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Research Article

The Imperative of a Comprehensive One Health Approach for Mosquito-Borne Disease Control in Indonesia

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This review provides information on the importance of a comprehensive one-health approach for controlling mosquito-borne diseases in Indonesia. Despite the use of various control methods, Indonesia still faces numerous challenges and threats to its public health. The One Health paradigm offers a comprehensive framework for understanding and addressing the complexity of mosquito-borne diseases in Indonesia. Understanding the linkages between human, animal, and environmental health enables a deeper understanding of disease dynamics and facilitates the development of comprehensive strategies for disease prevention, control, and eradication. Important points that must be implemented immediately and receive attention from policymakers include strengthening vector surveillance and monitoring systems, strengthening vector control strategies in various sectors, increasing human health and behavioral capacity, effective communication and collaboration, and increasing infrastructure capacity and resource allocation. The sooner these issues are resolved, the more likely the goal of a mosquito-borne disease-free Indonesia can be achieved.

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Introduction

Globally, mosquito-borne diseases have long been a major threat to public health, especially in tropical regions such as Indonesia (Socha et al., 2022). The complex interactions between various ecological, biological, socioeconomic, and environmental predispositions make the control and prevention of environmentally sourced diseases complex and highly intractable. This has resulted in ongoing challenges and threats to public health in the region (Adnyana & Utomo, 2023). In the last three decades, Indonesia has faced significant vector control challenges, despite the implementation of various control methods, such

as the mosquito nest eradication program (PSN), 4 M-Plus (draining, covering, burying, and monitoring, plus sowing larvicides, planting mosquito repellent plants, and others), the one-house *Jumantik* (1R1J) program, and other vector eradication programs; however, these methods have not achieved maximum results. This can be seen from the increasing number of cases, morbidity rates (IRs), and mortality rates (CFRs) in various regions of Indonesia (Adnyana, Utomo, et al., 2023; Adnyana & Utomo, 2023). Dengue virus infection, Zika virus infection, malaria, chikungunya, and other infections continue to be reported throughout the year, with a prevalence above the national target (Adnyana, Azhari, et al., 2022; Vicente et al., 2021). In view of this problem, various efforts have been made by the government, related sectors, and the community, one of which is adopting

a comprehensive One Health paradigm as an important strategy to overcome various challenges in controlling mosquito-borne diseases in Indonesia. The One Health concept seeks to integrate human, animal, and environmental health to address complex health problems collaboratively (Adnyana, Utomo, et al., 2023). However, until now, a single health approach has not yet been realized by the community. Therefore, it is important to explore the factors that need to be considered when developing a single health concept for mosquito-borne disease control, especially in Indonesia. Hopefully, this perspective can provide insights into understanding the essence of the One Health approach in an effort to accelerate the realization of the concept of mosquito-borne disease control and design effective strategies that consider the complex interactions of each predisposition to accelerate the eradication of these diseases in the future.

Understanding the One Health Approach

The One Health paradigm represents a holistic approach that recognizes the interconnectedness between human health, animal health, and the environment (Adisasmito et al., 2022; Ferrinho & Fronteira, 2023; Varela et al., 2023). It emphasizes the interdependence of the three fields and recognizes that the health of one field is closely related to the health of the other. In the context of mosquito-borne diseases, the application of the One Health concept is important because of the complex interactions among mosquitoes, humans, animals, and the environment in the transmission and control of these diseases (Adisasmito et al., 2023; Singh et al., 2023; Vesterinen et al., 2019). This approach involves collaborative efforts among diverse stakeholders, including public health officials, veterinarians, ecologists, environmentalists, policymakers, and communities, in an effort to maintain the stability of one health element (Elnaïem et al., 2023; Erkyihun & Alemayehu, 2022).

Interconnectedness of Human, Animal, and Environmental Health

The One Health approach seeks to present the concepts of stability and interdependence among human, animal, and environmental health. Mosquito-borne diseases exhibit complex ecological cycles involving vectors, human hosts, and various intermediate animal species. To cause a disease, there must be a change in one of the cycles or elements contained in the One Health paradigm (Destoumieux-

Garzón et al., 2018; Saba et al., 2023). Changes in the natural habitat of living organisms, especially mosquitoes, contribute to increased human contact with mosquitoes. The loss of natural breeding sites, a high number of artificial breeding sites, and a high number of unmaintained breeding pockets, accompanied by massive human activities in an effort to control vectors, have resulted in an increase in mosquito populations. This will certainly contribute to the explosion of vector populations, particularly mosquito populations, in the community. In addition, low human immunity or other disorders contribute to the easy introduction of viruses into the human body, which can cause disease. The interaction between humans and intermediate animals has accelerated the spread of pathogens, resulting in an increase in the incidence of environmental and mosquito-borne diseases in the community. The resulting sylvatic cycles from vectors to animals and from vectors to humans highlight the dangers of zoonotic diseases and the importance of animal health in disease control (Gebreyes et al., 2014; Gwee et al., 2021; Lempang et al., 2022; Wicaksono et al., 2019). The integration of veterinary surveillance and vaccination programs for livestock and the encouragement of animal health practices are necessary components of a One Health strategy (Negara et al., 2022).

Community engagement and health education

Central to the success of any public health-initiated programme, community engagement and health literacy in disease prevention and control should be increased. In Indonesia, customized health education strategies are needed for cultural practices, socioeconomic disparities, and diverse geographical landscapes. Empowering communities with knowledge of mosquito-borne diseases, preventive measures, and the importance of environmental conservation will encourage active participation in disease control efforts (Adnyana & Surya, 2023). In addition, providing knowledge, practices, and experiences in the field of green education is important for providing more comprehensive insights into the community to maintain the stability of one health element (Adnyana, et al., 2023). However, educational programs must go beyond information dissemination. The communities closest to the source of the disease and governments providing policy must be able to embrace local languages and cultural beliefs and actively engage community leaders to ensure sustainable behavioral change (Erkyihun & Alemayehu, 2022; Varela et al., 2023). Collaborative

efforts involving healthcare workers, educators, and community stakeholders are important in driving awareness campaigns and fostering a collective sense of responsibility for mosquito-borne disease prevention in communities (Khairani & Sagasiousman, 2022).

Cross-sector collaboration and policy implementation

Successful implementation of the One Health approach requires interdisciplinary collaboration and a cohesive policy framework, which emphasizes interdisciplinary collaboration between various sectors, such as human health, animal health, environmental science, and policy making (Kemenkes RI, 2019). In its application in Indonesia, it is imperative to synergize research and government agencies such as the National Innovation Research Agency (BRIN), the Ministry of Health, the Ministry of Agriculture, the Ministry of Environment and Forestry, and wildlife conservation agencies and universities to bridge research and innovation as well as policy coherence and coordinated actions for surveillance, early detection, rapid response, and development of comprehensive strategies in mosquito-borne disease control efforts and eradication plans. The establishment of joint task forces, interagency collaboration, and policy dialogue will facilitate the alignment of diverse agendas toward the unified goal of future disease prevention and eradication (Adnyana et al., 2023). In addition, the integration of the One Health principle into national health policies and laws strengthens long-term sustainability and resilience in combating mosquito-borne diseases, particularly in Indonesia. Currently, there is still a gap between institutions that have not jointly carried out vector control efforts, which is one of the triggers for the increase in cases, deaths, and predictive rates related to mosquito-borne disease sources throughout Indonesia.

Key focus areas for mosquito-borne disease control in Indonesia

Implementing the One Health approach is not only an option but also a necessity for safeguarding the health and well-being of the Indonesian people from the threat of mosquito-borne diseases. The key areas of focus for mosquito-borne disease control in Indonesia include strengthening vector surveillance and monitoring systems, as effective surveillance and monitoring systems are the cornerstones of disease

control efforts (Adnyana, 2023b; Sutriyawan et al., 2023). Strengthening this system requires a multidisciplinary approach, as the surveillance system in Indonesia is still limited. The availability of field personnel, alarming areas with extraordinary events, and early detection have not been maximized. Improved data collection, analysis, and early detection mechanisms are essential for a timely response to disease outbreaks (Adnyana, 2023a). Monitoring mosquito populations, human and animal disease prevalence, and environmental factors affecting vector habitats requires a coordinated effort from the household level to the Ministry of Health. Integrating data from different sectors helps policymakers identify disease hotspots, predict outbreaks, and implement targeted interventions. This can be achieved by incorporating advanced technologies, such as geographic information systems (GIS) and remote sensing, which can provide valuable insights into disease patterns, control strategies, and sectors that will help realize coordinated efforts (Adnyana, 2023c; Adnyana, Utomo, et al., 2023; Bhunia & Shit, 2019).

Furthermore, this approach strengthens vector control strategies across different sectors (Adnyana, Sudiartawan, et al., 2022; Adnyana & Surya, 2023). Traditional approaches to mosquito control have focused primarily on insecticides and elimination at breeding sites. However, the One Health perspective advocates integrated vector management (IVM) strategies that consider environmental, ecological, and social factors; chemical control minimization measures to minimize impacts on nontarget organisms and ecosystems; and the importance of diversifying approaches that facilitate community vector control. In IVM, control interventions include the judicious use of insecticides; biological control methods such as the introduction of larval predator fish; the use of repellent plants; and the modification of artificial and natural environments to disrupt mosquito breeding sites so that breeding sites can be minimized, leading to lower mosquito population numbers (Adnyana & Utomo, 2023). Collaboration among health authorities, environmental agencies, and local communities is fundamental to the successful implementation of integrated vector control in Indonesia.

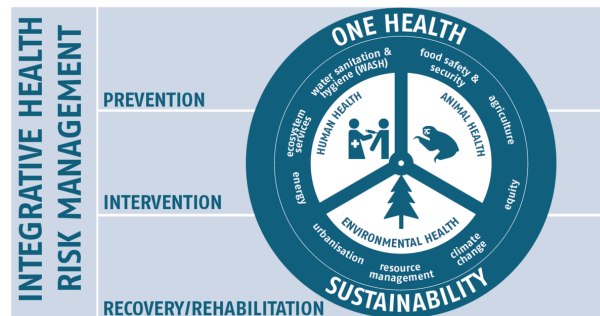
In addition, health capacity building and human behavior are needed early. Human behavior, population movement, and socioeconomic factors play important roles in the spread of mosquito-borne diseases. Effective disease prevention and control

strategies must consider human behavior, awareness, and access to health services. Increasing public awareness of minimizing breeding sites, teaching the basics of vectors, and presenting a clean and healthy environment are the smallest habit-forming efforts to realize the concept of one's health at the household level. Adopting a proactive attitude by fostering interdisciplinary collaboration will strengthen community behavior in efficiently combating mosquito-borne diseases. In addition, the One Health concept emphasizes interdisciplinary collaboration between various sectors, such as human health, animal health, environmental science, and policymaking. Effective communication and collaboration among these sectors is essential for surveillance, early detection, rapid response, and the development of comprehensive strategies to combat mosquito-borne diseases (Kittayapong, 2021). Finally, infrastructure capacity building and resource allocation are considered. Strong infrastructure and adequate resource allocation are necessary for the effective implementation of the One Health strategy. Strengthening healthcare systems, increasing laboratory capacity, and ensuring access to health services in remote areas are essential (Nugroho et al., 2019; Rahman et al., 2020; WHO, 2022). In addition, the allocation of sufficient funds for research, training, and program implementation is essential for sustaining efforts to eradicate mosquito-borne diseases. These key points should receive attention from relevant sectors to accelerate the eradication of mosquito-borne diseases in Indonesia.

Conclusion

The One Health paradigm offers a comprehensive framework for understanding and addressing the complexity of mosquito-borne diseases in Indonesia. Recognizing the interconnectedness of human, animal, and environmental health enables a deeper understanding of disease dynamics and facilitates the development of comprehensive strategies for disease prevention, control, and eradication. Implementing a holistic One Health approach can pave the way for a sustainable and resilient system capable of mitigating the burden of mosquito-borne diseases in Indonesia. Key points that must be implemented and given immediate attention by stakeholders include strengthening vector surveillance and monitoring systems, strengthening vector control strategies in various sectors, improving human health and behavioral capacity, effective communication and collaboration, and improving infrastructure capacity

and resource allocation. Implementing a proactive attitude by fostering interdisciplinary collaboration and investing in infrastructure will strengthen Indonesia's capacity to combat mosquito-borne diseases effectively. In the future, it will be important to map the key points of priority based on field conditions to maximize the One Health program in Indonesia.



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