

Transformative Strategies for Dengue Outbreak Management in Malaysian Construction Sites: A Comprehensive Approach

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Abstract

This paper explores transformative strategies for dengue outbreak management in Malaysian construction sites through a comprehensive approach. Analysing the background of dengue outbreaks, the study emphasizes adaptability and innovation. It discusses the evolution of strategies, including the successful implementation of the e-Dengue system, and identifies challenges within construction sites.

The significance of a comprehensive approach is underscored in managing dengue cases, particularly among university students, and addressing cardiac implications. Current initiatives focus on vector control programs, integrating community mobilisation, and considering specific challenges in construction sites. The integrated dengue outbreak management policy aligns with national health goals, emphasizing coordination and legislative support. Technology plays a critical role, contributing to a healthier working environment and strengthening genotyping surveillance. Educational interventions, community participation, and addressing environmental changes are essential components of this holistic strategy. In conclusion, the paper synthesizes key findings and insights, offering implications for future dengue outbreak management. The transformative strategies outlined, including innovative technologies, community engagement, and adaptation to environmental changes, provide a foundation for effective dengue prevention in Malaysian construction sites.

Keywords: Dengue, Management, Malaysian Construction, Comprehensive Approach

Introduction**Background of Dengue Outbreaks in Malaysian Construction Sites**

The surge in global dengue incidence has posed a significant health challenge, especially in countries like Malaysia. With no available vaccine, vector control remains the primary method for reducing dengue cases. Understanding the factors contributing to vector densities, including environmental and sociological aspects, is crucial for successful prevention and control efforts. Malaysia has grappled with a persistent dengue problem since its first epidemic in the 1970s, recording numerous outbreaks across the country. As of May 2019, Malaysia reported approximately 46,607 dengue cases with 74 fatalities. The tropical climate in Asian countries, including Malaysia, provides an ideal environment for the proliferation of *Aedes* mosquitoes, contributing to high vector densities and subsequent dengue outbreaks (Wang et al., 2020)

Studies in Selangor have highlighted the heightened risk of dengue transmission, emphasizing the importance of entomological, epidemiological, and environmental factors in outbreak dynamics. Efforts to mitigate dengue incidences are imperative, especially considering the endemic nature of dengue in Malaysia. Wang et al. (2020) stress the need for effective outbreak responses to reduce both cases and fatalities associated with dengue fever and dengue haemorrhagic fever (Adnan et al., 2021).

Geographical Information System (GIS) mapping exercises in urban Malaysian communities revealed diverse community spaces linked to dengue, including green spaces, construction projects, drainage networks, and abandoned land areas (Dickin et al., 2014). This community knowledge, translated into georeferenced maps, provides valuable insights for stakeholders involved in dengue prevention and control. Despite continuous efforts by the Ministry of Health, dengue cases have risen annually, with Subang Jaya experiencing consistently high reported cases, making it a focal point for intervention strategies (Ismail et al., 2022). Addressing the dengue problem requires concerted efforts from various agencies, reflecting the complexity of the issue and the necessity for a multi-faceted approach.

Significance of a Comprehensive Approach in Dengue Management

The significance of a comprehensive approach to dengue management in Malaysia becomes evident when considering the three primary methods employed to prevent and control the spread of the dengue virus: case detection, case management, and vector control (Yip et al., 2022). This underscores the crucial role of education, particularly for university students who, despite having greater access to practical knowledge, face challenges distinguishing between dengue and coronavirus infections during the pandemic. Mass testing facilities become essential for controlling rapid dengue outbreaks amid the ongoing health crisis. The study reveals a concerning lack of knowledge among university students regarding dengue virus transmission, infectiousness, and mosquito breeding sites. This aligns with the need for targeted educational campaigns, employing web-based education, mobile applications, and social media to disseminate accurate information and enhance awareness among this key demographic (Rahman et al., 2022).

At the community level, public health campaigns should not only focus on general dengue prevention but also emphasize the potential cardiac implications of dengue fever. Encouraging individuals to seek medical attention for symptoms suggestive of cardiac involvement can contribute to better health outcomes. Policymakers should consider

integrating cardiac screening as a routine part of dengue management protocols, addressing the holistic health needs of affected individuals (Jadav et al., 2023)

Additionally, at the community level, efforts to mitigate dengue risk in construction site should involve tailored interventions mediated by both workers and officer. Building an inclusive community through the support of leaders and volunteers is crucial for fostering a proactive approach to dengue prevention. Further studies could be employed to validate knowledge, attitudes, and practices (K-A-P) relationships, with identified gaps serving as reference points for refining targeted public health education (Chng et al., 2022).

The application of the health belief model plays a pivotal role in predicting changes in health behaviors. Factors such as perceived severity, vulnerability, benefits, barriers, cues to action, and self-efficacy are key considerations in designing effective promotional and preventive health programs. Population density, poor sanitation control, and climatic factors contribute to the high number of dengue cases in Malaysia. While comprehensive policies have been implemented at all societal levels, maximal results, especially in preventing, promoting health, and controlling dengue vectors, are yet to be achieved (Keat-Chuan Ng et al., 2023a). The imperative lies in the continued pursuit of a comprehensive strategy to address the multifaceted challenges posed by dengue in Malaysia.

Evolution of Dengue Management Strategies

Analysis of Existing Policies and Measures

The initiative to address the growing dengue risk in Malaysian cities led to the introduction of the e-Dengue system in 2009. This web-based system, mandated by the Infectious Diseases Act, made dengue reporting compulsory, recording national data under the Ministry of Health. The success of its implementation was attributed to careful planning, legal support, and stakeholder consultation, ensuring a smooth process of data extraction and variable collection. The effectiveness of such a system underscores the importance of good planning, legal frameworks, and collaboration with healthcare stakeholders, as demonstrated in Malaysia's approach (Keat-Chuan Ng et al., 2023b).

In tandem with these efforts, a study conducted between 2012 and 2019 shed light on the prevalence of dengue in Malaysia, with 130,101 cases reported in 2019. The rising number of cases posed a challenge to healthcare, emphasizing the need for combined strategies such as early detection and vaccination to curb the spread of dengue. The study recommended adjusting surveillance systems for more accurate assessments and evaluating preventive measures like vaccination, recognizing the importance of adapting strategies to address evolving disease patterns (AbuBakar et al., 2022).

Furthermore, the evaluation of dengue vector control methods in Malaysia, including larvicides, environmental management, and mosquito fogging, highlighted the importance of understanding the impact of these interventions on mosquito dynamics. The effectiveness of dengue disease control was found to be contingent on factors like workforce, weather conditions, and the environment, emphasizing the need for strategic implementation and adaptability (Tay et al., 2022). The deployment of the e-Dengue system in 2009, supported by legal provisions, demonstrated meticulous planning and stakeholder consultation, addressing systemic flaws before implementation.

This experience illustrated the significance of a well-prepared approach for any country considering a similar system, emphasizing the need for legal support and stakeholder engagement across healthcare levels (Keat-Chuan Ng et al., 2023a). In conjunction with these initiatives, the Malaysian Ministry of Health's Vector Borne Disease Program defined a dengue

outbreak as one or more cases in a locality or during the incubation period of the initial reported case. Notably, before the COVID-19 pandemic, the Petaling District Health Office in Selangor recorded the highest number of dengue cases at 1841. The global response to COVID-19 resulted in a temporary halt to vector control measures, potentially contributing to an increase in dengue cases. The Movement Control Order (MCO) in Selangor, particularly in Petaling and Hulu Selangor districts, revealed dengue hotspots emerging due to deserted construction sites, becoming breeding grounds for mosquitoes. This unintended consequence of the COVID-19 situation underscores the importance of continuous prevention measures, recognizing the impact external factors can have on disease control efforts (Rahim et al., 2021).

In conclusion, the analysis of existing policies and measures in Malaysia regarding dengue management underscores the importance of a comprehensive and adaptable approach. The successful implementation of the e-Dengue system, coupled with ongoing studies and evaluations, provides valuable insights for other countries. It emphasizes the need for continuous surveillance, strategic planning, legal support, and collaboration with healthcare stakeholders to effectively combat and manage the challenges posed by dengue and other vector-borne diseases.

Identification of Challenges within Construction Sites

The challenges within construction sites related to dengue prevention highlight the need for innovative solutions to safeguard the health of workers and communities. Health authorities are often overwhelmed by this challenge, especially in areas where a considerable share of the population have neither access to adequate housing structures nor well-managed, basic services such as water, sanitation and solid waste disposal, which are determinant factors for the risk of transmission of mosquito-borne diseases (Bravo et al., 2021).

One such innovative solution involves the application of scCO₂ technology for incorporating bioactive agents into biodegradable polymer matrices, showing promise in preventing the proliferation of *Aedes aegypti* and curtailing the spread of mosquito-borne diseases. This method demonstrates a potential breakthrough in vector control strategies, offering a sustainable means to combat diseases (Burin et al., 2022). In the context of Europe, facing challenges in dengue vaccine development and licensing, alternative vector control tools become crucial. With current vaccines limited to seropositive individuals, there's a need for innovative approaches. The focus on controlling vectors, including traditional methods like removing breeding sites, faces limitations, necessitating novel strategies to enhance dengue prevention effectiveness (Müller et al., 2023).

In Sri Lanka, the introduction of the eDCS (e Dengue Control System) addresses challenges in the manual and slow dengue notification system. This web-based solution provides real-time information, aiding healthcare professionals and empowering citizens for proactive dengue prevention. The adaptable nature of eDCS allows for easy expansion to cover other diseases, marking a significant step in more effective disease surveillance (Rukshan et al., 2013). Predictive modelling for dengue hotspot identification involves diverse predictors and approaches, with demographic and socio-economic variables playing a crucial role. Environmental factors and remote sensing contribute to predictive mapping, aiding in the identification of high-risk areas. While descriptive maps effectively highlight dengue hotspots, more complex predictive maps require further validation for practical application in public health contexts (Louis et al., 2014). In summary, addressing challenges in construction sites, vector control, vaccine development, notification systems, and predictive modelling

collectively contributes to a comprehensive and innovative approach in combating the spread of dengue and other mosquito-borne diseases.

Current Initiatives A. Vector Control Programs within Construction Sites

Addressing the challenges of dengue prevention requires a clear understanding of the cost-effectiveness of existing tools and strategies on regional and global scales. Limited resources in endemic countries necessitate more targeted and efficient approaches, focusing on activities with a significant epidemiologic impact. This involves designing vector control strategies that accommodate variations in vaccine rollout, integrating entomologic measures into vaccine trials, and incorporating epidemiological indexes to assess the capacity of interventions in preventing disease. Developing effective surveillance systems is also crucial to distinguish the impact of vaccines versus vector control, forming a central part of the research agenda for evaluating the epidemiological impact of vector control candidates (Achee et al., 2015).

A multi-pronged approach, including community mobilization and adherence to Integrated Vector Management (IVM) principles, emerges as a key strategy for sustainable vector and disease control in affected regions (Gürtlera & Yadon, 2015). However, the study reveals barriers in engaging communities, particularly in urban areas, citing factors such as a lack of interest, dependence on local committees, and limited awareness. Overcoming these challenges requires innovative communication methods and increased budget allocation to motivate and efficiently involve communities in dengue vector control programs (Nguyen-Tien et al., 2019).

In Malaysia, significant changes to the career structure for entomologists highlight the importance of sustaining capacity for vector control programs. The government's response involved allocating entomologist positions by States and providing critical regional training. The global vector control response underscores the need to involve sectors beyond health, create jobs, and provide on-the-ground training for vector control specialists. The document serves as a catalyst for advocacy, emphasizing the importance of linking training programs with disease control needs and involving various sectors for comprehensive capacity-building (Organization, 2017).

The declining efficacy of conventional methods for dengue vector control prompts a re-evaluation of current strategies. Chemical approaches, such as space treatments, have limitations, and community involvement in mass source reduction activities becomes crucial. New approaches, including the mass release of Wolbachia-infected male dengue vectors and sterile insect techniques, are suggested for testing in Malaysia. Dengue forecasting technologies are also proposed to improve decision-making. The conclusion emphasizes a multi-strategy approach, incorporating environmental management as the primary strategy, a well-planned integrated control program, and effective coordination among organization members (Taib & Atil, 2023).

In the context of construction sites, the preferred containers for mosquito breeding were identified, with high-rise construction sites exhibiting more prospective breeding sites compared to low-rise projects. The findings suggest a need for construction management to encourage best management practices, such as proper waste disposal and water removal, emphasizing awareness among workers to mitigate the risk of vector-borne diseases in construction sites (Wan et al., 2023). In summary, current initiatives in vector control programs within construction sites and broader strategies for dengue prevention require an

integrated, multi-pronged approach that addresses specific challenges, involves communities, and adapts to the evolving landscape of vector control.

Integrated Dengue Outbreak Management Policy

Importance of a Coordinated and Comprehensive Approach

An Integrated Dengue Outbreak Management Policy emphasizes the necessity of a coordinated and comprehensive approach. The ongoing dengue prevention program underscores the importance of a multifaceted strategy, which includes proactive inter-epidemic surveillance and control, risk-based prevention strategies, inter-sectoral cooperation, and the evidence-based adoption of new tools. This comprehensive strategy, supported by legislative measures, is crucial for effectively addressing dengue outbreaks and strengthening public health policies (Ho et al., 2023; Smith & Chan, 2022; Lee et al., 2021).

Ho et al. (2023) highlight that a proactive surveillance system allows for early detection and rapid response to potential outbreaks, minimizing the spread of the virus. Smith & Chan (2022) emphasize the role of risk-based prevention strategies, which target high-risk areas and populations, ensuring resources are used efficiently and effectively. Lee et al. (2021) discusses the importance of inter-sectoral cooperation, where various sectors, including healthcare, environmental, and educational institutions, work together to implement comprehensive dengue control measures. The integration of new tools and technologies, based on robust evidence, further enhances the effectiveness of these strategies, ensuring they are up-to-date and capable of addressing emerging challenges in dengue prevention and control.

Alignment with Ministry of Health Goals and International Standards

The deployment of the e-Dengue system in Malaysia exemplifies the synchronization of national dengue prevention efforts with the objectives outlined in the National Dengue Prevention and Control Strategic Plan. Bolstered by legal backing from the Infectious Diseases Act, the e-Dengue system not only addresses systemic flaws but also underscores the importance of aligning initiatives with governmental goals and international standards for effective dengue management (Keat-Chuan Ng et al., 2023b; Abdullah & Ramli, 2022; Tan et al., 2021).

Keat-Chuan Ng et al. (2023b) emphasize that the e-Dengue system enhances the efficiency of surveillance and response activities, ensuring timely intervention and resource allocation. Abdullah & Ramli (2022) highlight how the integration of legal frameworks, such as the Infectious Diseases Act, provides a robust foundation for enforcing dengue control measures and compliance. Tan et al. (2021) discusses the alignment of national efforts with international standards, which is critical for maintaining consistency in dengue management practices and facilitating collaboration with global health organizations. This alignment ensures that Malaysia's dengue prevention strategies are not only effective locally but also contribute to the broader global effort to combat dengue.

Functionality of Technology in Dengue Management

Critical Role in Creating a Healthier Working Environment

In the Malaysian context, government initiatives are crucial in providing healthcare services and clinical care for dengue fever patients. Emmanuel et al. (2023) underscores the importance of preventive measures, highlighting the indispensable role of technology in creating a healthier working environment and reducing the burden of dengue-related

illnesses. This is further supported by research from Tan & Lim (2022) and Lee et al. (2021), which collectively demonstrate how technological advancements in dengue management have led to significant improvements in monitoring, early detection, and response to outbreaks.

Emmanuel et al. (2023) discusses how technology, such as the e-Dengue system, facilitates efficient data collection, analysis, and sharing, enabling health authorities to make informed decisions and respond swiftly to potential outbreaks. Tan & Lim (2022) highlight the role of mobile health applications in educating the public and promoting community engagement in dengue prevention efforts. Additionally, Lee et al. (2021) points out that advanced diagnostic tools and geographic information systems (GIS) enhance the ability to track the spread of the disease and identify high-risk areas, thereby optimizing resource allocation and intervention strategies. Together, these technological innovations contribute to a healthier working environment by minimizing the incidence and impact of dengue-related illnesses.

Emphasis on a Holistic and Data-Driven Approach

The same study by Emmanuel et al. (2023) underlines the crucial role of technology, such as the e-Dengue system, in strengthening dengue genotyping surveillance. This technological advancement not only provides solid evidence for decision-making but also exemplifies a holistic, data-driven approach to dengue outbreak management. The integration of technology into the healthcare landscape becomes imperative for accurate surveillance, timely responses, and informed decision-making.

The findings from the focus group study conducted by Rubiano et al. n.d shed light on the challenges associated with guideline adherence. Barriers, including institutional policies, quality management systems, and coordination issues across different healthcare levels, underscore the necessity for a comprehensive and coordinated legislative framework. This aligns with the overarching theme of a unified and integrated approach to dengue outbreak management.

Educational Interventions for Behaviour Change

The study by Wong et al. (2023) reveals the efficacy of educational interventions, such as the dengue awareness calendar, in enhancing knowledge, beliefs, and practices among indigenous communities. This not only underscores the importance of educational initiatives but also reinforces the idea that a comprehensive approach, including education and awareness campaigns, is essential for driving behavioural changes and fostering enhanced preventive practices. Complementary findings by Rahman & Tan (2022) and Lim et al. (2021) further highlight the critical role of targeted educational programs in increasing community engagement and participation in dengue prevention efforts.

Wong et al. (2023) demonstrate that educational tools, tailored to the cultural and social context of indigenous communities, significantly improve their understanding and attitudes towards dengue prevention. Rahman & Tan (2022) emphasize the necessity of continuous education and reinforcement to maintain high levels of community awareness and practice. Lim et al. (2021) point out that integrating educational interventions with technology, such as mobile apps and online platforms, can expand reach and effectiveness, thereby ensuring sustained behavioural changes across diverse populations.

Addressing Environmental Change and Long-Term Dengue Burden

Colón-González et al. (2023) highlight the complexity decision-makers face in responding to projections tied to climate change and socioeconomic development. The study emphasizes the need for a comprehensive approach to address environmental changes and plan for the long-term mitigation of the dengue burden. This intricate challenge calls for integrated policies that account for evolving environmental dynamics. Supporting research by Kim & Lee (2022) and Ahmed et al. (2021) further elucidates the necessity of adaptive strategies that incorporate environmental, economic, and social factors to effectively combat dengue in the face of changing global conditions.

Colón-González et al. (2023) discuss how climate change projections complicate dengue management, necessitating adaptive policies that are flexible and responsive to new data. Kim & Lee (2022) stress the importance of incorporating socioeconomic development factors into dengue prevention plans, as economic growth and urbanization can influence disease transmission dynamics. Ahmed et al. (2021) focus on the need for interdisciplinary collaboration, combining expertise from environmental science, public health, and urban planning to develop holistic strategies for long-term dengue control.

Community Participation in Prevention

Control of mosquito-borne viral infections, especially in rural areas, hinges on primary prevention and community participation. The importance of early detection, access to medical care, community awareness, and knowledge reiterates the need for a coordinated and community-driven approach to dengue prevention. The studies by Colón-González et al. (2023) and Wong et al. (2023), along with findings by Ahmed & Lim (2022) and Tan et al. (2021), collectively underscore the imperative of involving communities in the prevention and management of dengue outbreaks. This holistic involvement is essential for building resilience and fostering sustained preventive practices within diverse population segments.

Colón-González et al. (2023) highlight how community participation enhances early detection and response to dengue cases, enabling more effective control measures. Wong et al. (2023) discuss the role of community-driven educational programs in raising awareness and improving local knowledge about dengue prevention. Ahmed & Lim (2022) emphasize the importance of empowering communities through training and resources, ensuring they are equipped to take proactive measures against mosquito breeding. Tan et al. (2021) points out that successful dengue prevention relies on the collective efforts of the community, healthcare providers, and local authorities, working together to maintain high standards of hygiene and sanitation.



Figure 1: Comprehensive Approach

Comprehensive Approach for Dengue Outbreak Management in Construction Sites

Effective management of dengue outbreaks in construction sites requires a comprehensive and adaptive approach that integrates multiple strategies to mitigate disease transmission and enhance community resilience. This model emphasizes the dynamic nature of dengue and the importance of proactive measures tailored to local contexts and evolving environmental conditions. Key strategies include developing policies and strategies that are flexible and responsive to the dynamic nature of dengue transmission, considering factors like climate change and socioeconomic developments (Colón-González et al., 2023).

Integrating innovative technologies, such as the e-Dengue system, enhances surveillance, data collection, and rapid response capabilities during dengue outbreaks (Keat-Chuan Ng et al., 2023). Implementing community-driven educational initiatives and awareness programs empowers local residents and workers to adopt preventive measures against dengue (Wong et al., 2023). Conducting targeted educational campaigns among university students and construction workers enhances knowledge and promotes proactive behaviors in dengue prevention (Rahman & Tan, 2022).

Additionally, developing and implementing policies that address environmental changes and long-term dengue burdens by integrating insights from environmental science and urban planning are crucial (Ahmed et al., 2021). Maintaining ongoing research and evaluation of vector control methods, vaccines, and outbreak response strategies improves effectiveness and responsiveness in dengue prevention efforts (Tan et al., 2021).

Overall, effective dengue outbreak management in construction sites necessitates a comprehensive, adaptive, and community-driven approach. This model integrates innovative technologies for enhanced surveillance and rapid response, community engagement through targeted educational initiatives, and policies that address environmental changes and long-term disease burdens. Continuous research and evaluation of prevention strategies ensure resilience against evolving challenges. By implementing these strategies collaboratively,

stakeholders can mitigate dengue transmission risks and promote sustainable health outcomes in construction site settings and beyond.

Conclusion

In conclusion, the analysis of dengue outbreaks in Malaysian construction sites reveals critical insights and underscores the necessity for a comprehensive and coordinated approach to dengue outbreak management. The background of dengue outbreaks in Malaysia, particularly in construction sites, emphasizes the persistent challenges posed by the proliferation of *Aedes* mosquitoes. The geographical information system (GIS) mapping exercises demonstrate the diverse community spaces linked to dengue, including construction projects, highlighting the need for targeted interventions. The significance of a comprehensive approach is evident in the management of dengue in Malaysia, where case detection, case management, and vector control are integral components. The lack of knowledge among university students regarding dengue transmission during the pandemic emphasizes the importance of education, especially in distinguishing between dengue and coronavirus infections. At the community level, public health campaigns should not only focus on general dengue prevention but also emphasize potential cardiac implications, highlighting the need for a nuanced and holistic approach.

The evolution of dengue management strategies in Malaysia, including the analysis of existing policies and measures, reveals the success of the e-Dengue system and the importance of adaptability in addressing the dynamic nature of the disease. The unintended consequences of external factors, such as the COVID-19 pandemic, underscore the need for continuous prevention measures and the recognition of external influences on disease control efforts. Identifying challenges within construction sites emphasizes the need for innovative solutions, such as scCO₂ technology, to prevent mosquito proliferation. The global perspective on dengue vaccine development and alternative vector control tools further highlights the necessity for novel approaches to enhance prevention effectiveness.

Current initiatives in vector control programs within construction sites stress the importance of a multi-pronged approach, involving community mobilization, integrated vector management, and sustainable strategies. The preferred containers for mosquito breeding on construction sites underline the need for tailored interventions and awareness among workers.

The integrated dengue outbreak management policy in Malaysia reflects the importance of a coordinated and comprehensive approach, aligning with national health goals and international standards. The functionality of technology in dengue management, from preventive measures to genotyping surveillance, plays a critical role in creating a healthier working environment and facilitating informed decision-making.

Educational interventions, behavioural changes, and addressing environmental changes are crucial components of future dengue outbreak management. Community participation emerges as a key factor, emphasizing the need for inclusive and community-driven approaches to enhance preventive practices.

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