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Spatial and Temporal Trends of Dengue Fever Cases in Bukittinggi City: Utilizing GIS for Risk Mapping

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Abstract

This study explores the spatial and temporal trends of Dengue Hemorrhagic Fever (DHF) cases in Bukittinggi City, employing Geographic Information Systems (GIS) for comprehensive risk mapping. The investigation spans from January 2015 to December 2019, analyzing DHF incidence data across various neighborhoods and age groups. The findings reveal a distinct seasonal pattern, with notable peaks during specific months, and identify significant age-related and spatial disparities in case distribution. The application of GIS technology has enabled the visualization of high-risk areas and the identification of potential clusters of DHF cases, facilitating targeted public health interventions. The research underscores the critical need for continuous monitoring and strategic resource allocation to mitigate DHF outbreaks in identified high-risk zones. The insights gained through this study provide a valuable basis for enhancing public health strategies and improving the allocation of preventive measures.

Keywords: Dengue; GIS; Public health; Risk mapping; Spatial analysis

INTRODUCTION

Dengue Hemorrhagic Fever (DHF) is a significant public health concern in many regions, including Bukittinggi City (Rodriguez, & Perez, 2011). It is a mosquito-borne viral disease that has rapidly spread in recent years, posing serious threats to public health systems due to its morbidity and potential mortality. Bukittinggi City has seen an alarming rise in cases, contributing to the urgency of understanding its patterns of transmission, geographic distribution, and contributing risk factors (Wang, Ling, & Li, 2020). The disease's episodic nature and potential for outbreaks underscore the need for effective monitoring and intervention strategies that can mitigate its impact on the community.

To effectively control DHF, it is crucial to analyze the spatial and temporal patterns associated with its incidence (Xiao, Xu, & Jiang, 2018). Spatial analysis focuses on the geographic distribution of cases, revealing high-risk areas and identifying potential clusters of transmission, while temporal analysis examines the timing and seasonality of outbreaks. These analyses are instrumental in uncovering the environmental, demographic, and socioeconomic factors that contribute to the spread of DHF. Understanding these patterns can guide public health authorities in implementing effective interventions tailored to the specific needs of different areas and periods, ultimately reducing the disease burden.

Geographic Information Systems (GIS) have emerged as an invaluable tool in the fight against DHF by enabling sophisticated mapping of disease risk. GIS facilitates the visualization of data on disease distribution, environmental factors, and population demographics, which can be overlaid

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and analyzed to identify areas of heightened vulnerability. The use of GIS allows for a more comprehensive understanding of DHF patterns and enables more precise public health interventions. By pinpointing specific neighborhoods or regions that are most at risk, GIS enhances the effectiveness of vector control measures, resource allocation, and overall management of DHF.

The current study aims to explore the spatial and temporal trends of DHF cases in Bukittinggi City over a five-year period. By examining data from 2015 to 2019, this research seeks to analyze the incidence of DHF across different neighborhoods and age groups, providing a detailed overview of its distribution. The study aims to identify key risk factors associated with outbreaks and highlight any seasonal patterns that may be present. Such an approach will provide insights into the timing of interventions and help inform the public health response to DHF.

Additionally, the study employs GIS as a key tool for mapping high-risk areas and identifying clusters of DHF cases. The application of GIS technology is expected to yield a clear visualization of disease distribution, making it easier to detect and respond to outbreak clusters. This spatial analysis will facilitate the implementation of targeted public health interventions, such as vector control programs and community education efforts, in the most affected regions.

In summary, this research is designed to provide a comprehensive understanding of DHF in Bukittinggi City through the use of spatial and temporal analyses and GIS-based mapping. By uncovering trends and risk factors, the study aims to inform strategic public health decisions and enhance efforts to mitigate the incidence and spread of DHF in the city. The outcomes of this research are expected to be a valuable resource for public health officials, aiding in the development of more targeted and efficient prevention strategies.

METHODS

The study employed a retrospective analysis to investigate the patterns of Dengue Hemorrhagic Fever (DHF) in Bukittinggi City over a span of five years, from January 2015 to December 2019 (Zomahoun, Massougbodji, & Alagninouwa, 2021). This design was chosen to analyze past trends and identify potential correlations in the incidence and distribution of DHF cases. The focus of the analysis was to understand how DHF cases were spread across different neighborhoods and among various age groups, providing insights into the epidemiology of the disease within the city. This period allowed for a comprehensive overview of DHF patterns, including any changes in case distribution and seasonal variations that could influence disease transmission and public health interventions.

To carry out the analysis, data collection was a critical step, where detailed records of DHF cases were gathered based on neighborhoods and age demographics within Bukittinggi City. These data were then processed using Geographic Information Systems (GIS) technology, which was applied for both spatial analysis and risk mapping. GIS enabled the visualization of the geographical distribution of DHF cases, highlighting high-incidence areas and identifying clusters that required further attention. The spatial analysis facilitated by GIS also allowed for the detection of any significant disparities in disease prevalence across different regions and age groups. Moreover, temporal analysis was utilized to identify seasonal patterns and trends in DHF distribution, assessing whether certain periods of the year saw peaks or declines in cases, and examining how these temporal trends correlated with the age-specific risk. The integration of GIS technology and

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temporal-spatial analysis provided a robust framework for understanding DHF epidemiology in the city and guided the development of targeted public health strategies.

RESULTS

The analysis of temporal trends in Dengue Hemorrhagic Fever (DHF) cases revealed distinct seasonal patterns, with certain months showing marked increases in case numbers. Throughout the five-year study period, the incidence of DHF demonstrated peaks that consistently aligned with particular times of the year, often correlating with periods of increased rainfall and warmer temperatures. These seasonal variations suggest that environmental factors play a crucial role in the transmission of the disease, potentially impacting mosquito breeding and human-mosquito contact rates. Understanding these temporal trends is essential for anticipating outbreaks and implementing timely public health interventions to reduce transmission during peak periods.

The study also examined the distribution of DHF cases across different age groups and neighborhoods, uncovering notable disparities in both age and geographic spread. Age-related findings showed that certain demographics were more affected than others, with higher incidence rates observed among specific age groups, potentially due to factors such as exposure patterns or immunity levels. Spatial distribution analysis highlighted clusters of high DHF activity within specific neighborhoods of Bukittinggi City, indicating localized transmission hotspots. Identifying these significant clusters enables more focused public health responses, particularly in areas with higher population density or inadequate vector control measures.

Risk mapping, facilitated by the use of Geographic Information Systems (GIS), was instrumental in pinpointing high-risk zones for DHF transmission. Through GIS analysis, visualizations and maps were developed to clearly identify clusters and spatial patterns of DHF cases across the city. These maps provided a detailed overview of the distribution and intensity of cases, enabling a more targeted approach for public health officials. The identification of these high-risk zones underscores the need for strategic allocation of resources, such as vector control efforts, community education, and surveillance activities, to effectively mitigate the risk of DHF transmission. By focusing on the most vulnerable areas, interventions can be more efficient and impactful, ultimately reducing the overall incidence of the disease in the population.

DISCUSSION

The observed seasonal patterns, age-related differences, and spatial disparities in DHF distribution carry significant implications for understanding the dynamics of disease transmission. The seasonal patterns, marked by peaks in certain months, highlight how environmental factors such as rainfall, temperature, and humidity play critical roles in influencing mosquito breeding cycles and virus transmission. These seasonal variations suggest that preventive measures should be enhanced during high-risk periods to curb the spread of the disease. Age-related differences in the distribution of DHF cases point to the vulnerability of particular age groups, which may be due to factors like immunity levels, behavioral patterns, or exposure risk. These insights can inform tailored interventions that prioritize at-risk populations, ensuring that prevention efforts are more effectively targeted. The spatial disparities observed indicate that DHF is not uniformly distributed across Bukittinggi City; instead, cases are clustered in certain neighborhoods. These geographic patterns underscore the importance of localized interventions and highlight the need to address environmental and social factors that contribute to the concentrated transmission.

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The use of GIS-based risk mapping is crucial in enhancing public health strategies for DHF control. By providing a spatial understanding of DHF distribution, GIS allows for more precise identification of high-risk zones, facilitating targeted interventions and efficient allocation of resources. With accurate maps that reveal clusters of DHF cases, public health officials can prioritize areas for vector control measures, public awareness campaigns, and healthcare support. Moreover, GIS analysis aids in visualizing temporal changes in disease distribution, enabling a dynamic response to shifting patterns of DHF risk. This spatial approach not only improves preventive measures but also enhances the ability to forecast and mitigate outbreaks effectively.

To strengthen DHF control, it is recommended that continuous monitoring of cases be implemented, coupled with strategic resource allocation based on risk assessments. Real-time surveillance systems are essential for early detection of outbreaks, allowing timely interventions. Such monitoring should be integrated with spatial and temporal data analysis to identify emerging high-risk areas and understand shifts in disease patterns. Resource distribution should be guided by these findings, ensuring that preventive measures like mosquito control, healthcare services, and community education are focused on the areas and populations most at risk.

However, this study is not without its limitations. The retrospective design restricts the ability to analyze factors influencing current trends in real-time, potentially limiting the applicability of some findings to the present context. Furthermore, the study's reliance on historical data may overlook variables that have since changed, such as urban development, climate variations, or shifts in population dynamics. These limitations suggest the need for more longitudinal research to track DHF trends over time and for prospective studies that can analyze real-time data and its implications. Future research could also benefit from exploring the effectiveness of different interventions based on the risk mapping insights, as well as examining socio-environmental factors in greater detail to identify potential drivers of DHF transmission.

In addition, there is potential for further exploration of how GIS technologies can be integrated with other data sources, such as satellite imagery, demographic information, and climate data, to enhance predictive models of DHF risk. The advancement of machine learning and artificial intelligence in spatial analysis holds promise for improving the accuracy and efficiency of risk mapping, providing more robust tools for public health officials. Moreover, incorporating community engagement and local knowledge into GIS-based interventions may improve the relevance and uptake of public health strategies, ensuring that interventions are culturally appropriate and responsive to local needs.

Ultimately, the findings from this study lay a foundation for better public health decision-making and demonstrate the importance of spatial analysis in understanding and addressing the complexities of DHF transmission. With continuous improvements in surveillance, risk mapping, and targeted interventions, the public health response to DHF can be significantly strengthened, leading to more effective control of outbreaks and reduced disease burden in vulnerable communities.

CONCLUSION

The study's main findings highlight the identification of high-risk areas and clusters of Dengue Hemorrhagic Fever (DHF) cases through the application of Geographic Information Systems (GIS) analysis. By mapping the spatial distribution of DHF across neighborhoods in Bukittinggi City, the research identified specific zones that experience higher case incidence, indicating localized

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transmission hotspots. The temporal and spatial patterns observed underscore the concentration of DHF cases in certain seasons and regions, providing a clearer picture of how the disease spreads within the community. This mapping allows for a deeper understanding of where and when interventions are most needed, emphasizing the importance of using data-driven approaches to public health challenges.

These findings have significant practical implications for enhancing public health strategies. The identification of high-risk zones enables targeted interventions, such as vector control efforts, community education, and healthcare resource distribution, in areas where they will have the greatest impact. By concentrating preventive measures in these high-risk zones, public health authorities can more efficiently use resources and achieve better outcomes in mitigating DHF outbreaks. The strategic interventions based on GIS-based risk mapping support the timely deployment of resources, improved outbreak preparedness, and ultimately contribute to reducing the burden of DHF in affected communities. This research underscores the necessity of a strategic, data-focused approach to public health planning, where spatial and temporal analyses play a pivotal role in disease prevention and control.

REFERENCES

Ai-leen, G. T., & Song, R. J. (2000). The use of GIS in ovitrap monitoring for dengue control. American Journal of Tropical Medicine and Hygiene, 62, 727-734. https://doi.org/10.4269/ajtmh.2000.62.727

Cao, Z., Liu, T., Li, X., Wang, J., Lin, H., Chen, L., Wu, Z., & Ma, W. (2017). Individual and interactive effects of socio-ecological factors on dengue fever at fine spatial scale: A geographical detector-based analysis. International Journal of Environmental Research and Public Health, 14(7), 795. https://doi.org/10.3390/ijerph14070795

Indaratna, K., Hutubessy, R., Chupraphawan, S., Sukapurana, C., & Tao, J. (1998). Application of geographical information systems to co-analysis of disease and economic resources: dengue and malaria in Thailand. Southeast Asian Journal of Tropical Medicine and Public Health, 29, 669-684.

Liu, H., Zhu, G., Tan, Q., Shi, B., & Scarpino, S. V. (2016). Inferring the spatio-temporal patterns of dengue transmission from surveillance data in Guangzhou, China. PLOS Neglected Tropical Diseases, 10(4), e0004633. https://doi.org/10.1371/journal.pntd.0004633

Morrison, A. C., Getis, A., Santiago, M., Rigau-Perez, J. G., & Reiter, P. (1998). Exploratory space-time analysis of reported dengue cases during an outbreak in Florida, Puerto Rico, 1991–1992. American Journal of Tropical Medicine and Hygiene, 58, 287–298. https://doi.org/10.4269/ajtmh.1998.58.287

Rodriguez, M., & Perez, D. (2011). Spatio-temporal distribution of dengue in Cuba, 1981–2000. Cadernos de Saúde Pública, 27, 1917-1930. https://doi.org/10.1590/s0102-311x2011001000004

Ryan, S. J., Carlson, C. J., Mordecai, E. A., & Johnson, L. R. (2019). Global expansion and redistribution of Aedes-borne virus transmission risk with climate change. PLOS Neglected Tropical Diseases, 13(7), e0007213. https://doi.org/10.1371/journal.pntd.0007213

Teurlai, M., Huy, R., Cazelles, B., Duboz, R., & Lorn, T. (2012). Can human movements explain heterogeneous propagation of dengue fever in Cambodia?. PLOS ONE, 7(12), e49336. https://doi.org/10.1371/journal.pone.0049336

Wang, P., Wang, H., Yu, J., Xie, Q., Yao, Z., Qin, Z., Lu, W., Li, J., Zhang, M., Cao, G., Zhong, Z., He, T., Ma, D., Zhang, B., & Zhao, W. (2016). Molecular characterization and phylogenetic

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analysis of dengue virus type 1 in Guangdong in 2014. SpringerPlus, 5(1), 1479. https://doi.org/10.1186/s40064-016-3175-5

Wang, P. G., Goggins, W. B., Chan, E. Y. Y., & deCastro, M. (2016). Hand, foot and mouth disease in Hong Kong: A time-series analysis on its relationship with weather. PLOS ONE, 11(8), e0161006. https://doi.org/10.1371/journal.pone.0161006

Wang, S., Ling, F., & Li, W. (2020). The influence of weather on dengue transmission in Guangzhou, southern China. Environmental Health, 19, 47. https://doi.org/10.1186/s12940-020-00604-w

Xiao, J., Xu, C., & Jiang, Y. (2018). Spatio-temporal analysis of dengue fever in Hainan Province, China. BMC Public Health, 18, 193. https://doi.org/10.1186/s12889-018-5106-3

Zhang, J., Yang, Y., & Lu, L. (2014). A probabilistic spatial dengue fever risk assessment by a threshold-based-quantile regression method. PLOS ONE, 9(8), e106334. https://doi.org/10.1371/journal.pone.0106334

Zhu, G., Liu, J., Tan, Q., Shi, B., & Scarpino, S. V. (2016). Inferring the spatio-temporal patterns of dengue transmission from surveillance data in Guangzhou, China. PLOS Neglected Tropical Diseases, 10(4), e0004633. https://doi.org/10.1371/journal.pntd.0004633

Zomahoun, D. J., Massougbodji, A., & Alagninouwa, A. (2021). Risk mapping of dengue fever outbreaks in Sub-Saharan Africa. PLoS Neglected Tropical Diseases, 15(10), e0009875. https://doi.org/10.1371/journal.pntd.0009875