Mosquito Control Methods and Dengue Fever Disease: a Literature Review

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Abstract

Dengue Hemorrhagic Fever (DHF) is one of the vector-borne diseases that remains a public health challenge in Indonesia, characterized by high incidence rates, widespread vector distribution, and an increased risk of outbreaks in various endemic areas. The transmission of the dengue virus is greatly influenced by community behavior, residential environmental conditions, and the bioecology of the Aedes aegypti mosquito, which is able to breed in clean water puddles around homes. The dengue virus consists of four serotypes and can survive through vertical and horizontal transmission mechanisms, thereby strengthening the chain of transmission in the environment. On the other hand, vector control efforts using larvicides and chemical insecticides are still widely chosen by the community, even though improper use can cause insecticide resistance. This study aims to examine various methods of dengue vector control, including physical, mechanical, biological, chemical approaches, and the EcoHealth concept. The method used was a literature review of official guidelines, research articles, and the latest scientific publications on DHF and vector control. The results of the study show that physical control methods such as 3M Plus are the most effective and safest, while biological control through larval predators and environmentally friendly bacteria can reduce the larval population without causing negative ecological impacts. Chemical control still provides rapid effects, but must be used wisely to prevent resistance. The EcoHealth approach is considered more comprehensive because it involves environmental, social, cultural, and economic aspects of the community in sustainable control. In conclusion, optimal DHF control requires an evidence-based integrated strategy with cross-sector participation and the application of ecological principles to ensure long-term success in reducing disease incidence.

Keywords: Aedes aegypti, dengue fever, mosquito control

Metode Pengendalian Nyamuk dan Penyakit Demam Berdarah Dengue: Tinjauan Pustaka

Abstrak

Demam Berdarah Dengue (DBD) merupakan salah satu penyakit yang ditularkan oleh vektor yang masih menjadi tantangan kesehatan masyarakat di Indonesia, ditandai dengan tingkat insidensi yang tinggi, penyebaran vektor yang luas, dan risiko wabah yang meningkat di berbagai daerah endemik. Penularan virus dengue sangat dipengaruhi oleh perilaku masyarakat, kondisi lingkungan perumahan, dan bioekologi nyamuk Aedes aegypti, yang mampu berkembang biak di genangan air bersih di sekitar rumah. Virus dengue terdiri dari empat serotipe dan dapat bertahan melalui mekanisme penularan vertikal dan horizontal, sehingga memperkuat rantai penularan di lingkungan. Di sisi lain, upaya pengendalian vektor menggunakan larvasida dan insektisida kimia masih banyak dipilih oleh masyarakat, meskipun penggunaan yang tidak tepat dapat menyebabkan resistensi insektisida. Studi ini bertujuan untuk mengkaji berbagai metode pengendalian vektor demam berdarah, termasuk pendekatan fisik, mekanik, biologis, kimia, dan konsep *EcoHealth*. Metode yang digunakan adalah tinjauan literatur terhadap pedoman resmi, artikel penelitian, dan publikasi ilmiah terbaru tentang DHF dan pengendalian vektor. Hasil penelitian menunjukkan bahwa metode pengendalian fisik seperti 3M *Plus* adalah yang paling efektif dan aman, sementara pengendalian biologis melalui predator larva dan bakteri ramah lingkungan dapat mengurangi populasi larva tanpa menimbulkan dampak ekologi negatif. Pengendalian kimia masih memberikan efek cepat, tetapi harus digunakan dengan bijak untuk mencegah resistensi. Pendekatan EcoHealth dianggap lebih komprehensif karena melibatkan aspek lingkungan, sosial, budaya, dan ekonomi masyarakat dalam pengendalian berkelanjutan. Kesimpulannya, pengendalian DHF yang optimal memerlukan strategi terintegrasi berbasis bukti dengan partisipasi lintas sektor dan penerapan prinsip-prinsip ekologi untuk memastikan keberhasilan jangka panjang dalam mengurangi insiden penyakit.

Kata kunci: Aedes aegypti, demam berdarah, pengendalian nyamuk

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Introduction

Dengue Hemorrhagic Fever (DHF) remains a significant public health issue in Indonesia. This disease occurs due to dengue virus infection, which is transmitted from infected individuals to others through the bite of the Aedes aegypti mosquito. DHF is also a major public health challenge globally,

particularly in tropical and subtropical regions such as Southeast Asia, Latin America, and parts of Africa.[1]

The spread of Dengue Hemorrhagic Fever (DHF) cases in Indonesia occurs in almost all provinces. All regions in Indonesia have the potential for DHF transmission because the dengue virus and its mosquito vectors are widespread, both in residential areas and public facilities, except in areas with an altitude of more than 1,000 meters above sea level.[3] According to data from the Ministry of Health, since the beginning of January 2019, the number of DHF cases in Indonesia has reached 13,683 cases spread from the western to the eastern regions.[3]

In Lampung Province, the Health Office recorded that in 2018 there was an extraordinary outbreak of dengue fever in Bandar Lampung City with a total of 1,113 cases, some of which resulted in death. From January to February 2019, the number of cases in the city rose again to 436 cases. This spike in cases is closely related to the low level of public awareness about the importance of maintaining environmental hygiene, especially in waste management, which can be an ideal breeding ground for Aedes mosquitoes.[3]

The transmission of dengue fever (DBD) is influenced by various factors, including high vector density, population density, uncontrolled urbanization, economic development, availability of clean water, and community behavior that pays little attention to environmental hygiene, coupled with climate change. In Jakarta, an outbreak of DHF with 2,282 cases and several deaths was reported between January and early March 2019.[4]

Therefore, rapid and comprehensive countermeasures involving all levels of society, including higher education institutions, are needed. Dengue fever is a viral infectious disease that remains a public health problem in various countries, especially in tropical and subtropical regions such as Southeast Asia, Latin America, and parts of Africa. In Indonesia, this disease is endemic and the number of cases can increase sharply, especially during the rainy season. The transmission of dengue is highly dependent on the presence of Aedes aegypti and Aedes albopictus mosquitoes as the main vectors. Various environmental factors, such as high rainfall, increased humidity, relatively warm temperatures, and suboptimal sanitation, contribute to the development of mosquitoes and increase the risk of dengue virus transmission.[3]

Various efforts have been made to combat dengue fever (DF), both through prevention and treatment. One important step in handling DHF is controlling the virus-carrying vector, Aedes aegypti, which can be done through physical, chemical, or biological methods. Until now, chemical control is still the main choice of the community because it is considered to be able to eradicate the vector more quickly and effectively. Various types of larvicides and insecticides have been used to kill larvae and adult mosquitoes. However, the use of synthetic chemicals in insecticides has the potential to cause resistance in mosquitoes due to repeated exposure or errors in dosage application.[5]

The Director of Vector-Borne and Zoonotic Disease Prevention and Control at the Ministry of Health, Didi Budijanto, urges the public to implement Mosquito Breeding Site Elimination through the 3M Plus strategy. The 3M Plus PSN method is considered the most effective effort in controlling Dengue Hemorrhagic Fever (DHF). The 3M actions include draining water reservoirs, covering containers that have the potential to become water pools, and reusing old items that still have value. The "Plus" element includes various additional actions to suppress the mosquito population, reduce breeding habitats, and prevent mosquito bites, such as using mosquito nets, applying repellents, installing wire mesh on vents, and proper waste management. However, the tendency in society is still more towards chemical-based prevention efforts rather than physical or biological methods that are more environmentally friendly.[6]

Based on Regulation of the Minister of Health of the Republic of Indonesia Number 50 of 2017 concerning Environmental Health Quality Standards and Requirements for Vectors and Disease Carrying Animals and Their Control, vector control is defined as a series of activities or actions aimed at reducing the vector population to the lowest possible level so

that its presence no longer poses a risk of disease transmission in an area. Control also includes efforts to prevent contact between the community and vectors, thereby minimizing the transmission of vector-borne diseases.

This literature review aims to analyze various methods of controlling Aedes mosquitoes and strategies for preventing dengue fever based on the latest scientific evidence, as well as to evaluate the effectiveness, advantages, and limitations of each method in the context of public health. This study uses a literature review design by examining scientific articles published in the last ten years. Data sources were obtained from electronic databases such as PubMed, Google Scholar, ScienceDirect, and DOAJ. The keywords used included "dengue," "mosquito control," "Aedes aegypti," "vector control," "Wolbachia," and "larvicide."

The inclusion criteria included articles in Indonesian or English that discussed mosquito control or dengue prevention methods, were fully accessible, and contained research data. Articles that were irrelevant, not fully available, or not scientific publications were excluded from the analysis. The collected data were synthesized narratively to provide a comprehensive overview of the development of mosquito control and dengue fever prevention methods.

Contents

Dengue hemorrhagic fever (DHF) is an infection caused by the dengue virus and transmitted to humans through the bite of Aedes aegypti and Aedes albopictus mosquitoes. Common clinical manifestations include sudden high fever, headache, pain behind the eyeballs, nausea, and various signs of bleeding such as nosebleeds, bleeding gums, and the appearance of a red rash on the patient's skin.[8]

The virus that causes Dengue Hemorrhagic Fever (DHF) and Dengue Shock Syndrome (DSS) belongs to the Flavivirus group and has four serotypes, namely serotypes 1, 2, 3, and 4 (dengue-1, dengue-2, dengue-3, and dengue-4). Transmission of this virus to humans occurs through the bite of an infected female Aedes aegypti mosquito. The dengue virus can survive in the environment through two main mechanisms.

The first mechanism is vertical transmission within the mosquito's body, which occurs when infected female mosquitoes transmit the virus to their eggs, causing their offspring to carry the virus. Transmission can also occur from male mosquitoes to female mosquitoes through sexual contact. The second mechanism involves the cycle of transmission between mosquitoes and humans. Mosquitoes acquire the virus when they bite humans who are in the viremia phase, which is when the dengue virus is circulating in the blood. The virus that enters the mosquito's body replicates in its digestive tract, then migrates to the salivary glands, enabling the mosquito to transmit the virus when it bites humans.[9]

Aedes aegypti mosquitoes generally rest in dark and humid places, both indoors and outdoors, especially in areas close to their breeding habitats. These locations also serve as places where mosquitoes wait for their eggs to mature. Female Aedes aegypti mosquitoes have an average flight range of around 40 meters, but they can travel much further passively, for example by being carried by the wind or vehicles. This species is widespread in residential and public areas and can live and breed at altitudes of up to approximately 1,000 meters above sea level. In areas above 1,000 meters, lower air temperatures do not support mosquito development, so populations tend not to survive.[10]

According to the Indonesian Ministry of Health (2016), patients with dengue hemorrhagic fever (DHF) generally experience three phases of fever. The first phase occurs on days 1 to 3, characterized by a high fever that can reach around 40°C. The second phase, the critical phase, usually occurs on the 4th to 5th day, during which the patient's condition can worsen if not treated properly. The third phase occurs on the 6th to 7th day, during which the fever may return. In this final phase, there are two possible developments in the patient's condition. First, the platelet count gradually increases and returns to normal. Second, the condition may worsen, characterized by symptoms such as restlessness, cold extremities, and excessive sweating. If the

situation persists, the patient may experience shock, characterized by extreme weakness, weak or even undetectable pulse, and sometimes accompanied by decreased consciousness.[8]

Based on Regulation of the Minister of Health of the Republic of Indonesia Number 50 of 2017, mosquito vector control includes several approaches, namely physical and mechanical control, control with biotic agents, and chemical control. Physical and mechanical control methods include various efforts to prevent, reduce, or eliminate breeding habitats and suppress vector populations through physical actions. Some forms of implementation include modifying and manipulating breeding environments, such as applying 3M Plus, cleaning moss, drying water reservoirs, and improving drainage systems; installing mosquito nets on beds; wearing long-sleeved clothing; using animals as bait (cattle barriers) to divert mosquitoes from humans; and installing wire mesh on house vents to prevent mosquitoes from entering the room.[10]

Physical and mechanical control methods are various efforts to prevent, suppress, or eliminate breeding habitats and vector populations through the use of biotic agents. Some actions included in this method are the use of predatory larvae eaters such as betta fish and rice field minnows, the use of bacteria, viruses, and fungi, as well as genetic manipulation techniques such as the application of sterile male mosquitoes. Meanwhile, chemical control methods are a series of actions to reduce or eliminate vectors through the use of chemicals. Examples of measures used include indoor residual spraying (IRS), the use of insecticide-treated mosquito nets, the application of larvicides, the use of hot (fogging) or cold (ULV) fumigation or spraying, and the use of household insecticides such as repellents, mosquito coils, liquid vaporizers, paper vaporizers, mats, and aerosols.[10]

Ecohealth-based dengue fever control is an effort to control the disease using an ecosystem approach that focuses on the entire environment in which humans live and carry out their activities. The EcoHealth approach views humans as having close connections with their surrounding biophysical, social, and economic environments, and these connections are reflected in the health conditions of a population. In its application, EcoHealth indicators include various ecosystem factors physical, biological, and social that influence dengue prevention and control efforts.[11]

Specifically, the EcoHealth approach focuses on studying changes in the biological, physical, social, and economic environments with the aim of improving the health and well-being of humans, animals, and ecosystems. EcoHealth-based dengue control is a prevention strategy that considers all aspects of the environment, from natural, social, and economic factors to the cultural of the community. This approach emphasizes the importance of control methods that are safe, healthy, and environmentally friendly.[11]

Thus, the control efforts implemented are expected to preserve the environment and uphold conservation principles in the local area. This approach emphasizes the importance of sustainable disease control. EcoHealth is a strategy that prioritizes all aspects of the ecosystem, where disease control measures are implemented based on the principles of safety, rationality, convenience, effectiveness, socioeconomic conditions, local potential, and community culture. In addition, this approach considers sustainability, long-term success, and environmental preservation in every control measure.[12]

The principles of the EcoHealth approach to dengue control emphasize that all actions must be based on valid and evidence-based data, such as research results, special studies, or scientific publications that describe the bioecology of vectors, transmission dynamics, ecosystem conditions, and community behavior that is specific and local in nature. Furthermore, disease control and prevention require the active involvement of various related sectors, including the government, non governmental organizations, the private sector, and direct community participation.[13] This approach also encourages the use of non-chemical control methods as much as possible, while the use of pesticides is carried out rationally and prudently only when other methods are ineffective. Furthermore, every control effort must take into account ecological principles and

environmentally friendly economic aspects, so that control can be carried out sustainably and does not cause negative impacts on the environment.[14,15]

Conclusion

Dengue Hemorrhagic Fever (DHF) is a disease caused by the dengue virus from the Flavivirus group, which consists of four serotypes, and is transmitted through the bite of an infected female Aedes aegypti mosquito. The dengue virus is able to survive in nature through vertical transmission between mosquito generations and transmission between mosquitoes and humans. The Aedes aegypti mosquito itself has characteristics that favor dark and humid places around human settlements, with a flying range of about 40 meters but can spread further passively. This mosquito can breed at altitudes of ±1,000 meters above sea level, but its population will decline at low temperatures.

Clinically, DHF patients experience three phases: a high fever phase on the first to third days, a critical phase on the fourth to fifth days, and a recovery phase on the sixth to seventh days. During the critical phase, the condition can worsen into shock, characterized by decreased consciousness, weak pulse, and cold extremities, requiring close monitoring.

Mosquito vector control efforts are carried out through physical and mechanical approaches, such as 3M Plus and the installation of mosquito nets; biotic approaches through the use of larvae predators, bacteria, or other biological agents; and chemical approaches such as the use of larvicides and fumigation. However, chemical control methods must be used rationally.

The EcoHealth approach is a more comprehensive model for dengue control because it integrates biological, physical, social, economic, and cultural aspects. This approach emphasizes that dengue fever control must be based on local scientific evidence, involve multiple sectors and communities, prioritize non-chemical methods, and consider environmental sustainability. With these principles, dengue fever control can be effective, sustainable, and environmentally friendly.

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