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MALARIA SITUATION IN THE SOUTH KALIMANTAN PROVINCE, 2010–2018

Situasi Malaria di Provinsi Kalimantan Selatan Tahun 2010 – 2018

M. Rasyid Ridha[1], Kasman Kasman[2], Evi Laini[3], Liestiana Indriati[4]

[1]Tanah Bumbu Unit for Health Research and Development, National Institute of Health Research and Development, National Ministry of Health of Indonesia, ridho.litbang@gmail.com

[2] Faculty of Public Health, Universitas Islam Kalimantan Muhammad Arsyad Al Banjari (MAB), Banjarmasin, Indonesia, kasman.ph@gmail.com

[3]Disease control Departement, the South Kalimantan Provincial Health Office. eviliani@gmail.com

[4]Tanah Bumbu Unit for Health Research and Development, National Institute of Health Research and Development, National Ministry of Health of Indonesia.lies_alla@yahoo.com

Correspondence Author: M. Rasyid Ridha, ridho.litbang@gmail.com, Tanah Bumbu Unit for Health Research and Development, National Institute of Health Research and Development, National Ministry of Health of Indonesia. Loka Litbang Street, Batulicin sub-district, Pondok Butun, , Batu Licin, Tanah Bumbu District, South Kalimantan, 72211, Indonesia.

ABSTRACT

Background: Malaria has caused high morbidity and mortality rates and has decreased the productivity of human resources and national development. Malaria is endemic in several districts in South Kalimantan. **Purpose**: This study aims to describe the malaria situation in South Kalimantan by examining the malaria cases, Case Fatality Rate (CFR), Annual Parasite Incidence (API), and Slide Parasite Rate (SPR) in the South Kalimantan Province during the period of 2010–2018. **Method**: This research was a descriptive study with the South Kalimantan population, who were at risk of getting malaria. This study adopted a total participation technique and included all the cases of malaria recorded in the electronic-Surveillance Information System of Malaria (e-SISMAL) data of South Kalimantan province in the period 2010–2018. The study used secondary data from the South Kalimantan Provincial Health Office during 2010–2018. The data included the number of malaria cases, morbidity, and the mortality rate of malaria. The data collected was analyzed using CFR, API, and the SPR formulae. **Results:** The number of malaria cases in South Kalimantan from 2010 to 2018 fluctuated. The highest number of malaria cases occurred in 2011, while a decreasing trend was observed up to 2018. At the same time, the number of deaths during 2012–2018 increased. The death rate from 2010–2018 decreased in South Kalimantan. **Conclusion:** The number of cases as well as deaths caused due to malaria in South Kalimantan continues to decrease. By 2025, all districts in South

Kalimantan could be free from malaria.

ABSTRAK

Latar Belakang: *Malaria menyebabkan angka morbiditas dan mortalitas yang tinggi serta menurunkan produktivitas sumber daya manusia dan pembangunan secara nasional. Kasus malaria masih terjadi di beberapa kabupaten yang ada di Kalimantan Selatan.* ***Tujuan:*** *Penelitian ini bertujuan untuk mendiskripsikan situasi malaria di Kalimantan selatan dengan melihat kasus malaria, Case Fatality Rate (CFR), Annual Parasite Incidence (API) dan Slide Parasite Rate (SPR) di Provinsi Kalimantan Selatan pada rentang waktu 2010 – 2018.* ***Metode:*** *Penelitian ini adalah penelitian deskriptif dengan populasi Kalimantan Selatan yang berisiko menderita malaria. Penelitian ini menggunakan teknik partisipasi total yang melibatkan semua kasus Malaria yang tercatat dalam Data E-Sismal Provinsi Kalimantan Selatan untuk 2010 – 2018. Data yang digunakan adalah data sekunder yang diperoleh dari Dinas Kesehatan Provinsi Kalimantan Selatan pada Tahun 2010 – 2018, yaitu jumlah kasus malaria, morbiditas dan mortalitas akibat malaria. Data dianalisis menggunakan rumus CFR, API dan SPR.* ***Hasil:*** *Jumlah kasus malaria di Kalimantan Selatan pada tahun 2010 hingga 2018 berfluktuasi. Jumlah kasus malaria terbanyak tahun 2011 sementara hingga tahun 2018 cenderung menurun, sedangkan kematian di pada 2012 – 2018 sudah cenderung menurun.* ***Kesimpulan:*** *Malaria di Kalimantan Selatan terus mengalami penurunan kasus dan kematian, sehingga target tahun 2025 yaitu semua kabupaten di Provinsi Kalimantan Selatan bebas malaria bisa tercapai.*
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INTRODUCTION

Malaria is an infectious disease and has become a public health concern in Indonesia. It has caused high morbidity and mortality rates and has decreased the productivity of human resources (Lukwa, Mawoyo, Zablon, Siya, & Alaba, 2019) and national development (Degarege, Fennie, Degarege, Chennupati, & Madhivanan, 2019; Nonvignon et al., 2016). To overcome the malaria problem, a global commitment was made to eliminate malaria in all countries during the 60th World Health Assembly (WHA) in 2007 (World Health Organization, 2019).

Based on data obtained from the WHO, (2019), the number of malaria cases in the world was 228 million in 2018. The number of deaths was 405,000. Malaria caused losses of up to 2.70 billion dollars. The malaria control program in Indonesia began intensively during 1952–1959. On November 12, 1959, President Soekarno, the first president of the Republic of Indonesia, launched the start of a malaria eradication program known as the Malaria Eradication Operation Command (Kopem). The date of the Kopem declaration (November 12) was subsequently enshrined as the national health day (Ebisawa & Fukuyama, 1975).

Malaria control efforts undertaken by the Indonesian government include issuing a Ministry of Health Decree No. 293/MENKES/SK/IV/2009, with the target of malaria elimination in all regions of Indonesia, which is expected to be achieved by 2030. The program of free malaria in 2010 targeted DKI Jakarta, Bali, Batam Island, Rempang Island, Galang Island, Bintan Island, and Karimun Island (Barelang Bingkar). In 2015, the targeted areas were Java, Nanggroe Aceh Darussalam (NAD), and Riau Islands. In 2020, the areas targeted to be free from malaria were the islands of Sumatra, West Nusa Tenggara (NTB), Kalimantan, and Sulawesi. The final target for malaria eradication in 2030 include the following

areas: West Papua, Maluku, East Nusa Tenggara (NTT), and North Maluku (Ministry of Health RI, 2009). Malaria in South Kalimantan, until 2018, had been reducing, both in terms of the number of cases and deaths. The number of malaria cases in 2010 was 5,161, with an Annual Parasite Incidence (API) of 1.15, while in 2018, the number dropped to 844 cases, with an API of 0.21. Efforts to reduce cases were carried out by providing mass campaign mosquito nets, mapping the migrant population, increasing the malaria management capacity in hospitals, investigating the epidemiology in malaria endemic areas, performing mass blood surveys, and conducting malaria cadre training (South Kalimantan Provincial Health Office, 2019).

In 2016, the number of districts that eliminated malaria reached 247 from the target of 245. Later, in 2017, the number of districts that were free from malaria reached 266 from the target of 265. In 2019, the government targeted to have 300 districts free from malaria. By 2020, the government targeted no more malaria-endemic areas. In 2025, all regencies are expected to reach this elimination target. In 2027, all provinces are expected to reach the target. For the final target, in 2030, Indonesia is expected to completely eliminate malaria (Sitohang et al., 2018). Kalimantan, especially the South Kalimantan province, targeted in 2020 to eliminate all of the province's high endemicity areas. Therefore, further acceleration efforts are required to achieve malaria elimination in the South Kalimantan province (South Kalimantan Provincial Health Office, 2019).

Acceleration of elimination strategies can be done in high malaria endemic areas by intensifying elimination strategies in areas that have a case focus (moderate endemic areas) and eliminating malaria in areas with low endemic levels. However, in areas that are malaria free, maintenance can be performed with the aim of preventing the emergence of malaria transmission (Sitohang et al., 2018). Measures for malaria elimination can be taken by distributing mass insecticide mosquito nets, by selectively distributing these nets to the high-risk populations (Self, 2016), by establishing diagnostic standards using a microscope, by examining the proportion of positive malaria cases treated according to program standards, by conducting epidemiological surveillance periodically, and by Indoor Residual Spraying (IRS) in areas with resting mosquito behavior in the house (Benelli & Beier, 2017).

Based on this background, it is crucial to analyze the malaria situation to help formulate a strategic action plan and thereby achieve malaria elimination in the South Kalimantan Province. This study aims to describe the malaria situation in South Kalimantan by investigating the malaria cases, Case Fatality Rate (CFR), API, and the Slide Parasite Rate (SPR) in the South Kalimantan province in the period 2010–2018.

METHODS

This research employed a descriptive approach to describe the number of cases, CFR, API, and the SPR in South Kalimantan during 2010–2018. This study accounted for the entire population of South Kalimantan that was positively infected by malaria during 2010–2018. It employed a total population technique, including all malaria cases recorded in the electronic-Surveillance Information System of Malaria (e-SISMAL) application during 2010–2018. Data on malaria cases was obtained from secondary data, retrieved from all districts in South Kalimantan during 2010–2018. The variables analyzed were as follows: malaria cases that were diagnosed only on the basis of clinical symptoms and signs; confirmed cases were suspected patients, whose diagnoses was confirmed by microscopic examination; and deaths were malaria patients who succumbed to death. The data was then analyzed using CFR, API and the SPR formulae as follows:

$$API = \frac{Confirmed\ cases\ during\ one\ year}{Population\ under\ surveilance} \times 1000‰$$

$$CFR = \frac{The\ number\ of\ positive\ malaria\ cases}{Total\ population} \times 100\%$$

$$SPR = \frac{Slides\ confirmed\ as\ positive\ for\ malaria}{Total\ slides\ examined} \times 100\%$$

The data was then analyzed descriptively and presented in tables and graphs. Research activities included the processing of library materials to prepare research reports (conducted from March to June 2020). This research has received ethical approval from the Research And Community Service Institute, Muhammad Arsyad Al Banjari Islamic University, with the certificate number 291/ UNISKA-LPPM/VII /2020.

RESULTS

The number of malaria cases in South Kalimantan decreased from 2010 to 2018. The exception was 2011, when the cases rose significantly to 10,124 compared to 5,161 in 2010. The decrease in cases from 9,041 to 828 occurred from 2012 to 2018 (Figure 1). The suspected cases identified tended to fluctuate. The highest number of cases in 2011 was 29,847, while the lowest number was in 2016: 8,441 cases (Figure 1).

The highest mortality of malaria in South Kalimantan was noticed in 2010, with 37 deaths and a CFR of 0.05; the lowest mortality was noticed in 2018, with the death of one person and a CFR of 0.12, however, the highest CFR data was observed in 2017, with the value of 0.24 (Figure 2).

Plasmodium types found in South Kalimantan were diverse: *p. falciparum, p. vivax*, and *p. malariae*, but the dominant species was *p. vivax* (Figure 3). The highest number of positive slide confirmations of *p. vivax* and *p. falciparum* were identified in 2011, with the number of positive slides obtained as 4,779 and 3,572, respectively. The lowest was in 2018, with 349 and 300 slides, respectively. With p. malariae, the highest number of slide confirmations was noticed in 2015, with 82. The lowest was observed in 2010, with 3 slides. The highest API in South Kalimantan was recorded in 2011 at 2.80‰, while the lowest was recorded in 2018 at 0.21‰. The highest SPR data was recorded in 2011 at 2.80%, while the lowest was recorded in 2018 at 0.21% (Figure 4).

Malaria stratification in South Kalimantan revealed an increasing trend. In 2010, there were no districts that were free from malaria. The highest number of APIs was in Kotabaru, which was followed by Tabalong, Tanah Bumbu, and the Tanah Laut districts. In 2018, all districts showed low API scores, and there were six districts that received the malaria-free area certification: Hulu Sungai Utara, Hulu Sungai Selatan, Barito Kuala, Tapin, Banjarmasin city, and Banjarbaru (Figure 5).
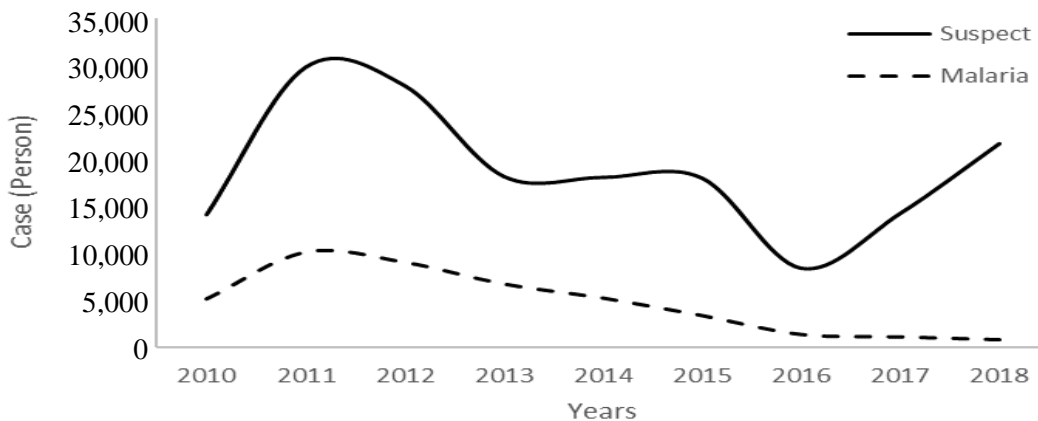

Figure 1. The Graph of Suspected and Confirmed Malaria Cases from 2010 to 2018 in South Kalimantan
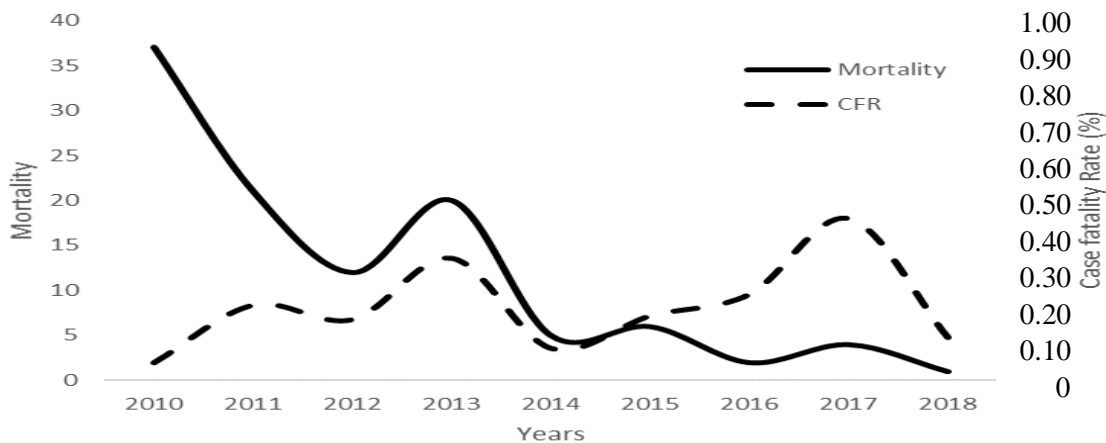

Figure 2. The Graphs of Number of Deaths and CFR of Malaria for 2010–2018 in South Kalimantan
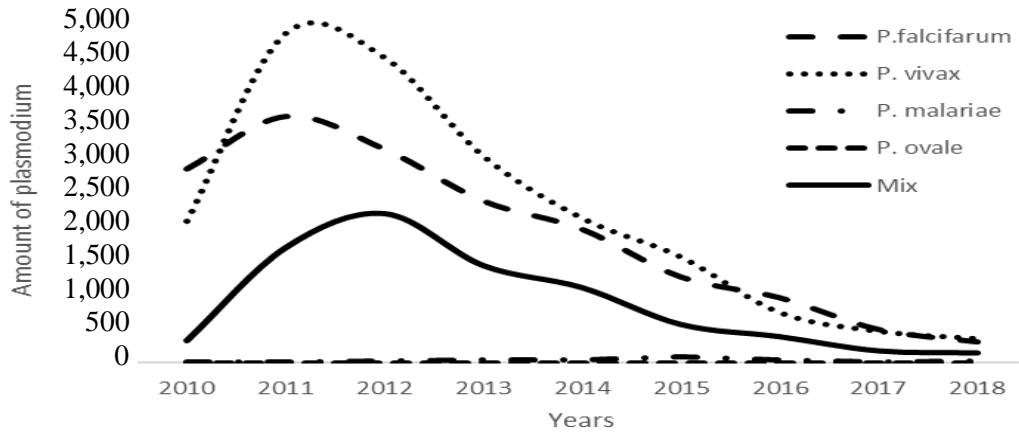
Figure 3. The Graphs of Plasmodium species found during 2010–2018 in South Kalimantan
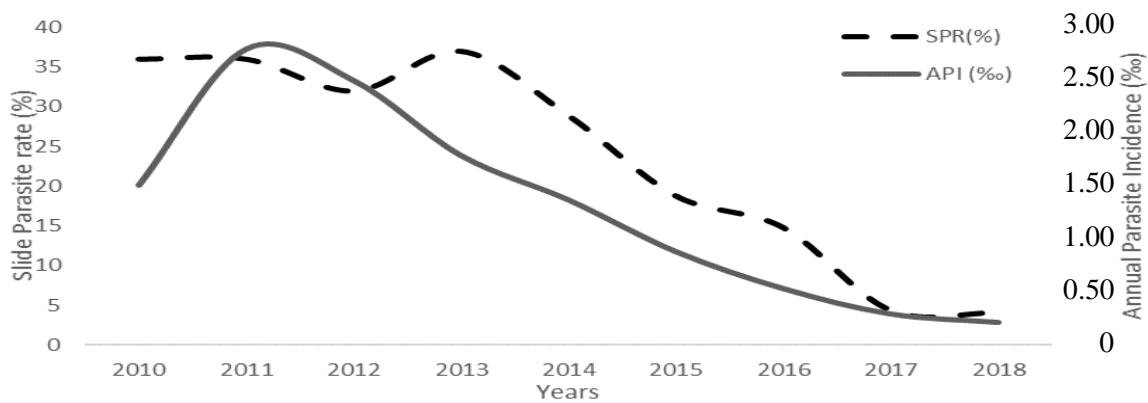

Figure 4. The Graphs of SPR (%) and API (‰) of Malaria during 2010–2018 in South Kalimantan
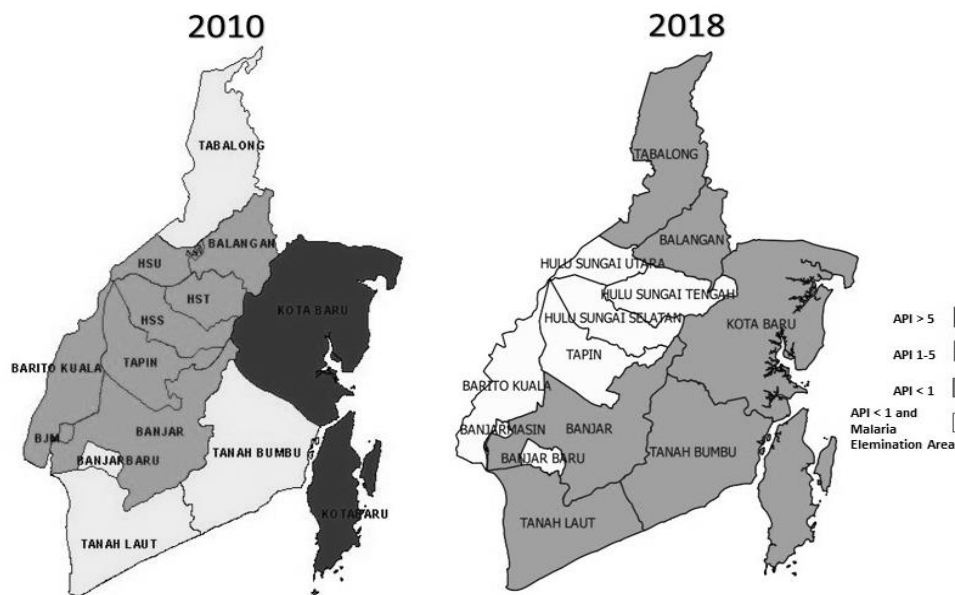

Figure 5. Malaria Stratification on the Basis of API and Malaria Elimination Areas in 2010 and 2018 in South Kalimantan

DISCUSSION

Malaria is one of the infectious diseases and still remains an important issue in Indonesia, especially in eastern Indonesia. Thus, there must be efforts made to reduce malaria cases. WHO has set one of the indicators for pre-eliminating malaria: the API should be less than one per 1,000 inhabitants (Jontari et al., 2016). In the year 2020, the following regions were targeted to make them

free from malaria: Sumatra, West Nusa Tenggara (NTB), Kalimantan and Sulawesi (Ministry of Health RI, 2009; Ompusunggu, 2015).

The number of malaria cases in South Kalimantan revealed a declining trend from 2011 to 2018. The death rate from malaria in South Kalimantan also showed a declining trend. This indicated that the malaria control program in South Kalimantan was being implemented successfully and that the implementation of malaria control programs in South Kalimantan [especially in the South Hulu Sungai (HSS) district and in the city of Banjarbaru] was being implemented successfully and was being received well by managers and service providers (Rogayah, Mahendradhata, & Padmawati, 2015).

Several research results have revealed the relationship of various risk factors that influence the incidence of malaria in South Kalimantan. Workers in forests, mostly illegal gold miners, are at a greater risk of contracting malaria in forests. Thus, control efforts to eliminate malaria can focus more on people who have jobs that place them at risk of contracting malaria, e.g., forest loggers, who often venture out at night from their homes (Maharso, Noraida, & Aulia, 2017).

The lower incidence of malaria in South Kalimantan was also influenced by factors of community knowledge and improvement in people's behavior. This can be observed through the behavior survey that was conducted in malaria endemic areas in South Kalimantan. The people there showed knowledge about malaria and were included in the good category. Similarly, the behavior of usage of mosquito nets was also included in the good category. The behavior of staying out at night was reduced and was included in the good category (Rahayu, Meliyanie, & Kusumaningtyas, 2019).

Breeding places also affect the incidence of malaria. A research conducted by Dlamini, Franke, & Vounatsou (2015) revealed that the main determinant of malaria incidence in endemic areas was breeding places. Many human activities provide breeding grounds that are suitable for the growth of malaria vectors, e.g., puddles, gutters, basins filled with rainwater, and rice fields with irrigation water. Another research conducted in malaria endemic areas in South Kalimantan revealed that as many as 55.12% of the residents' homes were situated near breeding places for mosquitoes (Rahayu, Meliyanie, & Kusumaningtyas, 2019).

SPR in South Kalimantan indicated a declining trend, from 2.80% (2011) to 0.21%

(2018). Diversity of SPR was due to work factors. Forest loggers were five times more likely to contract malaria than non-loggers (Ompusunggu, 2015). Other factors that can affect SPR are the length of stay in the forest, sleeping behavior in the forest, and vector behavior as noticed in Vietnam (Son et al., 2017).

P. vivax is a species that is commonly found in South Kalimantan (Figure 3). This is consistent with research conducted by Ompusunggu in 2013, which suggests that *p. vivax* dominates malaria incidence in the Tanah Bumbu district. The dominance of *p. vivax* in three villages indicated that the possibility of radical malaria treatment was not proceeding well, so long-term relapses, which are the hallmark of *p. vivax*, still occur. Long-term recurrence of *p. vivax* caused by dormant stages in the liver can occur repeatedly if not treated completely with primaquine for 14 days (Ompusunggu, 2015). The dominance of p. vivax, as found in several villages in South Kalimantan, was similar to that reported from Peru, which also faced difficulties in eradicating this parasite (Rosas-Aguirre et al., 2016).

This study also revealed a high incidence of *p. falciparum* in South Kalimantan. The dominance of p. falciparum indicated that most malaria cases are infections that resulted only from local transmission, so care must be taken in this regard so as to not lead to any outbreak (Griffin et al., 2016). Other factors, such as the presence of antibodies to blood-stage antigen, *p. falciparum*, play an important role in strengthening human immunity against malaria. During the development of *p. falciparum* in the blood, many proteins play a role, from intracellular parasites to the surface of erythrocytes infected with *p. falciparum* (Chan et al., 2016). The dominance of *p. falciparum* revealed that most malaria cases are infections that result only from local transmission, so care must be taken in this regard so as to not lead to any outbreaks (Ompusunggu, 2015).

The API in South Kalimantan in 2018 indicated a low API score (<1‰) in all regions. In fact, six districts received certifications of being malaria-free areas. This means that South Kalimantan has reached its pre-elimination target in accordance with WHO requirements: the API is to be less than one for a population of 1,000 (World Health Organization, 2019). This proves that the malaria control program in South Kalimantan has been a successful one and has effectively reduced the malaria cases from 2012 to 2018.

Some efforts are needed to be taken to maintain or even improve what has been achieved through malaria pre-elimination programs in South Kalimantan. Increasing community knowledge is important. This needs to be done with the hope that the community behavior to prevent malaria can be improved. Providing education to people who work as loggers in forests is also crucial. At the minimum, the loggers can wear long clothes, use repellents (mosquito repellents), and use mosquito nets to avoid mosquito bites if they have to stay overnight in the forest. In malaria endemic areas, the practice of venturing out at night must be reduced unless there is a need to do so (Stoney et al., 2016).

Communities and related organizations, especially in endemic areas, must be active in preventing a malaria outbreak. They must put efforts to prevent and eradicate malaria, such as cleaning breeding places (Barry et al., 2020). Continued research in mapping the malaria risk factors must be carried out as a form of evaluation effort from programs that have been conducted in South Kalimantan.

Research Limitation

This research adopted a descriptive approach, which was being used by the community in South Kalimantan. Therefore, this study could not account for the difference in values between certain variables.

CONCLUSION

Malaria cases in South Kalimantan have decreased. South Kalimantan has fulfilled WHO's pre-elimination objective of eradicating malaria. There is a need for ongoing control efforts, with support rendered by the community, to improve community behavior to reduce the potential for transmitting malaria.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTION

MRR and K were the main contributors. They conceptualized the idea, performed data analysis, and worked on the methods, introduction, and discussion sections of this article. EL prepared the data and analyzed the e-SISMAL application. LI helped in writing it in English and corrected the grammar.

REFERENCES

Barry, N., Toé, P., Pare Toe, L., Lezaun, J., Drabo, M., Dabiré, R. K., & Diabate, A. (2020). Motivations and expectations driving community participation in entomological research projects: Target Malaria as a case study in Bana, Western Burkina Faso. *Malaria Journal, 19*(1), 199. https://doi.org/10.1186/s12936-020-03277-7

Benelli, G., & Beier, J. C. (2017). Current vector control challenges in the fight against malaria. *Acta Tropica, 174*, 91–96. https://doi.org/10.1016/j.actatropica.2017.06.028

Chan, J. A., Howell, K. B., Langer, C., Maier, A. G., Hasang, W., Rogerson, S. J., … Beeson, J. G. (2016). A single point in protein trafficking by Plasmodium falciparum determines the expression of major antigens on the surface of infected erythrocytes targeted by human antibodies. *Cellular and Molecular Life Sciences, 73*(21), 4141–4158. https://doi.org/10.1007/s00018-016-2267-1

Degarege, A., Fennie, K., Degarege, D., Chennupati, S., & Madhivanan, P. (2019). Improving socioeconomic status may reduce the burden of malaria in sub Saharan Africa: a systematic review and meta-analysis. *PLoS ONE, 14*(1), 1–26. https://doi.org/10.1371/journal.pone.0211205

Dlamini, S. N., Franke, J., & Vounatsou, P. (2015). Assessing the relationship between environmental factors and malaria vector breeding sites in Swaziland using multi-scale remotely sensed data. *Geospatial Health, 10*(1), 88–98. https://doi.org/10.4081/gh.2015.302

Ebisawa, I., & Fukuyama, T. (1975). Chloroquine resistance of plasmodium falciparum in West Irian and East Kalimantan. *Annals of Tropical Medicine & Parasitology, 69*(3), 275–282. https://doi.org/10.1080/00034983.1975.11687011

Griffin, J. T., Bhatt, S., Sinka, M. E., Gething, P. W., Lynch, M., Patouillard, E., … Ghani, A. C. (2016). Potential for reduction of burden and local elimination of malaria by reducing plasmodium falciparum malaria transmission: a mathematical modelling study. *The Lancet Infectious Diseases, 16*(4), 465–472. https://doi.org/10.1016/S1473-3099(15)00423-5

Jontari, H., Kusnanto, H., Supargiyono, S., Hamim, S. A., Satyagraha, A. W., Novijanti, N., ... & Hananta, L. (2016). Malaria pre-elimination assessment in Eastern Indonesia. *Outbreak, Surveillance and Investigation Reports, 9*(1), 1–7.

Lukwa, A. T., Mawoyo, R., Zablon, K. N., Siya, A., & Alaba, O. (2019). Effect of malaria on productivity in a workplace: The case of a banana plantation in Zimbabwe. *Malaria Journal, 18*(1), 1–8. https://doi.org/10.1186/s12936-019-3021-6

Maharso, Noraida, & Aulia, J. (2017). Perbedaan risiko lingkungan pekerjaan di kawasan hutan terhadap kejadian malaria diantara pasien Puskesmas Binuang. *Jurnal Kesehatan Lingkungan, 14*(2), 467–474.

Ministry of Health RI. (2009). *Ministry of Health RI decree number 293/MENKES/SK/IV/2009 about malaria elimination in Indonesia*. Jakarta: Ministry of Health RI.

Nonvignon, J., Aryeetey, G. C., Malm, K. L., Agyemang, S. A., Aubyn, V. N. A., Peprah, N. Y., … Aikins, M. (2016). Economic burden of malaria on businesses in Ghana: a case for private sector investment in malaria control. *Malaria Journal, 15*(1), 1–10. https://doi.org/10.1186/s12936-016-1506-0

Ompusunggu, S. (2015). Forest malaria in Central Kalimantan and South Kalimantan Province, Indonesia in 2013. *Jurnal Ekologi Kesehatan, 14*(2), 145–156.

Rahayu, N., Meliyanie, G., & Kusumaningtyas, H. (2019). Knowledge, attitude, and behavior of forest workers towards malaria in Miing Village, Tanah Bumbu District. *Journal of Health Epidemiology and Communicable Diseases, 5*(2), 54–61. https://doi.org/10.22435/jhecds.v5i2.2347

Rogayah, H., Mahendradhata, Y., & Padmawati, R. S. (2015). Evaluation of integrated malaria control program, maternal health care and routine immunization programs in Hulu Sungai Selatan and Banjarbaru City, in Kalimantan Selatan Province. *Jurnal Kebijakan Kesehatan Indonesia, 4*(1), 26–31.

Rosas-Aguirre, A., Gamboa, D., Manrique, P., Conn, J. E., Moreno, M., Lescano, A. G., … Vinetz, J. M. (2016). Epidemiology of plasmodium vivax malaria in Peru. *American Journal of Tropical Medicine and Hygiene, 95*(Suppl 6), 133–144. https://doi.org/10.4269/ajtmh.16-0268

Self, L. (2016). Perspective piece controlling malaria in western pacific with mosquito nets treated with pyrethroids in village communities, 1979-1999. *American Journal of Tropical Medicine and Hygiene, 95*(1), 10–14. https://doi.org/10.4269/ajtmh.15-0817

Sitohang, V., Sariwati, E., Fajariyani, S. B., Hwang, D., Kurnia, B., Hapsari, R. K., … Hawley, W. A. (2018). Malaria elimination in Indonesia: halfway there. *The Lancet Global Health, 6*(6), 604–606. https://doi.org/10.1016/S2214-109X(18)30198-0

Son, D. H., Thuy-Nhien, N., Von Seidlein, L., Le Phuc-Nhi, T., Phu, N. T., Tuyen, N. T. K., … Hien, T. T. (2017). The prevalence, incidence and prevention of Plasmodium falciparum infections in forest rangers in Bu Gia Map National Park, Binh Phuoc province, Vietnam: a pilot study NCT02788864 NCT. *Malaria Journal, 16*(1), 1–10. https://doi.org/10.1186/s12936-017-2091-6

South Kalimantan Provincial Health Office. (2019). *Monitoring and evaluation of malaria in South Kalimantan Province 2019*. Banjarmasin: South Kalimantan Provincial Health Office.

Stoney, R. J., Chen, L. H., Jentes, E. S., Wilson, M. E., Han, P. V, Benoit, C. M., … Barnett, E. D. (2016). Malaria prevention strategies: adherence among Boston area travelers visiting malaria-endemic countries. American *Journal of Tropical Medicine and Hygiene, 94*(1), 136–142. https://doi.org/10.4269/ajtmh.15-0565

World Health Organization. (2019). *World malaria report 2019*. Africa: WHO Regional Office for Africa. Retrieved March 24, 2020, from https://www.who.int/news-room/fact-sheets/detail/malaria