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The Relationship between Mosquito Nest Eradication Practices (3M Plus) and the Incidence of Dengue Hemorrhagic Fever: A Case Control Study in Bengkulu City, Indonesia

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Abstract
Dengue Hemorrhagic Fever (DHF) remains a major public health problem in tropical and subtropical countries, including Indonesia, where periodic outbreaks are strongly associated with environmental conditions and community behaviors. This study aimed to analyze the relationship between mosquito nest eradication through the implementation of 3M Plus draining, closing, recycling, and additional preventive practices and the incidence of DHF in the working area of the Beringin Raya Public Health Center, Bengkulu City. A case-control survey design was employed involving 72 respondents, consisting of 36 cases and 36 controls selected through total sampling. Data were collected using structured questionnaires and analyzed with the Chi-Square test to assess associations, while odds ratios with 95% confidence intervals were calculated to determine risk estimates. The findings revealed that 43.1% of respondents demonstrated poor implementation of 3M Plus and 56.9% showed good practices. Bivariate analysis indicated a significant relationship between mosquito nest eradication behaviors and DHF incidence (χ^2 = 6.977; p = 0.017), with individuals demonstrating poor preventive practices being 3.64 times more likely to contract DHF compared to those with good practices. These results emphasize the critical role of consistent environmental management and community participation in minimizing vector breeding and reducing disease transmission. The novelty of this study lies in providing localized empirical evidence from Bengkulu City, where research on dengue prevention remains limited, thereby contributing to the evidence base for community-based vector control programs. The implications suggest that health centers and policymakers should strengthen health promotion, monitoring, and community engagement strategies to improve adherence to 3M Plus as an effective measure for reducing dengue incidence in endemic areas.

Keywords: 3M Plus; Community Health; Dengue Hemorrhagic Fever, Mosquito Nest Eradication, Vector Control

INTRODUCTION

Dengue Hemorrhagic Fever (DHF) is a mosquito-borne viral infection that continues to be a pressing public health concern in tropical and subtropical countries. Transmitted primarily by *Aedes aegypti* mosquitoes, dengue affects individuals across all age groups and occurs throughout the year with periodic outbreaks in densely populated regions. The World Health Organization (WHO) estimates that approximately 390 million dengue infections occur annually, with nearly 40% of the global population at risk, especially in urban and peri-urban areas where breeding sites are prevalent (Bhatt et al., 2013; Jakobsen et al., 2019; Organization, 2022). Dengue's increasing prevalence is strongly linked to environmental conditions, rapid urbanization, population growth, and behavioral practices that facilitate mosquito proliferation (da Silva & Scalize, 2023; Mulligan et al., 2012; Ortiz et al., 2021).

In Indonesia, dengue is among the most frequently reported vector-borne diseases, imposing a significant burden on healthcare systems and communities. National surveillance data indicate a rising trend in dengue cases, with 138,127 cases reported in 2019 compared to 65,602 cases in 2018, and fatalities nearly doubling from 467 to 919 within the same period (Hariyanto et al., 2019; Indriani et al., 2018; Mirnawati et al., 2022). The national incidence rate increased from 24.75 per 100,000 in 2017 to 51.48 per 100,000 in 2019, highlighting the growing severity of dengue in the country. Within

provincial contexts, disparities are evident; Bengkulu Province reported an incidence rate of 74.25 per 100,000 in 2019, ranking among the highest nationally (Ng et al., 2023; Rubianti et al., 2018; Tian et al., 2022). Bengkulu City itself recorded 301 cases with three fatalities, while the Beringin Raya Public Health Center reported 30 cases without deaths in the same year, underscoring the localized persistence of DHF (Mardiani et al., 2022; Pratiwi et al., 2022; Triana et al., 2023).

Since no specific antiviral treatment is available for dengue and the effectiveness of current vaccines is limited by serotype variation, prevention strategies focus primarily on vector control (Hershan, 2023; Khan et al., 2023; Obi et al., 2021). The Indonesian government promotes the mosquito nest eradication program known as "3M Plus," which consists of draining water containers, tightly closing storage tanks, burying or recycling discarded materials, and adopting additional preventive practices such as using larvicides or mosquito repellents (Nurdin et al., 2023). This program emphasizes community participation as a central strategy for reducing mosquito breeding sites and thereby lowering disease transmission risk (Chandra et al., 2021; Overgaard et al., 2016). Research has consistently shown that active community engagement in 3M Plus significantly reduces dengue incidence, provided that preventive behaviors are practiced continuously and comprehensively (Ananta et al., 2019; Elsa et al., 2017; Rakhmani et al., 2018)

Nevertheless, challenges in sustaining behavioral compliance remain significant. Studies in endemic regions highlight that communities often neglect critical practices such as draining containers, covering water storage, or eliminating potential breeding grounds, resulting in recurring outbreaks despite long-standing control campaigns (Egid et al., 2023; Guad et al., 2021; LaDeau et al., 2013). Knowledge gaps and limited awareness further hinder preventive efforts, as many individuals lack understanding of mosquito life cycles, preferred habitats, and the importance of consistent environmental management (Agyemang-Badu et al., 2023; Forsyth et al., 2020; Kumar et al., 2021). These findings suggest that while the 3M Plus strategy is theoretically effective, its practical success depends heavily on local behavioral patterns, socioeconomic factors, and health promotion strategies tailored to specific communities.

Several Indonesian studies have examined the relationship between 3M Plus behaviors and dengue incidence. Research conducted in Andalas Village, for example, demonstrated that poor adherence to 3M Plus was associated with a more than fivefold increased risk of DHF (Akbar & Maulana Syaputra, 2019; Priesley et al., 2018; Purba et al., 2023). Similarly, studies in Pekanbaru reported that inadequate implementation of draining, covering, and recycling behaviors significantly increased household-level risk of dengue infection (BANK, 2022; Benelli & Senthil-Nathan, 2019; Headland et al., 2019). While these studies provide valuable insights, most were conducted in larger urban centers and emphasize general behavioral correlations without sufficient focus on smaller communities or localized contexts such as Bengkulu City.

This indicates a gap in the literature concerning empirical assessments of mosquito nest eradication behaviors and their relationship to dengue incidence in Bengkulu, particularly within the working area of the Beringin Raya Public Health Center. Existing research has rarely applied rigorous analytical designs, such as case-control studies, to quantify the strength of associations between preventive practices and dengue outcomes at the community level. Therefore, the present study aims to analyze the relationship between mosquito nest eradication practices specifically the implementation of 3M Plus and the incidence of DHF in the working area of the Beringin Raya Public Health Center, Bengkulu City. By filling this gap, the study contributes to localized evidence on dengue prevention strategies and offers practical implications for strengthening health education, community engagement, and environmental management in similar endemic areas.

METHODS

This study employed an observational analytic design using a case-control approach to investigate the relationship between mosquito nest eradication practices through the implementation of 3M Plus and the incidence of Dengue Hemorrhagic Fever (DHF) in the working area of the Beringin Raya Public Health Center, Bengkulu City. The population included all individuals residing in the designated area who had been diagnosed with DHF during the study period, and a total sampling technique was applied. The final sample comprised 72 respondents, consisting of 36 cases (individuals

who had been diagnosed with DHF) and 36 controls (individuals without DHF), matched by age and residence to minimize potential confounding factors.

Data collection was conducted using structured questionnaires that were developed based on the guidelines of the Indonesian Ministry of Health for mosquito nest eradication and the 3M Plus program. The instrument measured the frequency and consistency of key preventive behaviors, including draining water storage containers, tightly closing water reservoirs, recycling or disposing of discarded items that could collect water, and additional practices such as using larvicides, mosquito nets, or repellents. The questionnaire was validated through expert review by public health professionals and piloted with a small group of respondents to ensure clarity, reliability, and cultural relevance. Data were collected through face-to-face interviews by trained enumerators, ensuring that respondents understood each item and reducing response bias.

The primary variables measured were the quality of mosquito nest eradication practices (categorized as good or poor implementation of 3M Plus) and the incidence of DHF (case or control). Univariate analysis was performed to describe the distribution of demographic characteristics and preventive behaviors among respondents. Bivariate analysis using the Chi-Square test was applied to determine the association between the implementation of 3M Plus and DHF incidence. Odds ratios (OR) with 95% confidence intervals (CI) were calculated to estimate the strength of the association, with statistical significance set at $p < 0.05$. This analytical approach was selected for its suitability in identifying risk factors associated with disease incidence in community-based epidemiological studies.

To ensure ethical compliance, informed consent was obtained from all participants before data collection, and confidentiality of responses was strictly maintained. Ethical approval for the study was granted by the institutional review board of the Faculty of Health Sciences, Universitas Dehasen, Bengkulu. The methodological rigor of this study, combining a validated instrument, a matched case-control design, and robust statistical analysis, was intended to provide credible evidence on the role of 3M Plus practices in preventing dengue transmission at the community level.

RESULTS AND DISCUSSION

Characteristics of Mosquito Nest Eradication Practices (3M Plus)

Table 1. Overview of the 3M Plus PSN Frequency Distribution in the Work Area of the Beringin Raya Public Health Center, Bengkulu City

No	PSN 3M Plus	frequency	Percentage (%)
1	Less	31	43,1
2	Good	41	56,9
	Sum	72	100

Out of the 72 respondents in the working area of the Beringin Raya Public Health Center, 31 individuals (43.1%) demonstrated poor mosquito nest eradication (3M Plus) practices, while 41 respondents (56.9%) showed good implementation. Respondents categorized as having poor implementation generally reported infrequent draining of water containers, inadequate covering of water storage, and neglect in burying discarded items that could serve as mosquito breeding sites. In contrast, respondents with good implementation reported routinely draining containers, closing water reservoirs tightly, recycling or disposing of unused items, and adopting additional preventive actions such as sprinkling larvicide and using mosquito nets.

Association between 3M Plus Practices and DHF Incidence

Table 2. The Relationship between PSN and the Implementation of 3M Plus with DHF Incidence in the Work Area of the Beringin Raya Public Health Center, Bengkulu City

PSN 3M Plus	Incidence Of Dengue Hemorrhagic Fever	OR (95% CI)

	Case		Control		Total		^{2}	p	
	f	%	f	%	f	%			
Less	21	58,3	10	43,1	31	43,1		0,017	3,640
Good	15	41,7	26	56,9	41	56,9	6,977		(1,359-
Total	36	100	36	100	72	100			9,751)

The bivariate analysis using the Chi-Square test showed a statistically significant association between 3M Plus practices and DHF incidence ($\chi^2 = 6.977$, $p = 0.017$). The odds ratio (OR) was 3.640 (95% CI: 1.359–9.751), indicating that individuals with poor 3M Plus implementation were 3.64 times more likely to contract DHF compared to those with good implementation. Among the 36 DHF cases, 21 respondents (58.3%) had poor 3M Plus practices, whereas among the 36 controls, only 10 respondents (27.8%) reported poor practices. These findings strongly suggest that consistent implementation of 3M Plus behaviors plays a protective role against DHF.

DISCUSSION

The results of this study confirm the importance of mosquito nest eradication through 3M Plus in reducing the risk of DHF. These findings are consistent with research conducted in Andalas Village, which showed that individuals with poor 3M Plus behavior were 5.8 times more likely to contract DHF than those who implemented good practices (Ananta et al., 2019). Similarly, studies in Pekanbaru reported that the presence of uncovered water storage, failure to drain containers, and the habit of hanging clothes indoors significantly increased the risk of DHF (Putri et al., 2022; Toan et al., 2015). Another study in West Java found that household compliance with 3M Plus practices was inversely correlated with larval density and mosquito breeding, directly influencing local dengue incidence (Nurdin et al., 2023; Prihanti et al., 2022; Ridha et al., 2023). These comparisons reinforce the robustness of the current findings and highlight the universal effectiveness of 3M Plus across diverse Indonesian regions.

The association identified in this study also aligns with international literature. Research in Thailand demonstrated that consistent household-level vector control practices, including draining containers and covering water storage, significantly reduced mosquito indices and lowered dengue incidence (Fansiri et al., 2021; Overgaard et al., 2023; Waewwab et al., 2020). Annan (2022), found that limited knowledge and inconsistent practice of mosquito prevention behaviors were major predictors of dengue outbreaks. These studies emphasize that behavioral and environmental management interventions remain crucial in countries where dengue is endemic.

The novelty of this study lies in its localized focus on Bengkulu City, a region with relatively scarce empirical research on dengue prevention compared to other Indonesian provinces. Unlike previous studies that emphasized descriptive surveys, this research applied a case-control design with statistical analysis, thereby quantifying the strength of association between 3M Plus implementation and DHF incidence. By demonstrating an odds ratio of 3.64, the study provides strong empirical evidence that poor implementation of 3M Plus considerably elevates the risk of DHF in this community. This methodological rigor contributes new insights into the epidemiological evidence base for vector control strategies in Indonesia.

The implications of this study are multifaceted. For public health practitioners, the results underline the necessity of strengthening community engagement programs and sustaining behavioral change interventions that promote consistent implementation of 3M Plus. Health centers should intensify education campaigns and integrate regular monitoring of household practices into routine vector surveillance. At the policy level, the study supports the inclusion of behavior-focused interventions within national dengue control strategies, aligning with WHO's emphasis on integrated vector management as a cornerstone of dengue prevention.

Nevertheless, this study has several limitations. First, the sample size was limited to 72 respondents within a single health center's jurisdiction, which may restrict the generalizability of the findings to broader populations. Second, the reliance on self-reported behaviors may have introduced recall bias or social desirability bias, potentially affecting the accuracy of responses. Third, the study focused only on behavioral and environmental factors without incorporating entomological indices such as larval density or adult mosquito counts, which could have provided a more comprehensive

understanding of vector dynamics. Future research should therefore expand to multiple sites, include larger and more diverse populations, and integrate entomological and ecological data to strengthen the evidence base for dengue prevention strategies.

CONCLUSION

This study demonstrated a significant association between mosquito nest eradication practices through the implementation of 3M Plus and the incidence of Dengue Hemorrhagic Fever (DHF) in the working area of the Beringin Raya Public Health Center, Bengkulu City, with individuals who practiced poor mosquito eradication behaviors being 3.64 times more likely to contract DHF compared to those with good practices. These findings reinforce the critical role of consistent community participation in environmental management and preventive behaviors as the cornerstone of dengue control strategies in endemic areas. The novelty of this study lies in its localized case-control analysis, which provides empirical evidence from Bengkulu City where research on dengue prevention remains limited, thereby offering new insights for strengthening Indonesia's vector control programs. The results imply that health centers and policymakers should intensify health education, household monitoring, and community engagement to improve adherence to the 3M Plus program as an effective public health measure. While the study was limited by its relatively small sample size, self-reported data, and a focus on a single geographic area, it provides a valuable foundation for future large-scale and multi-regional studies that integrate behavioral, environmental, and entomological factors to advance comprehensive dengue prevention strategies.

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