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Strengthening Malaria Migration Surveillance at Village Level in Tanah Bumbu Regency, South Borneo, Indonesia

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Abstract: Tanah Bumbu Regency had implemented malaria migration surveillance in illegal mining areas. This study aimed to describe the implementation of malaria migration surveillance. The study conducted in five villages with high case incidence (HCI) i.e., Gunung Raya, Temunih, Mangkal Api, Guntung, and Teluk Kepayang, from March to October 2018. The study used an observational design with a cross-sectional approach, descriptive analysis for quantitative data, and thematic content for qualitative data. The research activity included a mass blood survey, malaria vector species, environmental survey, focus group discussion with mining workers, and in-depth interviews about the implementation of malaria migration surveillance. Socialization of malaria migration surveillance in 5 HCI villages has been carried out to the wider community. The slide positivity rate of malaria was 1.45% of 1996 participants and positive cases of malaria were detected in 75 subjects. *Anopheles* sp and potential larvae in swamps, rivers, ponds, and wells. Mine workers consider malaria as an occupational risk of working in forests. The workers are unwilling to get checked for blood examination or to report to the local Primary Health Centers (*Puskesmas*) before and after traveling to endemic areas. Cross-sectoral collaboration is carried out by community empowerment through village malaria posts.

Keywords: Malaria; Migration; Surveillance; Tanah Bumbu

Introduction

The malaria cases in Indonesia have been reduced by more than 50% from 465,764 cases (API 1,96‰) in 2010 to 222,085 cases (API 0.86‰) in 2018 (Ministry of Health of The Republic of Indonesia, 2020). South Kalimantan Province with its 13 regencies and municipalities fights malaria with cooperation from all governmental levels supported by the society so that Malaria Free Indonesia can be realized before 2030. In general, 53% of regencies and municipalities in South Kalimantan have been free of malaria. The Annual Parasite Incidence (API) in South Kalimantan is 0.21 less than 1‰ and Slide Positivity Rate (SPR) is 3.0 or less than 5%, making it categorized as a green zone (Ridha et al., 2021).

The problem of malaria among some migrant workers is undetectable malaria parasite in their blood. They can be a source of malaria transmission in their area of origin (Kementerian Kesehatan RI, 2020). Forest activities such as gold mining, agriculture, and logging are the high-risk occupations for malaria exposure in the Asia Pacific region (Wen et al., 2016). In Aceh, forest work are potentially exposed to malaria in diverse groups of forest workers (Ekawati et al., 2020). Most malaria patients in Trenggalek dominated by male, migrant workers, and most of them work as the private sector and farmers (Maryanto & Mirasa, 2019). In Tanah Bumbu, malaria parasites were found in adult men who worked as miners and forest protectors (Rahayu et al., 2020).

Malaria in Tanah Bumbu occur cause many factors such as of geography, workers' mobility recording

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system, workers behaviors, and supports from the neighboring regencies contribute to the malaria incidences in Tanah Bumbu because the majority of the workers who contracted malaria in the transmission focus area came from different regencies (Rahayu et al., 2016; Rahayu et al., 2020).

Several efforts have been made by the Tanah Bumbu Health Office and Community Health Centers (*Puskesmas*) to reduce API rates. It include mass blood surveys, epidemiological investigations, distribution of mosquito nets, spraying houses, counseling, treatment, presence of Village Malaria Post (*Posmaldes*), as well as employing health workers and malaria cadres (Dinas Kesehatan Kabupaten Tanah Bumbu, 2018). Tanah Bumbu Regency decreasing API value from 0.82 in 2015 to 0.48 in 2016. However malaria cases still occurred in five villages with the High Case Incidence (HCI) category in 2015-2016 and in 2017 it increased to six villages of HCI.

So it is very necessary to conduct a migration survey both active case detection (ACD) and passive case detections (PCD). This is because malaria cases occur due to miners outside the district who bring cases or the natural potential of Tanah Bumbu which has the opportunity to transmit to migrants who work in Tanah Bumbu Regency. Based on these problems, a study was conducted to analyze the implementation of migration surveillance on mining workers in Tanah Bumbu Regency.

The study was performed in five HCI villages that contain mining areas in the regency of Tanah Bumbu, South Kalimantan. Data collection include questionnaires about the characteristics of the mining workers, focus group discussions (FGD) on the malaria topic, mass blood surveys, vector survey, environmental survey, and in-depth interviews with the stakeholders of the local and the neighboring regencies. It is expected that a strategy to increase awareness of the emergence of malaria, especially in mining areas, will lead to the accelerated elimination of malaria in Tanah Bumbu.

Methods

The research design is descriptive cross-sectional observation with quantitative and qualitative methods. The activities of this research included a mass blood survey, malaria vector species, environmental survey, focus group discussions (FGD) with mining workers, and in-depth interviews with the local regulators about implementations of malaria migration surveillance (see Figure 1). This study was approved by the Health Research Ethics Committee, National Institute of Health Research and Development (LB.02.01/2/KE.117/2018).

The mass blood survey (MBS) was performed on residents who are willing to have their blood drawn according to the inclusion criteria. MBS was held by the community health centers (*Puskesmas*) of Mantewe and Teluk Kepayang as well as the Health Research and Development Unit of Tanah Bumbu. The sample selection was carried out by purposive sampling. The calculation results show that the minimum sample size for MBS held by Balai Litbangkes Tanah Bumbu was 100 respondents for each village. Sampling will be added 10% to 110 respondents for each village. Sample inclusion criteria included residents aged at least 5 years old, willing to participate in the survey, and met general requirements. The exclusion criteria were the selected samples that are not willing to have their blood drawn. The estimated sample size was calculated using the Lemeshow formula, et al. (Lemeshow, Jr, Klar, & Lwanga, 1990) as follows (Formula 1):

$$n = \frac{Z^2_{1-\frac{\alpha}{2}} p.q}{d^2} \quad (1)$$

Remarks:
n = number of samples
$Z^2_{1-\alpha}$ = Z statistic, with a 95% confidence level and α = 5%, so Z= 1.96
p = estimated proportion (prevalence)= 0.5 q = 1-p = 0.5
d = delta, absolute precision or desired margin of error on both sides of the proportion = 10%

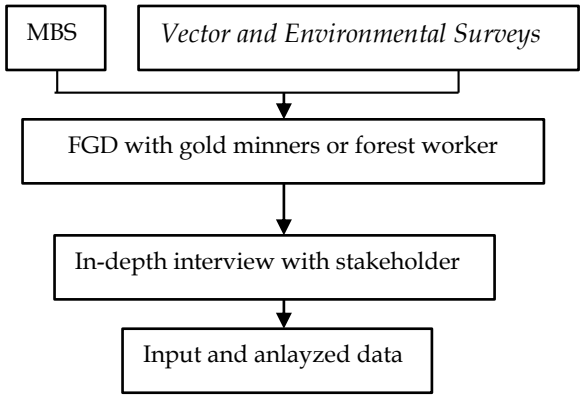

Figure 1. Research Flowchart

A focus group discussion (FGD) on malaria was conducted to find out aspects of community knowledge, attitudes, and behavior related to malaria (causes of disease, treatment, and prevention). The number of samples that participated in FGD was 10 mine workers.In-depth interviews were aimed at stakeholders regarding the implementation of malaria migration surveillance as the malaria elimination program in the levels of village, sub-district, and district of Tanah Bumbu. Vector and environment surveys were conducted to identify potential mosquito species as malaria transmission vectors, vector density, and peak

points of transmission. The analysis was carried out based on the type of data. Quantitative data in the form of epidemiological aspects of transmission (host, agent, and environment) and imported malaria case data will be described descriptively through graphs, tables, or pictures. Qualitative data include results from FGD and in-depth interviews with the stakeholders from Tanah Bumbu Health Office.

Result and Discussion

The epidemiological triad model of infectious disease consists of a susceptible host, an agent or pathogen, and an environment (physical, social, behavioral, cultural, political, and economic factors) that brings the host and agent together making infection and disease to occur in the host (Van Seventer & Hochberg, 2017). Malaria transmission occurs because of interaction between definitive host, intermediate host, agent, and environment (Bannister-Tyrrell et al., 2017; Hakim, 2011; Rokhayati et al., 2022).

Figure 2. Forest Work in Tanah Bumbu Regency

Mass Blood Survey

Early detection of patients in five villages resulted in a total SPR of 1.45%, namely 29 people who were positive for malaria from a total of 1996 slides examined with the following details pathogen are mix of *Plasmodium falciparum-vivax* in 10 respondents, *Plasmodium falciparum* in 3 respondents, and *Plasmodium vivax* in 16 respondents. This result is similar to another study that included 295 patients in North India that describe the most common species as *Plasmodium vivax* (62%) followed by *Plasmodium falciparum* (29%), and mixed *Plasmodium* spp. (9%) (Karoli et al., 2021). *Plasmodium vivax* is the cause of a large proportion of the global malaria burden. Efforts to control malaria have described that *Plasmodium vivax* is more resilient than the other major human malaria parasite, *Plasmodium falciparum* (Jennison et al., 2015). A detailed list of MBS results can be seen in Table 1.

Table 1. Results of the Mass Blood Survey (MBS) from August to September 2018

MBS	SPR	Remarks
Mantewe *Puskesmas*	18/639 (2.82)	• 5 mix • 2 *P. falciparum* • 11 *P. vivax*
Teluk Kepayang *Puskesmas*	11/773 (1.42)	• 5 mix • 1 *P. falciparum* • 5 *P. vivax*
Health Research and Development Unit of Tanah Bumbu	0/584 (0.00)	0
Total	29/1996 (1.45)	• 10 mix • 3 *P. falciparum* • 16 *P. vivax*

Source: Tanah Bumbu District Health Office in collaboration with the Health Research and Development Unit of Tanah Bumbu Tanah Bumbu in 2018

Vector and Environmental Surveys

The entomology survey found the presence of potential *Anopheles* mosquitoes, among others, in two villages, including Mangkalapi and Teluk Kepayang, while the presence of potential *Anopheles* larvae was found in four villages, including Gunung Raya, Temunih, Mangkalapi, and Teluk Kepayang with potential environments include swamps, rivers, former pools, ponds, and wells. A detailed list of vector and environmental survey results can be seen in Table 2.

Table 2. Vector and Environment Surveys Results

Village	Potential Vector	Presence of potential Anopheles larvae	Potential Environment
Gunung Raya	0	Exist	swamp (+), pond, river (+), used tires, drum
Temunih	0	Exist	river (+), swamp, pond, well
Mangkalapi	1 *An. nigerimus*	Exist	former pond (+), pond (+), pool (+), well (+), banana tree
Guntung	0	None	used jerrycans, swamps, wells, ponds,
Teluk Kepayang	11: 3 *An barbirostris*, and 8 *An vagus*	Exist	former gold mines, puddles, puddles, ponds (+), household waste disposal, rivers

In Mangkal Api Village, *An. nigerrimus* at night was captured with a human bait trap. *An. nigerrimus* is a member of the Hyrcanus group reported to act as a

vector of malaria and the spread is evenly distributed across Sumatra, Kalimantan, Java, and Sulawesi, but is not found in the Ambon and Papua areas (Udin et al., 2016). This species was also reported to be able to suck livestock located close to human presence and tend to be more exophagic (Mahdalena & Wurisastuti, 2021). *An. vagus* became a new potential vector in low endemic areas in Jambi, Central Kalimantan, South Sulawesi, and Yogyakarta. *An. barbirostris* became a new potential vector in the low-endemic areas in Central Kalimantan (Anggraeni et al., 2022). The night survey in Guntung Village with human bait did not find any *Anopheles* mosquitoes. This was probably because no breeding places were found around residents' housing. However, it should not be ruled out if there is migration from other adjacent areas.

The survey in Miing Hamlet, Teluk Kepayang Village, found *Anopheles barbirostris* and *Anopheles vagus*. *Anopheles barbirostris* has the behavior of biting humans (antrophilic) and animals (zoophilic), active at night (nocturnal) between 23.00-05.00, resting inside the house and on plants around the house (Irawan et al., 2014). Based on the breeding places, malaria vectors can be grouped into three types, namely breeding in rice fields, hills/forests, and beaches/streams. The malaria vector that breeds in rice fields is *An. aconitus*, *An. annularis*, *An. barbirostris*, *An. kochi*, *An karwari*, *An. nigerrimus*, *An. sinensis*, *An. tesellatus*, *An. vagus*, *An. letifer*. Malaria vectors that breed in the hills or forests are *An.balabacensis, An.bancrofti, An.punculatus,* and *An.umbrosu*s. Whereas for coastal areas or river basins, the types of malaria vectors found are *An. flavirostris, An.koliensis, An.ludlowi, An.minimus, An.punctulatus, An.parangensis, An.sundaicus,* and *An.subpictus* (Udin et al., 2016).

In Gunung Raya Village, an *Anopheles* breeding place was found in the form of a forest type (swamps and rivers in the forest). In the breeding places found by *Anopheles* larvae, there is moss vegetation. In general, *Anopheles* larvae really like waters overgrown with moss as a place to take shelter and find food. Natural predators are found in the brooding sites, namely fish, but with the presence of vegetation as a shelter, some *Anopheles* larvae can be protected from predators. Meanwhile, from the aspect of water temperature at 6 points in Gunung Raya Village, it ranges from 28.0–31.70 °C. The average temperature of the brooding sites where malaria larvae are most commonly found ranges from 28.9–33.8ºC (Mahdalena & Wurisastuti, 2021). Rainfall affects the increase in mosquito density. The optimum temperature supports the increase in mosquito density at 26.5-27°C. Optimum humidity, temperature, and rainfall support the increase in malaria incidence (Sulasmi et al., 2017).

In Temunih Village, *Anopheles* mosquito larvae were found in brooding areas in the form of rivers with stagnant waters, allowing mosquitoes to breed in these places. The place is also shaded by the leaves of the large trees around it. The type of Anopheles brooding found was forest type (river in the forest). The temperature of the waters ranges from 24.0 – 25.30°C, possibly this is influenced by the time of measurement taken in the morning, the geographical conditions of the village which is located in the mountains/plateaus, besides the average brooding area is shaded by vegetation. Research conducted in Purworejo described that the average temperature at the positive breeding place of Anopheles mosquito larvae was 26.74°C, the average water pH was 7.63 and the average humidity was 79.41% (Inunggita et al., 2019). In Mangkal Api Village, An's birthplace was found *An. nigerrimus* in the form of fairly clear waters former rice fields with direct sunlight. These results are in accordance with other research that *An. nigerrimus* prefers habitats containing fresh, clean sunlight or slow-flowing water (Udin et al., 2016).

In Miing Hamlet, Teluk Kepayang Village, Anopheles larvae were found in a pond with a salinity of 0 ppm and exposed to sunlight, which contained water grass plants. This is supported by the literature which states that the breeding habitat of *Anopheles barbirostris* in mountainous areas is rice fields whether it is planted, unplanted, or ready-to-plant. The main habitat of *An. barbirostris* are paddy fields with irrigation canals, ponds, and swamps. Each mosquito chooses a different habitat based on the turbidity of the water. This is aligned with another study that *Anopheles* species can live in clear or turbid water, for example, *An. barbirostris* was found in both cloudy and clear water (Mahdalena & Wurisastuti, 2021). Whereas found *An. barbirostris* in clear water (Shinta & Marjana, 2016). The characteristics of the habitat have a neutral pH (pH=7), which is very suitable for the geographical conditions and environmental conditions in Miing Hamlet. In addition to finding potential habitats for *An. barbirostris*, types of brooding sites for *an larvae* were also found. *An. vagus* habitats are in the form of rice fields, ditches, ditches, and puddles on vacant land and around housing with salt content ranging from 0-140/00, the pH of the water at the breeding sites varies between 7-9. The biological environment includes aquatic biota and the presence of predators in positive larvae breeding sites. This condition is in accordance with the literature which states that the optimal degree of acidity for *Anopheles* spp. more commonly found in waters that are alkaline (water pH ranges from 8-14) (Sopi & Triana, 2015). Types of breeding sites include paddy fields, ditches, vacant land, puddles, and puddles of used vehicle tires. Biota types include grass (musei), fish and tadpoles/frogs

(*Rana* sp), while the types of breeding sites. lagoons and irrigation canals contain moss and fish. The larvae take shelter in water plants, moss and hide in dry rice plants that are submerged in water (Sudirman et al., 2022).

Around the houses of Miing Hamlet, Teluk Kepayang Village, there are many bushes. The existence of lush shrubs and vegetation will reduce sunlight penetrating the soil surface so that the surrounding environment will be shady and moist. The existence of gardens or shrubs near the house if not properly maintained can become a breeding ground for mosquito vectors. Research in Nabire said that there was a significant relationship between garden spacing and the occurrence of malaria transmission with OR = 7 (Handayani, Pebrorizal, & Soeyoko, 2008).

Furthermore, geographically, *Anopheles* breeding sites are still to be found, as well as the community culture of the habit of mine workers going out at night, which increases transmission. This is aligned with the habitual behavior of forest workers going out at night in the work area which is still high (83.2%) as a risk factor for malaria incidence in Temunih Village, Kusan Hulu District, Tanah Bumbu Regency, South Kalimantan Province (Rahayu et al., 2016).

Focus Group Discussion (FGD)

Mine workers stated that they knew the area was endemic for malaria, according to the statement. The reason for mining workers to work in malaria-endemic areas is due to economic factors. This is in accordance with several statements in the FGD, namely:

"Yes, I know already" (Informant 1), "But I have to work, no matter what" (Informant 2), " If you want to look for sustenance, you have to visit (the source)" (Informant 3), "Ah not like that... all this time I just gave up if I got malaria, it was considered a mere fate" (Informant 4), "How can I not do it? My work is there, I have to do it no matter what" (Informant 5).

Based on the results of a previous study, drivers of these practices were tradition, lack of work and financial necessity (Awasthi et al., 2022). Population mobility to this occurs partly due to socio-economic conditions in their area of origin that cannot meet basic life needs, causing people to migrate to other areas to be able to meet their needs (Kementerian Kesehatan RI, 2020). In India, economic constraints and hardships made villagers migrate seasonally for work to malaria-endemic areas. This exposes them to the risk of malaria (Awasthi et al., 2022).

Based on the results of the study, forest workers in seeking treatment for malaria, some immediately seek help and some take it for granted, but if you already feel severe pain just seek help for malaria treatment (Ekawati et al., 2020). The model that using a time series analysis from 2005 until 2014 showed that migration (lag1), humidity (lag 2), precipitation (lag 3), precipitation (lag 12), and previous malaria cases (lag 12) had a significant relationship with malaria case in endemic area of Purworejo (Inunggita et al., 2019).

This condition is also reinforced by the mindset of mine workers who think that malaria is a common thing or a consequence of working in the forest and the limited skill factor because mining is considered the work of their ancestors or hereditary. A health promotion based on Health Belief Model (HBM) theory had been implemented in Taiwan can improving foreign migrant workers' awareness of diseases, emphasizing the severity of the disease, and eliminating possible hindrances in the future (Tai & Yang, 2022).

In-depth Interviews with Stakeholders

Some people, especially groups of mining workers, still consider malaria as one of the risks of working in the forest, both because of economic factors where the amount of income derived from mining is greater than from other jobs, and this mining work has been carried out for generations.

"Don't know ma'am... It's just that the problem is the problem of getting any kind of food... right there are mostly rubber farmers, it just so happens that the rubber is currently having dropped a bit, so what can I say, how do I survive here how to feed my wife and children? So like it or not, the results are also tempting too if (working) there."

The many local level are key drivers for the seasonal migration of people to malaria-endemic areas is, financial hardship and lack of employment (Awasthi et al., 2022). There is reluctance from some mining workers to be examined for MBS early or to report to the *Puskesmas* or health workers both before and after traveling to endemic areas. New workers will contact the health department if they are seriously ill, either by going to a health facility when they are in an endemic area or when they return to their area of origin. This is aligned with Banyumas Regency in 2021, which has several limitations to implementing malaria migration surveillance. The reasons are ineffective implementation of village regulations, the lack of human resources, and the lack of public awareness in reporting symptoms of malaria (Paramesti et al., 2022).

Reactivating the migration survey and the malaria-positive case-finding notification card with more complete data is needed to facilitate the tracking process for the continuation of the epidemiological investigation (Tanah Bumbu and neighboring districts). Mobility of malaria importation are key challenges to malaria elimination (Smith et al., 2019). Making the head of the miners' group as a village malaria cadre to accelerate malaria case finding, counseling in at-risk groups, and assist the patients to take the medication.

Implementation village regulation for detection and monitoring of community-based malaria cases treatment in Tetel Village, Purbalingga Regency made malaria cases decrease even to zero (Kesuma et al., 2018). Creating an entry-exit portal for the workers where MBS is performed for the incoming and leaving worker. Such frequent traveling workers could also be mapped together with residents who travel in and out across regencies. Similar to Banyumas Regency, it requires comprehensive training, improved partnerships, application-based village reporting, and policy socialization to maintain the elimination of migration surveillance (Paramesti et al., 2022). Based on the Precede Proceed theory by Lawrence Green, it is stated that community leaders can be a reinforcing factor and regulation can be a enabling factor that encourages a person to carry out health behavior (Notoatmodjo, 2010).

Coordination across regencies between Tanah Bumbu, Banjar, Tapin, as well as South Kalimantan Province has been carried out, among others, in the form of notification cards for malaria patients and communication via WhatsApp groups as well as telephone or short message service. This is in line with the malaria migration surveillance guidelines where notification of malaria must be carried out by regions that find malaria for the first time to the origin and destination of the patients so that these areas can follow up on cases and carry out active surveillance. The form of notification can be through communication media, including letters, email, telephone, and short message services (Kementerian Kesehatan RI, 2020).

In Purbalingga Regency, MMS has been well implemented in Sidareja and Pengadegan villages. Meanwhile, the implementation of migration surveillance in Tunjungmuli and Panusupan villages has not been optimal; case finding is carried out at any time but screening is only carried out at certain times, such as before Eid al-Fitr.; socialization needs to be carried out to the wider community; and it motivates the community to participate in reporting returning migrant workers (Pramestuti et al., 2022). As Indonesia approaches its malaria elimination goal to achieve its 2030 target and national vision to be malaria-free, surveillance systems need to be strengthened. Scaling of diagnostic and treatment interventions alongside vector control in high-transmission areas should be combined with tailored approaches in low-transmission areas (Sitohang et al., 2018).

Cross-sector collaboration and coordination have been carried out in controlling malaria in the three regencies with the sub-districts. The activities involve the community order and security officers, village heads, companies, police, soldiers, teachers, community leaders, religious groups, women groups, and related cross-sectors. This is because the malaria control program, which is focused on achieving malaria elimination, needs to be carried out in a comprehensive and integrated manner by the central and local governments, together with development partners, including NGOs, the business world, donor agencies, professional organizations, community organizations, and the community. This is in line with the malaria migration surveillance guidelines where migration surveillance is carried out by the Government, Provincial Health Office, City Health Offices, as well as Technical Implementation Units especially Port Health Offices and health service facilities (*Puskesmas* and hospitals) as well as the private sector, community, and across sectors (Kementerian Kesehatan RI, 2020).

Conclusion

Migration surveillance in mining areas of Tanah Bumbu regency is an alternative to accelerating the detection of malaria cases in endemic areas.

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Author Contributions

Conceptualization, N.R. and Y.S.; methodology, N.R.; formal analysis, N.R. and Y.S.; investigation, N.R.; resources, N.R.; data curation, N.R. and Y.S.; writing—original draft preparation, N.R. and Y.S.; writing—review and editing, N.R., Y.S and A.R.F.; visualization, N.R., Y.S and A.R.F.; supervision, N.R; project administration, N.R. and Y.S.; funding acquisition, N.R.

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Conflicts of Interest

The authors declare no conflict of interest.

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