and outdoor conditions. This highlights the need to better understand mosquito mosquito resting behaviour and transmission ecology [20]. Another study showed malaria vectors' diverse mosquito resting and feeding habits and Plasmodium infections despite long-lasting insecticidal nets (LLINs) [21]. Good house construction reduces malaria risk by blocking mosquito vectors. Mosquitoes and malaria risk are affected by Ugandan house construction [22].

4. Conclusion and Recommendation

Malaria control requires understanding mosquito mosquito resting behaviour . Understanding mosquito resting places is critical for vector control. Besides, changing the design of rural homes can reduce indoor mosquito populations and malaria transmission cost-effectively. Housing improvements give protection to current vector control measures in low-transmission areas.

The health office must collaborate with primary care physicians to enhance monitoring, particularly in unlawful mining sites. Facilitate malaria counseling through collaboration across sectors and community engagement efforts to persuade decision-makers to implement malaria-combating policies or alternatives. PHCs must collaborate with physicians and MCH officials to map malaria-endemic areas using routine data and surveys and educate the population about malaria's dangers, prevention, and treatment.

Controlling malaria requires an understanding of the mosquito resting behaviour of mosquitoes. Understanding mosquito resting sites is critical for vector control. In addition, changing the design of homes in rural areas can cost-effectively reduce indoor mosquito populations and malaria transmission. Improvements in housing design provide protection for current vector control interventions in areas with low transmission.

The health department needs to work with GPs to improve surveillance, especially in illegal mining areas. Facilitate malaria outreach through intersectoral collaboration and community engagement to convince decision makers to implement malaria control measures or alternatives. PHCs need to work with doctors and MCH officials to use routine data and surveys to map malaria areas and educate the population on the dangers of malaria, its prevention and treatment.

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References

[1] **H. Hasyim**, P. Dale, D. A. Groneberg, U. Kuch, and R. Muller, "Social determinants of malaria in an endemic area of Indonesia," *Malaria journal,* vol. 18, no. 1, p. 134, Apr 12 2019, doi: 10.1186/s12936-019-2760-8.

[2] **H. Hasyim** *et al.*, "Spatial modelling of malaria cases associated with environmental factors in South Sumatra, Indonesia," *Malaria journal,* vol. 17, no. 1, p. 87, Feb 20 2018, doi: 10.1186/s12936-018-2230-8.

[3] **H. Hasyim** *et al.*, "Does livestock protect from malaria or facilitate malaria prevalence? A cross-sectional study in endemic rural areas of Indonesia," *Malar J,* vol. 17, no. 1, p. 302, Aug 20 2018, doi: 10.1186/s12936-018-2447-6.

[4] **H. Hasyim** *et al.*, "Potential for a web-based management information system to improve malaria control: An exploratory study in the Lahat District, South Sumatra Province, Indonesia," *PloS one,* vol. 15, no. 6, p. e0229838, 2020, doi: 10.1371/journal.pone.0229838.

[5] A. Budiyanto, L. P. Ambarita, and M. Salim, "Konfirmasi Anopheles sinensis dan Anopheles vagus sebagai Vektor Malaria di Kabupaten Muara Enim Provinsi Sumatera Selatan," *ASPIRATOR - Journal of Vector-borne Disease Studies,* vol. 9, no. 2, pp. 51-60, 2017, doi: 10.22435/aspirator.v9i2.5998.51-60.

[6] R. I. Heroza, **H. Hasyim**, R. Kusriastuti, and P. Dale, "Design and Evaluation of Mobile-Based Applications for Supporting Malaria Surveillance Activities in Indonesian Regions " *International Journal of Advanced Multidisciplinary Research,* vol. 9, no. 1, pp. 37-45, 2022. [Online]. Available: https://ijarm.com/.

[7] Y. Yahya, D. Haryanto, R. I. Pahlevi, and A. Budiyanto, "keanekaragaman jenis nyamuk Anopheles di sembilan kabupaten (tahap pre-eliminasi malaria) di Provinsi Sumatera Selatan," *Vektora: Jurnal Vektor dan Reservoir Penyakit,* vol. 12, no. 1, pp. 41-52, 2020.

[8] H. Z. Soe, A. Thi, and N. N. Aye, "Socioeconomic and behavioural determinants of malaria among the migrants in gold mining, rubber and oil palm plantation areas in Myanmar," (in eng), *Infect Dis Poverty,* vol. 6, no. 1, p. 142, Nov 6 2017, doi: 10.1186/s40249-017-0355-6.
[9] F. Dao *et al.*, "Burden of malaria in children under five and caregivers' health-seeking behaviour for malaria-related symptoms in artisanal mining communities in Ghana," (in eng), *Parasit Vectors,* vol. 14, no. 1, p. 418, Aug 21 2021, doi: 10.1186/s13071-021-04919-8.
[10] P. Thornton, "Chinese miners and Ghana's golden reform opportunity," *International Growth Centre Blog,* 2014.
[11] J. Furnival-Adams, E. A. Olanga, M. Napier, and P. Garner, "Housing interventions for preventing malaria," *The Cochrane Database of Systematic Reviews,* vol. 2019, no. 8, 2019.
[12] M. E. Sinka *et al.*, "The dominant Anopheles vectors of human malaria in Africa, Europe and the Middle East: occurrence data, distribution maps and bionomic précis," *Parasites & Vectors,* vol. 3, no. 1, p. 117, 2010/12/03 2010, doi: 10.1186/1756-3305-3-117.
[13] M. M. Ippolito *et al.*, "House structure is associated with Plasmodium falciparum infection in a low-transmission setting in Southern Zambia," *The American journal of tropical medicine and hygiene,* vol. 97, no. 5, p. 1561, 2017.
[14] J. X. Liu *et al.*, "Is housing quality associated with malaria incidence among young children and mosquito vector numbers? Evidence from Korogwe, Tanzania," *PloS one,* vol. 9, no. 2, p. e87358, 2014.
[15] S. Thomas *et al.*, "Resting and feeding preferences of Anopheles stephensi in an urban setting, perennial for malaria," *Malaria Journal,* vol. 16, no. 1, p. 111, 2017/03/10 2017, doi: 10.1186/s12936-017-1764-5.
[16] A. O. Forson *et al.*, "The resting behavior of malaria vectors in different ecological zones of Ghana and its implications for vector control," *Parasites & Vectors,* vol. 15, no. 1, p. 246, 2022/07/08 2022, doi: 10.1186/s13071-022-05355-y.
[17] M. Pombi *et al.*, "The Sticky Resting Box, a new tool for studying resting behaviour of Afrotropical malaria vectors," *Parasites & Vectors,* vol. 7, no. 1, p. 247, 2014/05/29 2014, doi: 10.1186/1756-3305-7-247.
[18] M.-C. Chang, H.-J. Teng, C.-F. Chen, Y.-C. Chen, and C.-R. Jeng, "The resting sites and blood-meal sources of Anopheles minimus in Taiwan," *Malaria Journal,* vol. 7, no. 1, p. 105, 2008/06/09 2008, doi: 10.1186/1475-2875-7-105.
[19] H. Atieli, D. Menya, A. Githeko, and T. Scott, "House design modifications reduce indoor resting malaria vector densities in rice irrigation scheme area in western Kenya," *Malaria Journal,* vol. 8, no. 1, p. 108, 2009/05/19 2009, doi: 10.1186/1475-2875-8-108.
[20] K. P. Paaijmans and M. B. Thomas, "The influence of mosquito resting behaviour and associated microclimate for malaria risk," *Malaria Journal,* vol. 10, no. 1, p. 183, 2011/07/07 2011, doi: 10.1186/1475-2875-10-183.
[21] W. E. Ekoko *et al.*, "Patterns of anopheline feeding/resting behaviour and Plasmodium infections in North Cameroon, 2011–2014: implications for malaria control," *Parasites & Vectors,* vol. 12, no. 1, p. 297, 2019/06/13 2019, doi: 10.1186/s13071-019-3552-2.
[22] H. Wanzirah *et al.*, "Mind the gap: house structure and the risk of malaria in Uganda," *PLoS One,* vol. 10, no. 1, p. e0117396, 2015.