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IMPLEMENTATION OF INSECTICIDE FOR FOGGING AND LARVICIDATION IN DENGUE FEVER CONTROL AND ITS IMPACT ON VECTOR RESISTANCE IN BANJARMASIN CITY: A QUALITATIVE ANALYSIS

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Abstract

Introduction: *Dengue remains a major public health concern in Indonesia, including Banjarmasin. Insecticide-based interventions, such as fogging and larviciding, are key components of dengue vector control. However, improper implementation can lead to insecticide resistance, reducing program effectiveness.* ***Methods:*** *This qualitative study aimed to evaluate the implementation of insecticide use in the dengue control program in Banjarmasin. Data were collected through in-depth interviews, observations, and document reviews at national, provincial, and municipal levels. A total of 60 informants were purposively selected, including stakeholders from the Ministry of Health, provincial and city health offices, pharmaceutical warehouses, community health centers, sub-districts, and urban villages. Data were analyzed using a deductive Input-Process-Output (IPO) model and inductive gap analysis. Triangulation was applied to ensure data validity.* ***Results and Discussion:*** *The study revealed that the absence of national and local insecticide resistance mapping hinders the implementation of insecticide rotation policies. Other challenges include a shortage of trained entomology personnel, limited training, weak intersectoral coordination, and poor dissemination of vector control regulations, particularly regarding fogging procedures. Moreover, unsupervised community-led fogging often deviates from standard operating procedures.* ***Conclusion:*** *Strengthening human resource capacity, improving insecticide distribution planning based on resistance data, and enhancing regulatory enforcement are critical to improving program effectiveness. Promoting community-based approaches is also essential to support sustainable and responsive dengue vector control strategies.*

INTRODUCTION

The use of insecticides in dengue control programs, such as fogging and larviciding, has a significant impact on *Aedes aegypti* mosquito vector control. Fogging aims to kill adult mosquitoes, is effective in the short term but often only temporarily reduces populations, without addressing the full mosquito breeding cycle (1-2). Larviciding targets the pre-adult stage, which can inhibit vector development if done consistently (3). Fogging and larviciding have environmental health impacts. Fogging using pyrethroid or organophosphate-based insecticides can pollute the air, disrupt ecosystems by killing non-target insects, and trigger mosquito resistance if used repeatedly. In addition, long-term exposure to humans

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can cause respiratory irritation, neurological disorders, and other toxic effects (4). Meanwhile, larvicides applied in water run the risk of polluting aquatic ecosystems, killing non-target organisms, and may also induce resistance in mosquito larvae (5-6). Therefore, the use of chemical insecticides is a last resort and limited to avoid negative impacts. Prioritizing environmentally-based control strategies, community education, and integration of alternative approaches such as natural biolarvicides are important to increase program success.

Dengue hemorrhagic fever (DHF) is one of the tropical diseases that continues to increase globally, with approximately 390 million cases annually in the world according to WHO, of which 96 million show clinical symptoms (5-6). In Indonesia, the number of DHF cases continues to fluctuate, with more than 120,000 cases reported in 2022 and a mortality rate of 0.96%, still above the WHO target of a DHF case fatality rate (CFR) below 1% (7). In Banjarmasin City, DHF remains a major health problem, with an incidence rate (IR) of 5.79 per 100,000 population in 2019 to 12.10 in 2023, and a case fatality rate (CFR) of 2.4 in 2019 to 6.8 in 2023. WHO targets to reduce the incidence of DHF by 25% and CFR by 50% by 2030, in line with the Indonesian Ministry of Health's target to reduce DHF cases below 10 cases per 100,000 population (6). This effort requires strengthening environment-based vector control programs, increasing the role of the community in mosquito nest eradication (PSN), and technological support in disease surveillance and control.

The implementation of the Input-Process-Output (IPO) model plays an important role in identifying gaps in dengue control by providing a systematic framework (8). At the input stage, the model assesses available resources, such as epidemiological data, health worker capacity, vector control technology, and community involvement. The process stage evaluates the effectiveness of interventions such as fogging, larvacidation, mosquito nest eradication, and health education. Furthermore, the output stage analyzes the results achieved, including case reduction trends, case fatality rate (CFR), and the level of community participation. Using the IPO model, gaps such as lack of resources, weak program implementation, or ineffectiveness of interventions can be identified in a structured manner (9). This allows policy makers to design more targeted and sustainable solutions in dengue control.

The Input-Process-Output (IPO) model has been widely used in health research to evaluate the effectiveness of disease control programs. An evaluation of a disease control program using the IPO model to analyze the success of the program and its implementation was conducted in Sleman, Indonesia, especially in urban areas, by assessing inputs in the form of community involvement and resources, implementation processes, and outputs in the form of reduced incidence rates (10). Meanwhile, in the US, the IPO model was applied to assess the safety (risk) and effectiveness (benefit) of new drug products (11). In addition, IPO was also used to develop an integrated surveillance system to improve preparedness for arbovirus outbreaks in dengue endemic areas, where the input is epidemiological data, the process involves real-time data analysis, and the output is early case detection and rapid response (12). The application of the IPO model in these studies has demonstrated its ability to identify system weaknesses and provide evidence-based recommendations for improvement.

However, previous studies have been limited in evaluating the long-term impact of insecticide use on mosquito vector resistance, particularly in the context of local-level implementation such as Banjarmasin. Existing studies have mostly focused on the short-term effectiveness of fogging and larvicide interventions without examining overall vector resistance patterns. In addition, there are still few studies that use a qualitative approach in analyzing the challenges of vector control policy implementation, and the institutions that influence program effectiveness.

This study aims to fill the knowledge gap related to the implementation of insecticide program in dengue fever control in Banjarmasin City. Using the IPO Model approach and Gap analysis, this study provides an in-depth analysis of the program's inputs, processes, and outputs as well as the factors that influence its success. The results of the study are expected to provide evidence-based recommendations for the improvement of more effective and sustainable dengue control policies.

METHODS

The data analysis technique in this research uses qualitative analysis. This research is deductive based on IPO variables (inputs, processes and outputs), as aspects that can influence the implementation of a policy. Furthermore, these aspects are analyzed inductively based on gap analysis, namely finding gaps from the supposed conditions of a policy that has been implemented with the actual findings that occur in the research area. This study has been approved by the Health Ethics Committee of the National Research and Innovation Agency Republic of Indonesia with approval number 076/KE.03/SK/04/2024.

Study Design

This qualitative research was conducted in 2024. Utilizing the IPO model and gap analysis in this study, it provides a clear picture of the input aspects contributing to the process that produces certain results in the output to avoid insecticide resistance. Furthermore, the gap analysis will identify the gaps that occur so as to offer improvement options. The input aspect includes resources, facilities and infrastructure, including budget availability; the process stage includes programs/ activities that have been carried out in controlling DBD, the availability of standard operating procedures (SOPs) that have been implemented, including evaluation and supervision carried out; while the output includes resistance status and policies carried out to avoid resistance including obstacles that occur.

The framework of this study is as shown in Figure 1 below: (8,13)

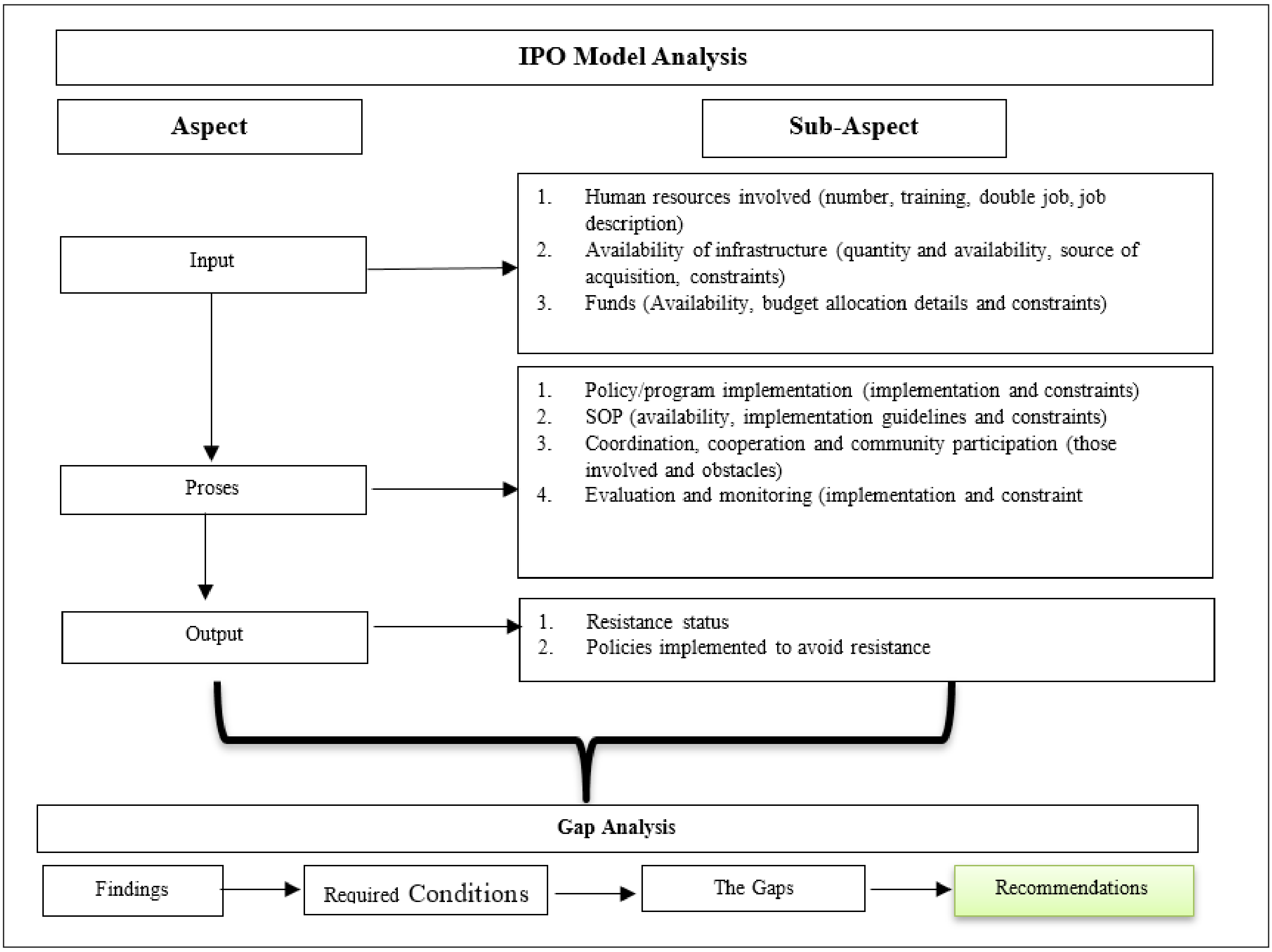

Figure 1. Conceptual Framework of the Study

Study Sites and Informants

The study locations and informants were determined by purposive sampling. The research location was determined by considering dengue endemic areas in Banjarmasin city. The informants were considered to have a role and insight into the central policy and its derivative policies in the regions that have been implemented in Banjarmasin city related to dengue fever control programs, especially the use of insecticides. Informants were also determined based on institutions related to the implementation of the program/ policy, divided into the central agency level, provincial and city levels to the implementer level. A total of 60 individuals served as key informants in this study, divided into primary and supporting informants. The primary informants included 8 informants at the provincial level (health department and pharmaceutical warehouse), 8 informants at the city level (health department and pharmaceutical warehouse), and 27 informants from 8 community health centers. Meanwhile, the supporting informants consisted of 3 informants at the central level, 4 sub-district informants from 4 sub-districts, and 10 village informants from 8 villages.

Data Collection and Analysis

The data collected came from in-depth interviews with informants, observations and document searches. In-depth interviews use triangulation techniques by comparing interview results involving informants from the central level to first-level implementers in the regions to maintain the quality and validity of the data obtained. Interviews were conducted in Bahasa Indonesia and local languages, transcribed verbatim. Face-to-face interviews were conducted with informants at the office where the informant works, while for central informants they were conducted online, using the zoom application to streamline time and budget. The questions asked were in accordance with the framework guidelines in this research, by first asking for the informants' willingness to be involved in this research without coercion.

The data were analyzed using the Qualitative Content Analysis (QCA) method to understand the meaning, patterns, and themes within the transcript content. Based on the transcripts, the coding process began with an initial analysis of the data to find the core of the data. Afterwards, the results were reviewed to ensure that the coding reflected a correct understanding of the data. In the early stages, categories were carefully created to avoid overlapping meanings between one category and another. Afterwards, the researcher reviewed all the codes that had been created to ensure they were relevant to the data. In the final stage, codes that were similar in meaning were grouped together into specific categories. The category was then given a name that represented the main meaning of the group. The researcher constantly checked the transcribed data to ensure it was significant and clearly understandable. In addition to documenting the data in the form of recordings, the researcher also recorded important observations that occurred during the data collection process as well as browsing related documents such as case data and published policy documents. The research process includes recording the main ideas and concepts from the data. These notes were then used as a basis for grouping data (categorization), simplifying redundant data (data reduction), and mapping relationships among data for interpretation. The researcher created a matrix in tabular form to see the relationships between the data interpretations that had been made.

The research method is expected to provide a detailed description of the research design to address the objectives of this study.

RESULTS

Informant Characteristics

The data collected in this study is based on information from 60 informants (Table 1).

Table 1. Informant Characteristics

Characteristics of Informants	n	%
Agency		
Ministry of Health	3	5
South Kalimantan Provincial Health Office	8	13
Banjarmasin Health Office	8	13
Public Health Center	27	45
Subdistrict	4	7
Village	10	17
Total	60	100%
Age		
23-50 years	42	70
>50 years	18	30
Total	60	100%
Length of work		
<1 year	7	11.67
1-5 years	36	60
>5 years	17	28.33
Total	60	100%
Last education		
Senior High School	1	1.67
Diploma	13	21.67
Bachelor/Master	43	71.67
Doctorate	3	5
Total	60	100%

Based on Table 1, most informants are found in Public Health Centre in accordance with the information needs needed in this study. The age of most informants is still at a productive age with the most years of work more than 1 year and the most undergraduate education, with these characteristics, it is considered that informants can provide good information and insight into the research needs.

Characteristics of DHF Cases in Banjarmasin City and History of Insecticide Use

DHF cases in Banjarmasin City over the past 6 years are shown in Table 2 below:

Table 2. Prevalence of DHF Cases in Banjarmasin City Over the Last 6 Years and History of Insecticide Use

Variables	Year					
	2019	2020	2021	2022	2023	2024
Case categories						
Dengue fever (DF)	670	151	36	1,005	1,023	208
Dengue Hemorrhagic Fever (DHF)	41	42	11	63	88	68
Die	1	2	0	3	6	3

Variables	Year					
	2019	2020	2021	2022	2023	2024
Gender						
Man	26	21	7	43	51	32
Woman	15	21	4	20	20	36
Age Category (Years)						
<5	4	3	0.0	5	3	4
5-14	18	15	1.0	12	16	29
15-64	19	24	10.0	46	69	35
>64	0	0	0	0	0	0
Total	41	42	11	63	71	68
Total Population	708,606	715,703	714,199	719,577	724,795	668,762
IR* per 100,000 Population	5.79	5.87	1.54	8.76	12.10	10.1
CFR (%)**	2.4	4.8	0.0	4.8	6.8	4.4
History of Insecticide Use						
Fogging	Cynoff (Cypermethrin)	-	-	Zeta (Cypermethrin)	Zeta (Cypermethrin)	Zeta (Cypermethrin)
Larvicide	Abate (Temephos)	Abate (Temephos)	Abate (Temephos)	Abate (Temephos), Bactivec	Abate (Temephos)	Abate (Temephos)

Based on table 2, cases are divided into 2, namely DF and DHF cases, of the two cases, 2021 is the lowest year, it is possible because cases rarely occur or because the health system is focused on controlling covid-19. However, cases increased again in 2022 and the highest in 2023 with an IR of 12.10 and fell back in 2024. From year to year, the most cases were found in the male gender with an age range of 15-64 years old then 5-14 years old, in 2024 the number of females was found slightly more than male cases.

Current State

One of the findings in this study is that insecticide resistance testing has never been conducted nationally, although indications of resistance have been found in several areas based on the results of research in the regional scope. Thus, specific policies related to insecticide resistance control have not been implemented in Indonesia, as expressed by one of the following informants:

"*There have been tests done and indications show in some places, indeed resistance to insecticides. But nationally we have no data to show. So, then we cannot make a policy*." (Ministry of Health)

Although tests have been carried out in a number of areas, insecticide resistance control policies cannot be carried out nationally, and in Banjarmasin City itself insecticide resistance tests have never been carried out, this is also supported by the following informant's statement:

"We have conducted tests in 2 districts in South Kalimantan Province, Banjarmasin City has never been tested. The results showed that the two districts were resistant to abate, but these results cannot be used as a basis because they were only conducted in sample areas, so they cannot be generalized to the district scope." (South Kalimantan Provincial Health Office)

Several other findings based on the aspects examined in this study, have been analyzed as shown in table 3.

Desired State

Desired State in this research is supported by policy documents that have been issued by the government, in the form of targets that must be achieved by policies and or programs that have been established, as in table 3.

Gaps

Based on table 3, it can be seen that the gaps that occur so that several improvement recommendations are made to overcome these gaps. Recommendations must be implemented consistently and continuously from the central to regional governments and up to the level of implementers in the community.

Table 3. Current State, Desired State, Gap Analysis and Recommendations from Research Results

Aspect	Current State	Desired State	Gap	Recommendation
Input	**HR:** 1. Don't have any experts yet 2. Human resource competency improvement has not been carried out routinely 3. Double job **Infrastructure:** 1. Tools and materials are obtained from the central government 2. Delay in dropping materials, resulting in independent purchases without reporting 3. Distribution of materials to each health center depends on stock in the warehouse **Funds:** 1. Funds are low if cases increase 2. There is no budget for fogging equipment maintenance 3. Sub-district/ward funds are only for mutual cooperation activities	1. Human resources involved in vector and DHF control have undergone education and/or training in the field of health entomology with appropriate division of tasks. 2. Insecticides should be rotated to prevent resistance. Insecticide use should always be monitored and evaluated continuously, and stocks should be adequate. 3. Vector control must have a special budget allocation, including for maintenance of facilities and infrastructure. The sub-district/ward level must support community-based preventive activities.	**HR:** 1. Training on dengue fever control, including insecticide use management, has not been scheduled routinely and continuously. 2. HR has many tasks besides controlling dengue fever **Infrastructure:** Distribution planning is less efficient and not based on resistance status. **Funds:** 1. Planning has not been done based on caseload projections 2. Limited funds are only for control when cases are high. 3. There is no specific funding for community-based prevention.	1. Improving human resource capacity up to the health center level, with the ability to carry out vector control, fogging, resistance management and insecticide resistance testing. and creating detailed job descriptions and workload analysis. 2. Procurement of insecticides by considering resistance status. If there is no resistance status data, then procurement of insecticides should consider rolling between groups in accordance with the guidelines. 3. Create a budget plan by considering the projected caseload and budgeting for infrastructure maintenance and community-based control models.
Process	**Implementation:** 1. The 1 house 1 mosquito larvae movement (G1R1J) is not active 2. There is still political intervention in the implementation of fogging **SOUP:** SOP is only for controlling DHF, there is none specifically for implementing fogging **Coordination, Cooperation, Community Participation:** 1. Cross-program and cross-sector coordination is still lacking 2. Lack of Community Participation **Evaluation and monitoring:** 1. The existence of a communication forum, SKPD mosquito larvae control, PES team, SKDR application and Silantor 2. Evaluation is carried out quarterly and at coordination meetings 3. There is no supervision of independent fogging 4. The implementation of the Larvae Free Rate (ABJ) is not yet uniform	1. policy for dengue control must be carried out continuously with periodic evaluation. Fogging is carried out based on epidemiological and surveillance data, not at the request of a particular party. 2. SOPs should cover technical aspects of vector control including the use of insecticides. 3. Vector control must involve cross-programs and sectors in a coordinated manner, one of which is to support community-based control. Community participation is a key element of community-based control. 4. Evaluation should include supervision of the implementation of technical and administrative controls. ABJ monitoring should be carried out uniformly and measurably throughout the region.	**Implementation:** 1. There is no continuity and evaluation of G1R1J 2. Fogging is carried out based on epidemiological needs, not intervention. **SOUP:** There are no detailed technical guidelines for implementing fogging based on epidemiological needs. **Coordination, Cooperation, Community Participation:** 1. Lack of cross-program integration at provincial and city levels and cross-sector synergy 2. Low public awareness in supporting PSN activities and vector control **Evaluation and Supervision:** 1. Lack of supervision of fogging implementation standards, including independent fogging by the community. 2. There is no uniform and coordinated ABJ monitoring system	1. Reactivate G1R1J with a focus on evaluation and funding, and integrate with community-based programs. 2. Form cross-program and cross-sector teams with measurable success indicators, involving the community, through education, mosquito larvae control training, and community-based campaigns. 3. Prepare technical SOPs for the use of insecticides and standardized monitoring of ABJ in all regions and supervise the implementation of fogging technically and administratively, including independent fogging control by the community and political intervention. 4. The Jumantik Forum that has been formed can be further developed to become the entry point for dengue vector control programs in the community.
Output	**Resistance status:** There is no resistance data at the national or regional level. **Policy:** 1. There is no policy regarding insecticide resistance 2. There are circulars on case alert and PSN, as well as innovations in the form of the BABASAH Movement, but without any evaluation.	1. Insecticide resistance monitoring should be carried out periodically as a basis for vector control. 2. The government is obliged to encourage the implementation of community-based control with regular evaluation with adequate budget support and including the development of models.	**Resistance Status:** Insecticide resistance surveillance has never been conducted **Policy:** 1. There are no insecticide rotation regulations in place. 2. There is no evaluation of the effectiveness of the circular and adequate budget for Community-based control.	1. Conducting national resistance mapping. Its implementation can be done with central and regional budgets with implementation coordination through networks that already have the capacity. 2. Regulations need to be made to minimize the use of insecticides and supervise use based on resistance status. If there is no resistance status data, rolling can be carried out every 2-3 years using insecticides from different groups. 3. Regular evaluation of the effectiveness of community-based control activities, with clear performance indicators.

DISCUSSION

Continuous use of insecticides triggers resistance, both metabolically and systemically (14-15). Banjarmasin City in fogging applications uses insecticides with the active ingredient cypermethrin from the pyrethroid group. Pyrethroid insecticides are widely used in controlling disease vectors such as the *Aedes aegypti* mosquito, but have impacts on health and the environment. In terms of health, short-term exposure to pyrethroids can cause skin, eye, and respiratory tract irritation, while chronic exposure risks disrupting the nervous system, causing endocrine disorders, and has the potential to be neurotoxic, especially in children and sensitive individuals (15-16). In the environment, pyrethroids are persistent in soil and water, so they can pollute aquatic ecosystems and have negative impacts on aquatic organisms such as fish and plankton. In addition, pyrethroid residues can disrupt beneficial insect populations such as bees and butterflies that play a role in plant pollination (17-18). Unwise use of pyrethroids also contributes to target insect resistance, which ultimately reduces the effectiveness of vector control and increases the need for higher doses of insecticides, which can worsen the impacts on health and the environment (19-20).

Organophosphate insecticides such as temephos are often used as larvicides in mosquito control, but have impacts on health and the environment. In terms of health, exposure to temephos in high doses can inhibit the activity of the cholinesterase enzyme, which plays a role in nerve function, potentially causing symptoms of poisoning such as nausea, dizziness, seizures, and even respiratory problems in humans (21–23). Chronic exposure has also been associated with endocrine system disruption and possible neurotoxic effects. Meanwhile, from an environmental perspective, temephos residues that pollute waters can harm aquatic organisms such as fish, amphibians, and aquatic invertebrates by disrupting the nervous system and ecosystem balance (24-25). In addition, the continuous use of temephos can trigger resistance in mosquito larvae, thereby reducing its effectiveness as a larvicide and increasing the risk of using stronger insecticides in the future, which can exacerbate negative impacts on health and the environment (26).

The implementation of the use of insecticide programs in efforts to control dengue fever needs to be evaluated periodically, especially regarding insecticide resistance which can be a barrier to efforts to control dengue fever. The widespread phenomenon of insecticide resistance requires the implementation of insecticide resistance management (IRM) which can be carried out in various forms, including the use of insecticide mixtures, mosaics or insecticide rotation. In some places, insecticide rotation is considered the most effective IRM approach (27). Meanwhile, the use of rational synergistic mixtures can also effectively increase insecticide efficiency and reduce the required dosage (28-29). There is no national insecticide resistance data, making it difficult to implement insecticide rotation policies. Research on the implementation of insecticide resistance management in Zambia also has the same constraints, namely that the available data only reveal a small portion of insecticide resistance in the country, but this data can be expanded through collaboration with other stakeholders, including research (local and international), private sector (mining and agriculture), non-governmental organizations, and insecticide companies. Then all partners agree to share data, joint and organized efforts to collect more data as needed (30). The same ideal can be implemented in Indonesia with cooperation between the Pesticide Commission, Ministry of Health, Ministry of Agriculture, government and private universities, private companies etc. in terms of implementing insecticide resistance tests in various regions. With data from the regions, appropriate recommendations can be made and reviewed about which locations need additional data and which organizations are in the best position to collect such data.

The results of the central informant interview also stated that in terms of human resources, the regional party in this case the Health Office is able to conduct resistance tests independently in the region because the facilities for controlling DHF are sufficient to the region, only the entomological materials for surveillance are still lacking. The Health Office in the region can conduct resistance tests because the materials are not expensive in order to have resistance data. This discourse is a very good and important consideration for the availability of insecticide resistance in each region and is supported by the establishment of Tier 2 Public Health Laboratories at the district level and Tier 3 at the provincial level, one of the functions of which in the Labkesmas is the implementation of environmental, vector and disease-carrying animal examinations which include insecticide resistance tests in these activities.

There has never been a cross-sector/program meeting to discuss insecticides, especially insecticide resistance. The implementation of insecticide resistance management in Zambia holds annual meetings with the main objective being to interpret resistance data to make informed decisions about which insecticides to use during the next spraying season based on the resistance data that has been conducted (30). Ideally, insecticide resistance that has occurred in many regions in Indonesia is used as a decision-making material for implementing the insecticide rotation policy every 2-3 years in accordance with the recommendations that have been submitted based on the results of research that has been conducted. However, based on the results of interviews at the central level of the Ministry of Health, the insecticide rotation policy is constrained by the large amount of remaining insecticide stock. This phenomenon does not only occur in Indonesia, but also in several other countries. The results of a survey of 94 countries through a questionnaire distributed to all WHO Member States regarding the practice of managing insecticides for vector control obtained information that (8-27%) countries have difficulty in estimating the appropriate amount of insecticide procurement, especially during emergency situations such as KLB (Extraordinary Events). Underestimation can have serious consequences for outbreak control. Overestimation can lead to the accumulation of expired pesticides; environmentally sound disposal of expired pesticides is known to be very expensive (31). The phenomenon of the risk of insecticide resistance is exacerbated by considerations of efficiency, such as the large amount of remaining insecticide available, so that current efforts to control dengue fever are prioritized on physical control activities, namely PSN (Mosquito Nest Eradication), while the use of chemical insecticides available through fogging is used as the last alternative for controlling dengue fever (32-33).

Based on the results of interviews at the South Kalimantan Provincial Health Office, it was stated that the quantity of available human resources was sufficient to carry out the coordination of the DHF control program, although there were no special entomology technical personnel for vector control, but the program was quite helped by the Silantor (Disease Vector and Beast Surveillance Information System) and SKDR (Early Alert and Response System) applications. However, in terms of quality, competence was considered not optimal, so it also affected the success of the DHF control program. The lack of human resource competence at the provincial, city, and health center levels in controlling DHF vectors is very relevant considering the role of trained and competent human resources in preventing and controlling the disease. Based on existing policies, human resources involved in vector control, such as health entomology, should have adequate education or training (34–36). However, in reality, many health centers and health workers have received less training or have never been trained specifically in this field.

In terms of resources and infrastructure, fogging machines, insecticides, larvicide and entomology kits obtained from the Ministry of Health are stored and distributed through pharmaceutical warehouses and multi-level supervision is required for the use of doses, storage practices and management of insecticide waste used. Based on the survey results, it was stated that the majority (29–78%) of countries across the region showed weaknesses in terms of worker safety, pesticide storage practices, and pesticide waste disposal (31). In some conditions when there is an increase in cases, there is still a shortage of insecticides and larvicides in several districts, so they procure them themselves from their respective regional budgets, but do not report this to the South Kalimantan Provincial Health Office.

Independent insecticide procurement by the District Health Office can have positive and negative impacts both in general and specifically for increasing or decreasing the risk of insecticide resistance in the district. In general, centralized pesticide procurement by the Ministry of Health program has advantages in terms of efficiency, control over product selection, price and quality negotiation, quality control, and prevention of expired stock accumulation. Meanwhile, independent procurement by the District Health Office raises concerns about not considering WHO-recommended products compared to centralized procurement by the program (31). In particular, if we look at the type of insecticide used by the district, the procurement of insecticides of a different type from the insecticides distributed in the program will have a positive impact because in principle the district has implemented rotation or replacement of the insecticides used, while the procurement and use of insecticides that are the same as the type of insecticide in the program will further increase the risk of insecticide resistance in the district.

At the Banjarmasin City Health Office level, it was stated that there was no supervision of the implementation of fogging independently, the implementation of fogging in health centers was not supervised and fogging officers were never trained. This phenomenon is in accordance with the results of research stating that efforts to control dengue fever in many cases do not have the resources available that are ideally allocated to support health checks for spraying teams, to provide insurance or compensation in the event of pesticide poisoning, or even to provide basic personal protective equipment (31). In ideal conditions, before implementing operational activities which are new policies, for example the use or replacement of insecticides, it is necessary to carry out training for trainers and tiered training which emphasizes the safe use, storage and disposal of insecticides (30). The Banjarmasin City Health Service stated that there had never been any ED insecticide eradication, all of the above are related to management where it is necessary to special efforts in advocacy and resource mobilization for vector control programs using insecticides by providing adequate budget allocation for insecticide resistance monitoring, pesticide quality control, pesticide procurement methods, worker safety, pesticide storage, and pesticide waste disposal.

DHF is an environment-based disease, so efforts to control DHF will not be optimal if only implemented by the health sector. The behavior of the community that stores water because PDAM is often blocked so that facilitating mosquito breeding due to the lack of adequate water service systems, a similar thing also happened in the Philippines (37). So that it is necessary to improve the system and ensure the continuity of piped water flow to prevent water storage by the community. In terms of controlling insecticide resistance, other sectors also play a role in increasing the risk of resistance because there are other sectors that also rely on the use of insecticides in their activities and programs, such as agriculture The similarity of active ingredients used in agriculture and vector control in health emphasizes the need for an integrated approach (38-39). Resistance management can only be effective if there is broad collaboration among stakeholders, including the crop protection industry, academics, regulators, crop advisors, farmers and other end users (40).

There is a phenomenon of politicization of fogging during the campaign period to attract public sympathy and support in regions including Banjarmasin City which takes advantage of the public's mistaken understanding that fogging is an effective effort. Fogging carried out for political interests often does not go through epidemiological investigations and proper procedures. This is due to the lack of supervision by the Health Service towards other parties who carry out fogging. In this case, the government must establish strong and firm policies to regulate and prohibit fogging efforts that violate procedures and are only used as political tools (for example: Regional Regulations with clear and rational sanctions). Every fogging must be carried out by, and/or with the approval and strict supervision of the Health Service. Widespread re-socialization to the community and stakeholders regarding the negative impacts of fogging, so that there is no more misunderstanding, and re-emphasis that fogging must always be accompanied by ongoing PSN (41-42).

AUTHORS' CONTRIBUTION

All authors actively participated in this research and writing process. JJ contributed to the formulation, methodology, and result analysis; MR, RY, and WPN contributed to the concept and formulation; LI, TAG, and MCH contributed to result interpretation; MH and II were responsible for reviewing, revisions, and editing; BJ editing, language translation, and visualization.

CONCLUSION

The implementation of insecticide use in dengue control in Banjarmasin City continues to face challenges due to the absence of resistance mapping, limited human resources, lack of cross-sectoral coordination, and weak oversight of insecticide application. To enhance program effectiveness, regular insecticide resistance mapping, the implementation of insecticide rotation policies, and the strengthening of regulations and supervision of fogging to ensure epidemiological needs-based application are necessary. Additionally, improving human resource capacity through technical training, optimizing budgets for fogging equipment maintenance, and strengthening community-based programs such as the *One House, One Larvae Observer Movement* (G1R1J) represent strategic steps in dengue control. The government must also reinforce cross-sectoral coordination and ensure environmentally based control measures as a sustainable effort to reduce case numbers and prevent insecticide resistance

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