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Malaria Vector Control in the Electronic Malaria Surveillance Information System (E-SISMAL)

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Abstract

In the Lahat District of South Sumatra Province, which has not yet been certified for malaria elimination, the 2019 Electronic Malaria Surveillance Information System (E-SISMAL) data revealed significant shortcomings in malaria vector control. Despite identifying six indigenous malaria cases, there were no recorded efforts towards vector control. This study used a qualitative approach, employing the Context, Input, Process, and Product (CIPP) model to evaluate the effectiveness of malaria vector control strategies using retrospective E-SISMAL data.

Seventeen informants were selected through purposive sampling, and data collection involved Focus Group Discussions (FGDs), in-depth interviews, participatory observation, and photovoice. Researchers validated the data using triangulation of methods and sources and performed the analysis using NVivo 12 Plus software.

The findings indicated significant challenges, notably in human resources with 30 coding references, additional responsibilities of program managers with 23 references, and issues with utilising Operational Health Assistance (BOK) funds cited 22 times. These factors significantly hindered the Vector Control Program (VCP), which was not running optimally. E-SISMAL reports were limited to case and logistics details, suggesting that the system had not effectively controlled malaria vectors or reported them, highlighting the need for improved strategies and resource management to enhance malaria control in the district.

Keywords: Malaria Surveillance Systems; Vector Control; Qualitative Research; Data Triangulation; Health Resources Management.

Introduction

Heads of Government from the Asia Pacific have committed to achieving a malaria-free area by 2030. In 2015, the

number of confirmed cases reported to the World Health Organization by 22 Asia-Pacific countries was 2,461,025 [1]. But globally, in 2019, there were an estimated 229 million malaria cases in 87 malaria-endemic countries [2]. Malaria killed 67% of children under five. From 2000 to 2019, malaria-related mortality fell steadily from 736,000 to 409,000 [3]. Annual Parasite Incidence (API) illustrates the concentration of malaria-endemic regions and cities in Eastern Indonesia. One hundred sixty districts and cities (31%) are low endemic, with 52.4 million people (19.6%) living in this environment, and 31 regencies and cities (6%), with 4.4 million Indonesians (1.7%), are moderately endemic (API 1-5 per 1,000). High-endemic locations (API greater than 5 per 1,000) include 23 regencies and cities (4%), and 2.9 million people (1.1%). In 2021, 345 districts/cities will eliminate malaria to achieve Malaria-Free Indonesia in 2030, and to meet this goal, malaria prevention must be intensified and integrated [4]. The WHO recommends accelerating malaria elimination in Sumatra, Indonesia, including effective surveillance and ensuring the system's completeness (E-SISMAL). Epidemiological surveillance of malaria cases is an effective method of eliminating malaria. Thus, it is necessary to evaluate and gain user acceptance for surveillance tools to inform malaria elimination efforts [5]. Malaria can cause various social, economic, and national security problems [6]. The Electronic Malaria Surveillance Information System (E-SISMAL) is an electronic reporting system that calculates detailed and recapitulates data using an integrated malaria reporting format [7]. Vector control encompasses all operations and actions to reduce vector populations to a level where they are no longer at risk of vector-borne disease transmission in an area or to minimise public contact with vectors to prevent transmission [8]. In E-SISMAL, malaria vector control efforts include the distribution of insecticide-treated bed nets, Indoor Residual Spraying (IRS), breeding site control, larvicide, biological control, and environmental management. Lahat District is 1 of 9 districts in South Sumatra Province with low endemic status and is the target of the malaria elimination program [9].

Malaria is still a public health concern throughout Indonesia, including South Sumatra[10][11][12]. The 2020 E-SISMAL data in the Lahat District shows a decrease in API for the last three years of 1.29, followed by a decline in 401 cases. However, this is still a concern for the government because there were six indigenous malaria cases without reporting malaria vector control in 2019. The situation was hampering the Lahat District Malaria Elimination certification by WHO in 2020. One of the evaluation models used is CIPP (Context, Input, Process, Product). The uniqueness of this model is that each evaluation is related to a decision-making tool concerning the planning and operation of a program [13]. Based on the background above, a CIPP evaluation model related to Malaria Vector Control in the Electronic Malaria Surveillance Information System (E-SISMAL) is needed. The research problem formulation is how to evaluate malaria vector control in an Electronic Malaria Surveillance Information System (E-SISMAL).

Method

This qualitative study uses the Stufflebeam theory to evaluate malaria vector control in the Lahat District[14]. This study was carried out at seven Community Health Centers within the Lahat District Health Office, selected based on having indigenous cases and an Annual Parasite Incidence (API) exceeding two in 2019. The research spanned five months, from March to August 2021. Seventeen informants were purposively selected, including the heads of Bandar Jaya, Senabing, Selawi, Pagar Gunung Bunga Mas, Merapi II, and Nanjungan Community Health Centers, the manager of the

malaria program, the head of the section for disease control and prevention of communicable diseases, and the director of the Lahat District Health Office. The research variables consisted of context, input, processes, and products, with context variables including purpose, vision, and mission sub-variables. Context, input, process, and product variables were further categorised. Input variables included human resources (H.R.), budget, and infrastructure, while the process variable encompassed supporting data collection, increasing advocacy to the government and stakeholders, and fostering cross-program and cross-sector partnerships.

The product variable focused on the coverage of malaria vector control in E-SISMAL. Data collection methods included Focus Group Discussions (FGDs), in-depth interviews, participatory observation, and photovoice, with data validation through source and method triangulation tests. Nvivo 12 Plus for Windows was used to analyse data during the reduction, display, and conclusion/verification stages. Context variables encompassed goal, vision, and mission sub-variables. Input variables included H.R., budget, and infrastructure sub-variables. The process variable involved supporting data collection, increasing advocacy, and raising partnerships. The product variable focused on malaria vector control coverage. Data reduction involved transcribing data in Microsoft Word, capturing informant details like name, age, gender, education, and tenure, and recording interview results, FGDs, observations, and photovoice. The transcribed data served as input for analysis in Nvivo Plus for Windows, where researchers classified sentences into themes based on the research variables and sub-variables using existing queries in the application. The study highlighted the most discussed and emphasised factors related to each research variable. The results were presented as flowcharts for each variable and its narrative, comparing the highest reference value of each research variable to identify the dominant factors affecting them.

Results

Context

From the results of FGDs and in-depth interviews, information on context variables from informants was obtained as follows:

> *"We are eliminating malaria by implementing a mosquito net program that prevents the occurrence of numerous malaria cases." (Head of Community Health Centre, Bandar Jaya)*
>
> *"Efforts to control malaria vectors are made, including the distribution of malaria-specific mosquito nets." (Head of Prevention and Control of Communicable Diseases, Lahat District Health Office)*

The context variable comprises three sub-variables and fourteen factors: purpose, vision, and mission. The element with the highest reference value in the mission sub-variable is eliminating malaria with insecticide-treated nets (5 coding references); in the objective sub-variable, the highest reference value is reducing malaria cases (4 coding references), and in the vision sub-variable, the highest reference value is undocumented malaria vector control in the district (3 coding

references). Figure 1 depicts the factors that have the most significant influence on the input variables.

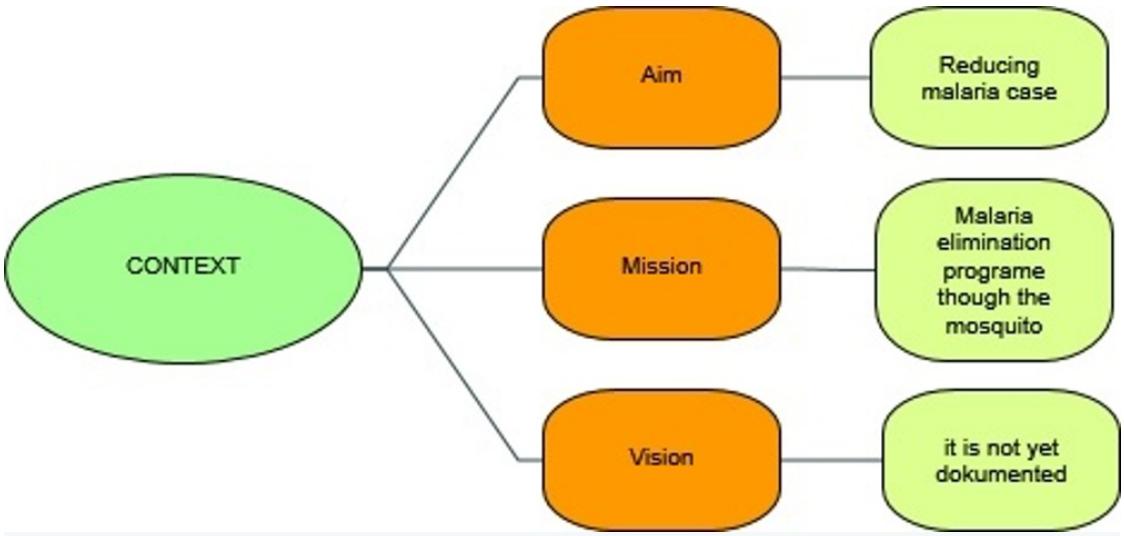

Figure 1. Dominant factors in the context variable

Input

From the results of FGDs and in-depth interviews, the input variables obtained information from informants as follows:

> *"We do not yet have special vector control officers; we only have empowered ones, such as nurses or midwives." (Head of Community Health Centre Bandar Jaya)*
>
> *"There is no dedicated officer tasked with eliminating malaria vectors. The number of health workers at the Community Health Centre is approximately twenty. With up to forty additional programs at the Community Health Centre, we maximise the use of existing health workers." (The head of the section for disease control and prevention of infectious diseases of Lahat District health office).*

The input variables comprised three sub-variables and 24 factors: human resources, budget, and infrastructure. Factors with the highest reference values were limited human resources (30 coding references), utilisation of operational health assistance (BOK) funding support (23 coding references), main tasks (22 coding references), and E-SISMAL equipment (17 coding references). Figure 2 presents the dominant factors influencing the input variables.

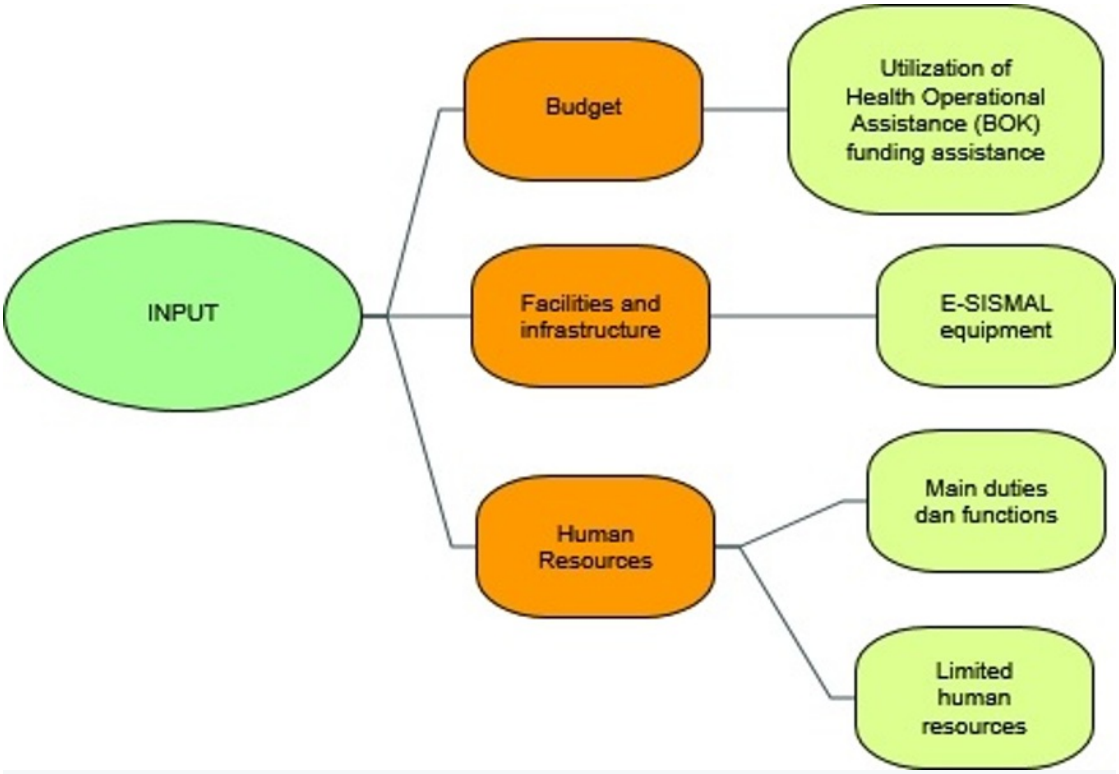

Figure 2. Dominant factors in the input variables

Process

From the results of the FGDs and in-depth interviews of the variable process, information was obtained from informants as follows:

> *"With the village head and health officers' cooperation in explaining health programs, the community participates in carrying out all village head's instructions." (Head of Community Health Centre Senabing)*
>
> *"We hold cross-sectoral and cross-program meetings in areas with high malaria cases." (Head of Community Health Centre Bandar Jaya)*

The process variable comprises three sub-variables and 23 factors: collecting supporting data, raising cross-program and cross-sector partnerships, and increasing advocacy to the government and stakeholders. Factors with the highest reference values are village meetings (7 coding references), cross-sector meetings (7 coding references), other cross-sector collaborations (6 coding references), and reports (5 coding references). Figure 3 presents the dominant factors influencing the process variable.

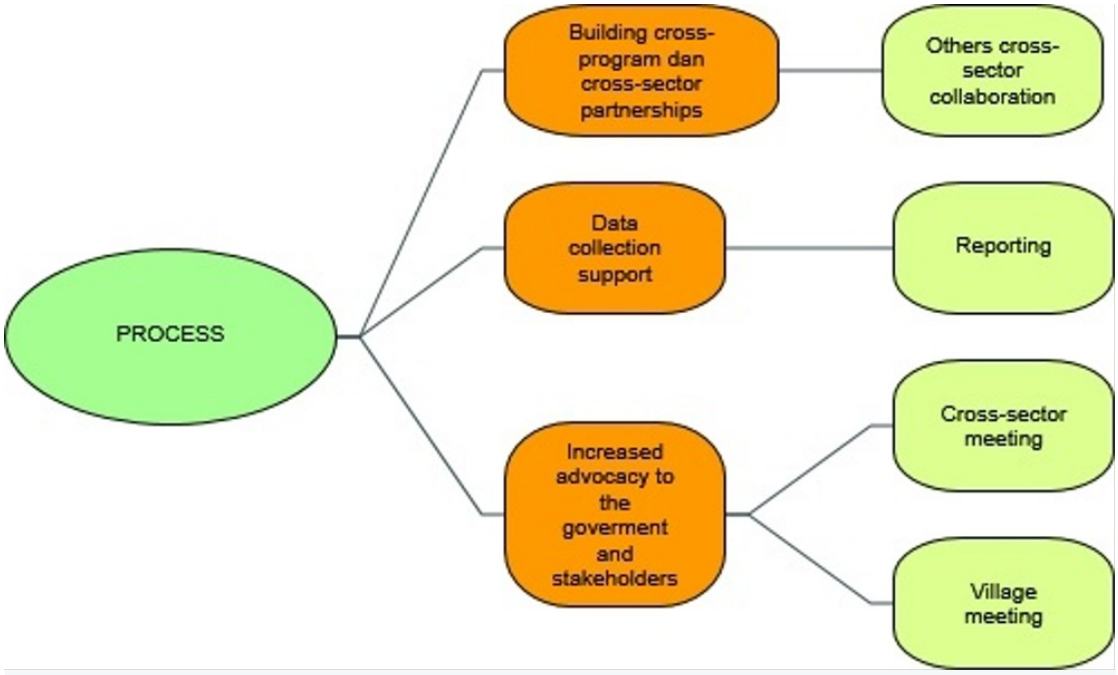

Figure 3. Dominant factors in the process variable

Product

From the results of FGDs and in-depth interviews, the product variable obtained information from informants as follows:

> *"E-SISMAL data is advantageous for planning health programs, particularly those involving malaria." (Head of Community Health Centre, Selawi).*
>
> *"Overall, an analysis of E-SISMAL data has been carried out, but specifically for vector and disease control data, no analysis has been carried out regarding the purpose of malaria elimination." (Lahat District Health Office, Malaria Program Manager).*

The product variable consisted of one sub-variable and three factors. The sub-variable indicated the extent to which malaria vector control was implemented at E-SISMAL in Lahat District. The most critical issue identified was the necessity of malaria vector control (5 coding references count). Figure 4 illustrates the primary factors affecting the product variable. The study of all variables with the most significant reference values revealed three major influencing factors on the Lahat District's malaria vector control program (VCP). These factors were part of the input variables: limited human resources (30 coding references count), main tasks (22 coding references count), and BOK funding support (23 coding references count).

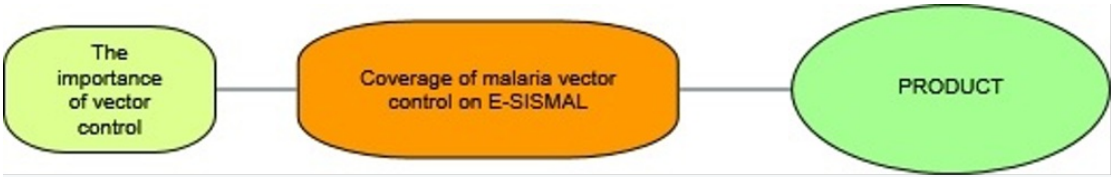

Figure 4. Dominant factors in the variable product

Furthermore, this study analysed all variables—context, input, process, and product—and identified nine dominant factors. In the context variable, the mission sub-variable focused on eliminating malaria with insecticide-treated nets, while in the objective sub-variable, the dominant factor was reducing malaria cases. In the H.R. sub-variable of the input variable, the dominant factors were limited human resources and main tasks and functions. The budget sub-variable of the input variable was primarily influenced by BOK funding support. In the process variable, the dominant factors were village and cross-sectoral meetings and increasing advocacy to the government and stakeholders. Other cross-sector cooperation mainly influenced the cross-program and cross-sector partnership improvement sub-variables. Regarding the product variable sub-variable, which focused on the coverage of malaria vector control in E-SISMAL, the dominant factor was the need for malaria vector control. Limited human resources and financial support from BOK were the factors with the highest reference values (30 and 23 coding references count, respectively), while the decrease in malaria cases had the lowest reference value (4 coding references count). Figure 5 presents the dominant factors in all variables.

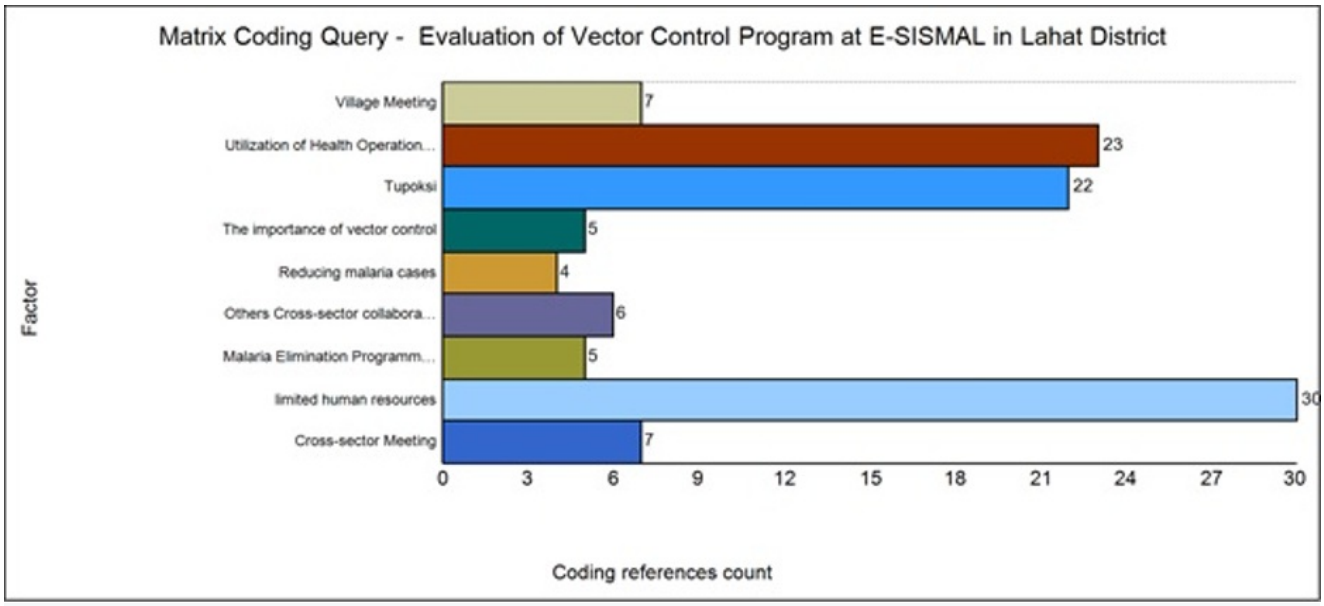

Figure 5. Graph Analysis of the Dominant Factors in All Research Variables

Discussion

Context

The data analysis findings on ten context variables reveal three significant aspects affecting this variable. These aspects include decreasing malaria cases (the objective), documenting unrecorded vision (the vision), and eliminating malaria through the use of insecticide-treated mosquito nets (mission). The informants know that controlling malaria vectors in the Lahat District aims to minimise malaria cases to the point where they can be held. Controlling malaria vectors in the Lahat

District uses an insecticide mosquito net scheme. In mass distribution, long-lasting insecticidal nets (LLINs) protect up to 55% against clinical malaria cases in children [15]. Research shows that insecticide-treated bed nets have been the most effective tool for reducing malaria morbidity and mortality in sub-Saharan Africa from 2004 to 2019 (Lindsay, Thomas, and Kleinschmidt, 2021). Social factors, poor use, and poor conditions of LLINs can make LLINs ineffective[15]. So, the community can monitor mosquito nets' use by Health Service officers [16]. However, the vision of vector control in Lahat is not documented in the malaria program policies at the community health centre and the health office. So, malaria vector control only focuses on using insecticide-treated bed nets without integrating other malaria vector control methods. Mass distribution of insecticide-treated bed nets with six rounds of Indoor Residual Spraying (IRS) can reduce vector and sporozoite density in high-intensity malaria transmission areas in Uganda [17]. Therefore, the malaria program policy in the Lahat District requires a more specific and documented goal and vision for malaria control. This document is essential for planning and selecting integrated malaria vector control activities.

Input

The results of data analysis on 25 factors in the input variable indicate that limited human resources, BOK funding support, main tasks, and equipment of E-SISMAL are the dominant factors affecting the input variable. The lack of entomology and epidemiology personnel at the community health centre occurs in Lahat District. Most malaria program managers have a nurse and health analyst background, and the average number of malaria program managers at the community health centre is one person. All malaria program managers have never participated in malaria vector control training, and only two people have attended E-SISMAL training. The malaria program manager at the community health centre has additional duties, such as treasurers, other health program managers, poly nurses, and the COVID-19 patient care team.

E-SISMAL equipment used by malaria program managers is limited to privately owned equipment, and there is no procurement from the government. Difficult signal conditions and frequent blackouts in the community health centre's operating area provide barriers to accessing and using E-SISMAL, mainly when reporting on malaria vector management. The limited BOK financial support related to malaria vector control is an obstacle for community health centre officers to carry out malaria vector control activities. The activities budgeted from the BOK funds are only in the form of officer travel expenses. In their opinion, the costs received are not following the activities carried out. Malaria surveillance must be supported by professional human resources, adequate funds and facilities, and infrastructure so that officers can process and analyse data properly and utilise the resulting information, so that activities can be carried out optimally, especially in decision-making [18]. Lack of skilled operators, computer availability, and internet access hinder reporting information systems [19]. Diagnostic facilities with good data provide good epidemiological and entomological evidence to determine the achievement of sustainable malaria control and elimination in the target population [20]. Elimination of malaria depends on the officers in the field. Entomologists, field workers, and health system managers are essential in eliminating malaria [21]. So, it is necessary to increase the ability of malaria program managers, provide e-system equipment, and support vector control data as a basis for budgeting for the next vector control activity. Adequate skills and knowledge, access to training, and availability of hardware, including computers, are challenges in using electronic-based reports [22].

Low resources are a significant challenge in malaria-endemic countries [21]. They are besides, using a mobile technology-based participatory mapping approach to geolocating health facility participants for malaria surveillance in low-resource settings. Further research is needed to integrate this with other health data management systems and apply it in a more comprehensive operational context [23].

Process

The data analysis findings on 23 variables in the process indicate that four significant factors are affecting the process. They are village meetings, cross-sectoral meetings (advocacy), other cross-sectoral collaborations, and reports. The meetings held in the villages helped the malaria program manager provide counselling and education to the community and cadres and advocate for village heads directly. So that the community follows all programs, malaria was instructed by the village head. Mini-workshops involving participants from all cross-sectors and related programs enabled cross-sector collaboration. In this activity, malaria program managers' intervention was limited to counselling and collecting data from across sectors and programs. There should be feedback from the community health centre to all participants present on the results of these activities so that they can be followed up immediately on implementing activities that support the meeting results. The malaria program manager sent the E-SISMAL reporting data from the community health centre to the malaria program manager at the Lahat District Health Office.

The report is a monthly report according to the malaria program reporting form in Lahat District regarding cases and logistics without vector control, with a period of once a month. The malaria program manager carries out E-SISMAL data entry in Lahat District. The malaria program manager does not use E-SISMAL as a surveillance tool for reporting malaria programs. Most of the officers have not attended the E-SISMAL training. Timely entomological surveillance is essential in malaria vector control to eliminate malaria [24]. The primary program strategy to strengthen surveillance to support elimination is to introduce electronic surveillance tools and systems to integrate and improve the use of data for decision-making [25]. Coordinated implementation of community-based education with vector control interventions has significantly reduced malaria cases [26]. Routine vector surveillance and epidemiology activities, combined with real-time data reporting, are critical to sustainable reductions in the achievement of malaria elimination [27]. Political commitment is essential in malaria control strategies [28]. So, a strong health system, firm leadership, appropriate incentives, effective surveillance systems, and regional collaboration support malaria elimination [29]. There is a need for policymakers, regulators, and the public regarding new interventions [30]. One of the recent intervention efforts can be evaluated[31].

Product

A paper-based reporting system (manual) is less than optimal due to a lack of transportation, communication, and human capacity [19]. The analysis highlights the critical importance of malaria vector control within the broader context of the product variable, likely referring to the effectiveness or impact of malaria control efforts. The lack of data on malaria vector control at the community health centre is concerning, as it hampers effective budget planning and program evaluation. This suggests a need for improved data collection and analysis practices within E-SISMAL in Lahat District, particularly

regarding malaria vector control. The reference to improving coherence and making the system active voice in another study likely suggests a need for clearer communication and more proactive, engaged management of the malaria control program [32].

Information technology has a critical role in transforming digital surveillance. This technology is a crucial intervention in the fight against malaria [33]. In particular, there needs to be a concerted regional effort to support the inclusion of data on mobile and migrant populations and the private sector and emphasise electronic reporting and data harmonisation across organisations. This situation will provide a more accurate and up-to-date picture of malaria's burden and distribution. It will significantly assist in realising the elimination of malaria in the Asia Pacific by 2030.

In Indonesia, malaria control efforts are generally carried out in two integrated ways: vector control and malaria cases. Malaria control is incomplete if it only focuses on case management without malaria vector control. Activities to increase surveillance coverage and integrate case data, along with other information, visualisation, and data utilisation, can accelerate malaria elimination. Malaria surveillance uses dynamic, interconnected systems requiring rapid data exchange between platforms. The success of malaria prevention, control, and eradication efforts requires an integrated and consistent source of knowledge to empower informed decision-making [34]

Insufficient practical knowledge about insecticide resistance management is the leading cause in determining vector control policies [35]. Encourage strengthening the strategic framework by adopting an integrated vector management strategy (IVM). In addition, initiate a global plan for insecticide resistance management (GPIRM), intensify malaria vector surveillance, and improve DDT data collection and reporting systems. Furthermore, update the indoor residual spraying data collection and reporting tool (IRS) and increase the geographic survey to eliminate malaria in Namibia [36]. Besides, vector control requires knowledge of malaria mosquito resting behaviours [37]. The study's results indicate that the main factors influencing the malaria VCP at E-SISMAL in the Lahat District are limited human resources, main tasks (H.R.), and BOK (budget) funding support on the input variables. So, it's important to integrate various malaria control measures [38].

Limitations and suggestions

To address the limitations of this study, we propose several approaches. Firstly, conducting repeated in-depth interviews would allow us to collect and analyse data at multiple points, capturing changes in stakeholder perspectives and significant project milestones. Secondly, triangulating data, sources, and methods would enhance data validation. Lastly, increasing the number of eligible informants would provide a broader range of perspectives, enriching our research outcomes. These strategies strengthen the study's validity and provide more comprehensive insights into malaria vector control in the Lahat District.

Conclusions

This study evaluated the effectiveness of the malaria vector control program (VCP) in Lahat District using data from the

Electronic Malaria Surveillance Information System (E-SISMAL), identifying significant impediments such as a critical shortage of human resources, additional burdens on program managers, and insufficient funding from Operational Health Assistance (BOK). These factors have significantly hindered effective malaria control and reporting, highlighting a systemic issue within Lahat's public health infrastructure. Recommendations include hiring more specialised staff like entomologists and epidemiologists, enhancing manager training, limiting non-core duties for program managers, and securing additional funding to compensate for the lack of BOK support. These measures are crucial for improving the effectiveness of malaria control in Lahat District and could serve as a model for similar regions facing public health challenges in vector management and disease elimination. Future research should focus on assessing the impact of these interventions on malaria control effectiveness, providing a basis for further public health strategy enhancements.

Statements and Declarations

All authors listed have contributed substantially to the manuscript and qualify for authorship. Each author has participated sufficiently to take public responsibility for appropriate portions of the content.

Ethical approval

The Ethics Committee at the Faculty of Public Health, Sriwijaya University No: 151/UN9.FKM/TU.KKE/2021 approved the study protocol.

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Competing interests

There are no conflicts of interest (COIs) declared by any of the authors.

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