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Spatiotemporal Trend of Hand-Foot-Mouth Disease and Its Relationship with Environmental Factors in Negeri Sembilan

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SUMMARY

Hand-Foot-Mouth Disease (HFMD) is a rising public health concern with exorbitant potential pandemic risks. In the public health field, tools such as Geographic Information System (GIS) and forecasting are gaining importance due to their capability of anticipating the future trend of disease distribution through space and time. This study aimed to produce a thematic map of HFMD case distribution and develop a forecasting model using environmental factors to predict the cases of HFMD. This study has shown that GIS has facilitated the identification of the significant hotspot in the study area and the ARIMA model was able to predict HFMD cases.

Keywords

HFMD, environment factors, GIS, ARIMA model, forecasting modelling

INTRODUCTION

By August 2018, Negeri Sembilan had been shown as the third state with significant Hand-Foot-Mouth Disease (HFMD) cases reported. The state of Negeri Sembilan also recorded a significant case increment of 281 percent to 2,386 compared to 627 cases in the same period in 2017(1). Nonetheless, the HFMD study involving GIS and forecasting modeling has not been extensively studied in Malaysia. Earlier epidemiological spatial research on HFMD concludes that Geographic Information System (GIS) data on the spatial distribution of HFMD cases had been useful in assisting decision-making in outbreak control measures (2). Similarly, a study done in (2016), discussed the application of GIS in mapping the distribution of HFMD and also attempted to model a time series forecasting of HFMD cases in Sarawak. This study found that the ARIMA model fits the trends of HFMD in the study area very well (3). Unfortunately, neither of these studies examined the effect of environmental factors on the incidence of HFMD. Therefore, Spatial-temporal analysis modeling was preferred by combining GIS and time series analysis, which will help to recognize the spatial and temporal trend of HFMD disease and determine the contributing effect of environmental factors.

MATERIAL & METHODS

GIS was used to map the distribution of HFMD and identify the significant hotspot locality using Moran's I cluster analysis. While, autoregression integrated moving average (ARIMA) was constructed to create an optimal forecasting model based on the weekly HFMD cases and weather parameters from 2013-2017 in Negeri Sembilan, Malaysia. The performance of the model was evaluated using Bayesian Information Criteria (BIC), Root Mean Square Error (RMSE), and Mean Absolute Percentage Error (MAPE).

RESULTS

Moran's I spatial analysis reveals a significant clustering from 2013-2017 with hotspots identified consistently in the central, southwest, and northwest areas of Seremban District. Six ARIMA models were constructed, with three univariate ARIMA models (0,1,1),(1,1,1), and (2,1,1) and three multivariate ARIMAX models of the same order. The performance of these models was compared and analyzed. The univariate ARIMA model (0,1,1) (BIC = 4.039, RMSE=7.455, MAE=5.553) was chosen as the base model, and adding weather factors as external regressor significantly increases the model prediction accuracy (0,1,1)x (BIC=4.001, RMSE= 7.229, MAE=5.501).001.

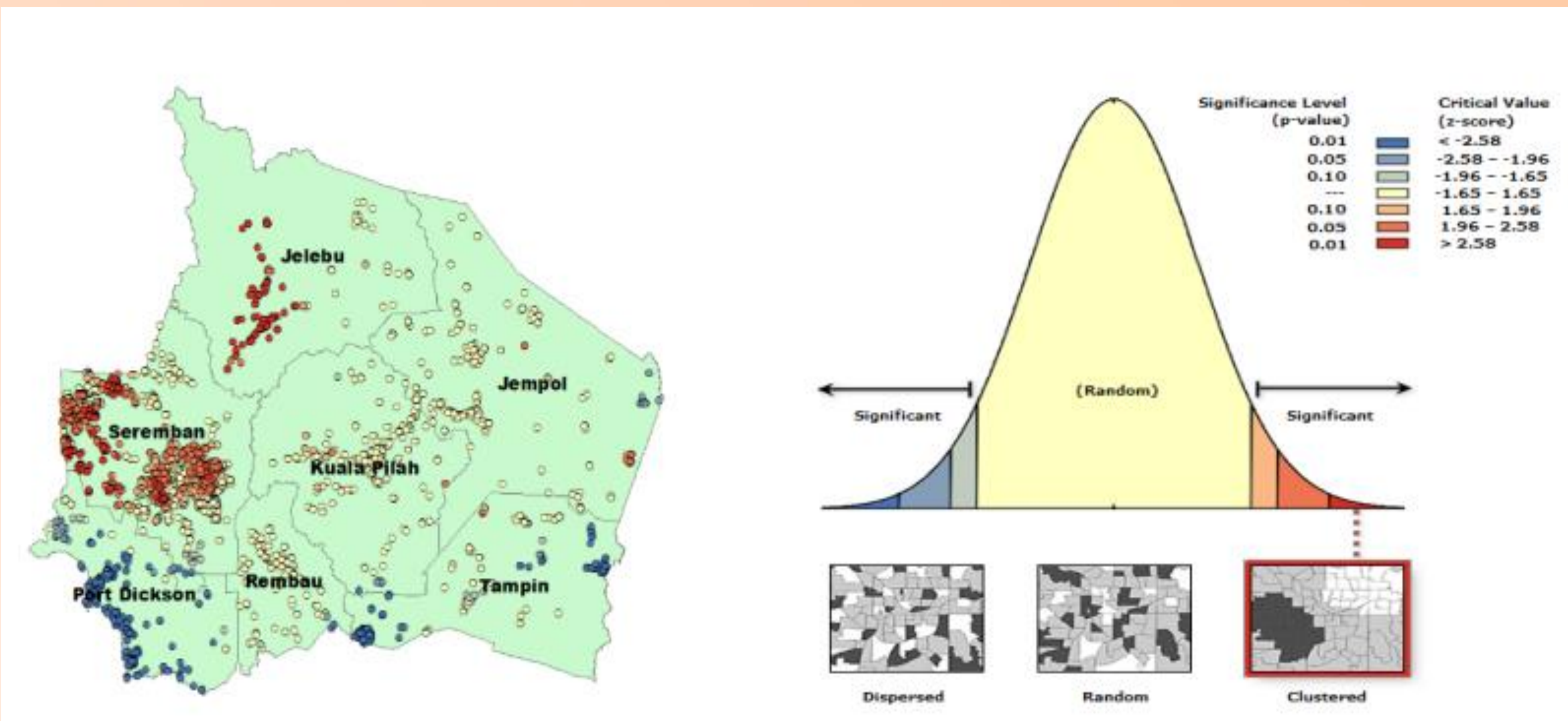


Figure 1. Moran's I analysis of HFMD Cases from 2013-1017 in Negeri Sembilan

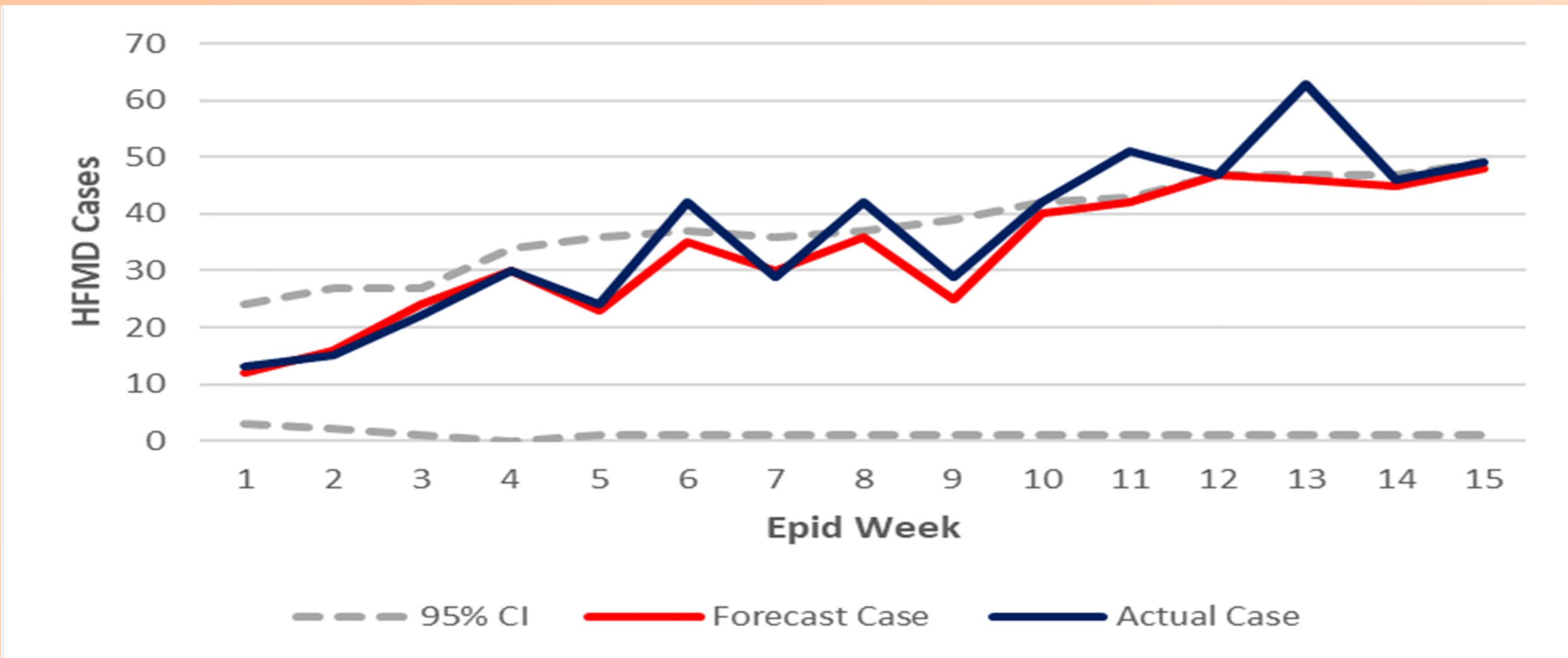
Table 1. Statistics Summary of Model Performance Measures

Model ARIMA (p,d,q)	Value of Model Selection Criteria				
	R^2	RMSE	MAPE	MAE	BIC
(0,1,1)	0.625	7.455	51.815	5.553	4.039
(1,1,1)	0.637	7.362	51.891	5.496	4.057
(2,1,1)	0.637	7.379	51.848	5.495	4.083
x(0,1,1)*	**0.658**	**7.229**	**51.630**	**5.501**	**4.001**
x(1,1,1)	0.677	7.091	55.441	5.382	4.089
x(2,1,1)	0.653	7.251	49.142	5.436	4.112

x( ) ARIMA model with environmental factors integrated. ( )* model selected with the highest performance

Table 2. Regression Estimation of model ARIMAx (0,1,1)

	Estimated	Standard Error	Z Value	P Value
MA (1)	0.427	0.58	7.339	0.001
Min. Temperature	2.779	0.946	2.937	**0.004**



Figures 2. Forecast of HFMD cases in 2018

DISSCUSSION

The minimum temperature was the only significant factor in predicting HFMD cases. An increase of 1°c in minimum temperature will increase HFMD cases by 27.7% in 4 months. The trend of HFMD in Negeri Sembilan is still increasing. GIS has enabled this study to visualize the spatial distribution pattern of HFMD and Moran' I spatial analysis has facilitated the identification of hotspots in the study area. This study has also shown that the ARIMA model was able to predict HFMD cases with fairly good estimation. The introduction of the weather factors and their one-lagged order significantly improved the prediction accuracy of the ARIMA model and revealed that weather parameters can be incorporated into disease surveillance as an early warning system for potential outbreaks (4).

CONCLUSION

The combination of Spatio-temporal analysis in this study allows for HFMD preventive measures to be planned and implemented by public health authorities ahead of any predicted outbreak in the identified disease-prone area.

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