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Relative Risk Estimation for the Epidemiology of Hepatitis B in Malaysia: An Analysis Based on SMR Method and Poisson-Gamma Model

Anggaran Risiko Relatif bagi Epidemiologi Hepatitis B di Malaysia: Suatu Analisis Berdasarkan Kaedah SMR dan Model Poisson-Gamma

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Abstract

Disease mapping is used to display the geographical distribution of disease occurrence. The focus of a disease mapping is to estimate the true relative risk of a disease and to display the disease risk on map so that further attention can be made. In Malaysia, there are no specific methods that are used to estimate the relative risk of Acute and Chronic Hepatitis B. The areas that are reported to have high number of cases are spotted to have a high risk area for the disease, whereas the area with low number of cases spotted as low risk area for disease. Therefore, the main objective of this research is to find a better method to estimate the relative risk of Acute and Chronic Hepatitis B in Malaysia. This study will used the commonest methods that are the Standardized Morbidity Ratio (SMR) and Poisson-gamma model based on count data of Acute and Chronic Hepatitis B in Malaysia. For the Poisson-gamma model, the data are analysed using WinBUGS software. In this research, the results of relative risk estimation based on SMR will be compared to Poisson Gamma Model by using graph, maps and tables. At the end of this study, it is expected that a better method can be used to estimate the relative risk and produced an accurate disease maps for Acute and Chronic Hepatitis B in Malaysia.

Keywords acute and chronic Hepatitis B, disease mapping, standardized morbidity ratio, poisson-gamma model, relative risk

Abstrak

Pemetaan penyakit digunakan untuk memaparkan taburan geografi kejadian penyakit. Fokus pemetaan penyakit adalah untuk menganggarkan risiko relatif sebenar penyakit dan untuk memaparkan risiko penyakit pada peta supaya perhatian lanjut dapat dilakukan. Di Malaysia, tidak ada kaedah tertentu yang digunakan untuk menganggarkan risiko relatif bagi akut dan kronik Hepatitis B. Kawasan yang dilaporkan mempunyai jumlah kes yang tinggi akan dikesan mempunyai kawasan yang berisiko tinggi untuk penyakit itu, manakala kawasan dengan jumlah kes yang rendah dikesan mempunyai kawasan risiko rendah untuk penyakit. Oleh itu, objektif utama kajian ini adalah untuk mencari kaedah yang lebih baik untuk menganggarkan risiko relatif akut dan kronik Hepatitis B di Malaysia. Kajian ini akan menggunakan kaedah lazim iaitu *Standardized Morbidity Ratio* (SMR) dan model

Poisson-gamma berdasarkan data kiraan akut dan kronik Hepatitis B di Malaysia. Bagi model Poisson-gamma, data dianalisis menggunakan perisian WinBUGS. Dalam kajian ini, keputusan anggaran risiko relatif berdasarkan SMR akan dibandingkan dengan model Poisson-Gamma dengan menggunakan graf, peta dan jadual. Pada akhir kajian ini, adalah dijangkakan bahawa kaedah yang lebih baik boleh digunakan untuk menganggarkan risiko relatif dan menghasilkan sebuah peta yang tepat untuk penyakit akut dan kronik Hepatitis B di Malaysia.

Kata kunci akut dan kronik Hepatitis B, pemetaan penyakit, *Standardized Morbidity Ratio* (SMR), model poisson-gamma, risiko relatif

INTRODUCTION

This paper presents and discusses the study of disease mapping related to Acute and Chronic Hepatitis B in Malaysia. In the study of disease mapping, there are two common methods that have been used to estimate the relative risk. These methods are Standardized Morbidity Ratio (SMR) and Poisson-gamma model. SMR are the traditional method used to estimate the relative risk. First, we describe the SMR and its drawbacks. Then, we review the application of Poisson-gamma model as suggested by Samat and Percy (2012). Consequently, we applied these methods to estimate the relative risk of Acute and Chronic Hepatitis B in Malaysia for the high risk and low risk area of the disease and then, determine a better method to estimate the Acute and Chronic Hepatitis B risk.

METHODOLOGY

Standardized Morbidity Ratio (SMR)

In disease mapping, to estimate the relative risk, we usually start with SMR method. Mostly in SMR, the ratios are the observed incidence with the expected incidence. It is used to analyzed counts within tracts that has been explained in Lawson (2006). In this study, the definition of the SMR value obtained is based on the definition suggested by Samat and Percy (2008), where SMR represents the probability of a person within a specific region contracting the disease divided by the probability that a person in the population contracting the diseases.

Here, the study areas are mapped into M mutually exclusive regions ($i = 1, 2, \ldots, M$), where, each region contains its own observed number of cases o_i and expected number of cases e_i based on an assumption of homogeneity in its simplest form. Then, we can calculate the relative risk θ_i by

$$\theta_i = \frac{o_i}{e_i} \qquad 1$$

Equation (1) is used and discussed by Samat and Percy (2012) in their study on standardized morbidity ratio and its application to dengue disease mapping in Malaysia.

Based on Equation (1), the SMR will be zero when there are no observed count data in the areas. This value can be wrongly interpreted as there is zero risk in those current areas. Thus, further attention need to be done before we interpret the SMR.

Poisson-Gamma Model

Since the SMR have drawbacks, this study uses the Bayesian methods as modern approaches to estimate the relative risk. The earliest example of Bayesian mapping is the use of Poisson-gamma model in the estimation of risk as discussed by Lawson (2006), where Poisson distribution is used to model the number of occurrences of rare events that occurs randomly in time or space at a constant rate during a fixed time interval. In this model, for $i = 1, 2, \ldots\ldots, M$ study regions and $j = 1, 2, \ldots\ldots, T$ time periods, the numbers of new infectives y_{ij} are assumed to follow a Poisson distribution within a given period of time, with mean and variance $e_{ij}\ \theta_{ij}$ where e_{ij} is the expected number of new infectives and θ_{ij} is the relative risk :

$$y_{ij} \left| e_{ij}, \theta_{ij} \sim Poisson \left(e_{ij} \theta_{ij} \right) \right. \quad 2$$

The relative risk parameter has a gamma prior distribution with parameters α and β:

$$\theta_{ij} \sim (\alpha, \beta) \quad 3$$

The output of the analysis includes the posterior expected relative risks for all regions and for all time periods, based on this Poisson-gamma model.

Application of Standardized Morbidity Ratio and Poisson-Gamma Model to Acute and Chronic Hepatitis B

This section represents the results of the application of SMR method and the Poisson-gamma model. Both methods use observed data of Acute and Chronic Hepatitis B in Malaysia. The data are analysed using WinBUGS software that is designed to produce wide variety of Bayesian Model. Then, the results are compared and presented in tables, graphs and maps that are suitable for the relative risk estimation of Acute and Chronic Hepatitis B in Malaysia.

The Data Set

The data for this research were provided by Disease Control Division of Ministry of Health Malaysia. This research considers all 15 states in Malaysia, where Putrajaya is included in Kuala Lumpur state. The data used in this study are based on the data from January to December 2013 for Acute and Chronic Hepatitis B.

RESULT AND DISCUSSION

The Results

According to the definition of relative risk explained in Lawson (2006), a relative risk less than one means that susceptible people within the region is generally less likely to contract Acute and Chronic Hepatitis B compared with people in the overall population. Figures 1 and 2 show the time series plots of SMR for Acute and Chronic Hepatitis B in 15 states

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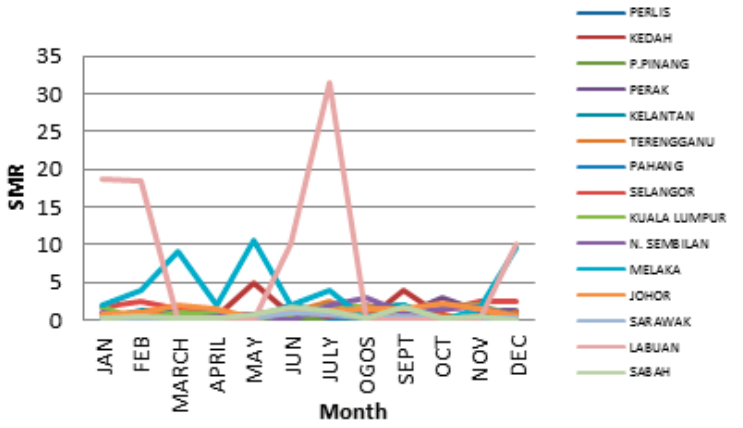

Figure 1 Time series plot of the SMR for Acute Hepatitis B

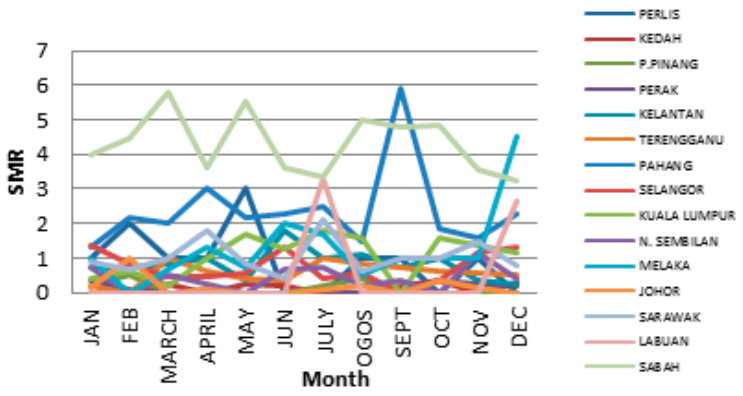

Figure 2 Time series plot of the SMR for Chronic Hepatitis

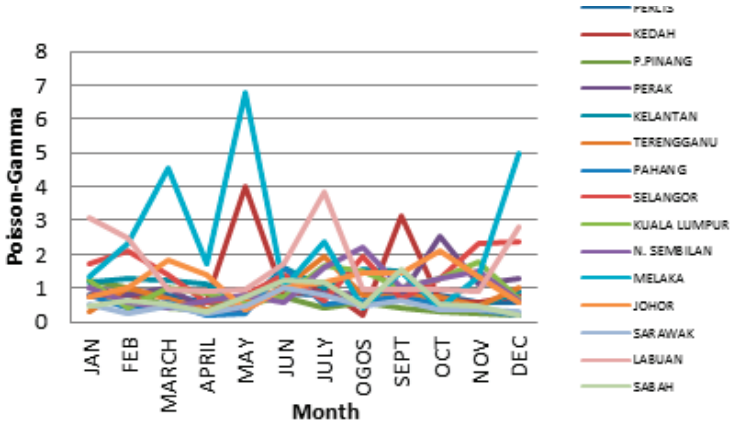

Figure 3 Time series plot of the relative risk for Acute Hepatitis B based on Poisson-Gamma model

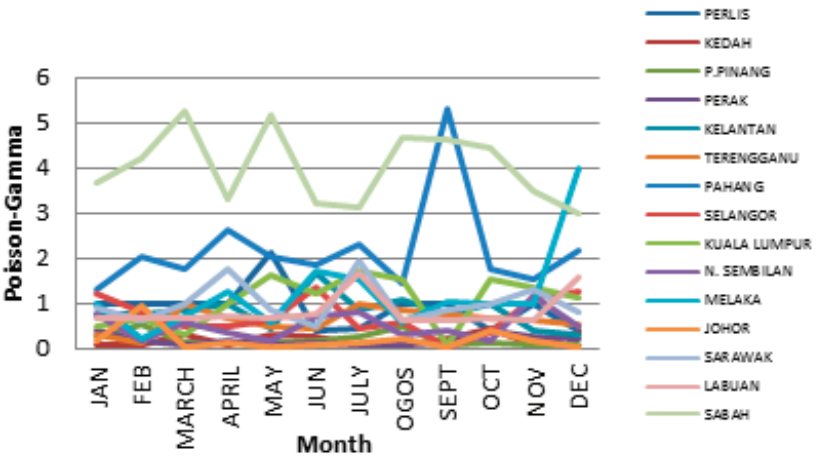

Figure 4 Time series plot of the relative risk for Chronic Hepatitis B based on Poisson-Gamma model

in Malaysia from January to December 2013. In Figure 2, it can be seen that the state of Selangor had the highest number of relative risk for Acute Hepatitis B in September with SMR equal to 1.429 and the lowest cases were reported in Perlis with SMR equal to 0 which means that there is no observed Hepatitis B case in the region. For Chronic Hepatitis B in Figure 2, the highest number of relative risk was reported in Pahang, also in the month of September with SMR equal to 5.889 and the lowest cases were reported in Perlis, Kedah, Pulau Pinang and Labuan with SMR in the range less than 0.5.

Figures 3 and 4 show the time series plot of the estimated risk for Acute and Chronic Hepatitis B cases based on Poisson-Gamma model for all 15 states in Malaysia from

Table 1 Comparison of the relative risk estimation for Acute Hepatitis B in January

STATES	Relative Risk based on SMR Method	Relative Risk based on Poisson-Gamma Model
Perlis	0.000	0.763
Kedah	0.100	0.817
Pulau Pinang	0.190	1.245
Perak	1.000	1.002
Kelantan	0.241	1.201
Terengganu	0.000	0.321
Pahang	0.091	0.776
Selangor	1.818	1.739
Kuala Lumpur	1.667	1.253
Negeri Sembilan	1.000	1.027
Melaka	2.000	1.324
Johor	0.714	0.767
Sarawak	0.400	0.531
Labuan	18.75	3.087
Sabah	0.333	0.455
Mean	0.000	0.321
Standard Deviation	4.578	0.672

January to December 2013. In Figure 3, for Acute Hepatitis B the highest relative risk are 5.888 in Pahang on May and the lowest relative risk are Melaka with 0 relative risk on December. In Figure 4, for Chronic Hepatitis B the highest relative risk are also Pahang with 5.333 and lowest in Johor with zero relative risk.

In Table 1, it can be seen that by using SMR method, the relative risk for Acute Hepatitis B in January is 18.75. Then, by using the Poisson-Gamma Model the relative risk for Labuan have been reduce to 3.087. For Perlis and Terengganu the relative risk using the SMR is equal to zero because there are no Acute Hepatitis B recorded in January for this two states. The mean for SMR is 0 and for Poisson-Gamma is 0.321, whereas the standard deviation for SMR is 4.578 reduces to 0.672 by using Poisson-Gamma. While the estimation using the Poisson-Gamma Model is 0.763 for Perlis and 0.321 for Terengganu. In Table 2 for Chronic Hepatitis B shows that the zero risk area in Kedah and Labuan have increased to 0.077 and 0.662 which means there are still a very low risk of contracting Chronic Hepatitis B in this area. The mean for SMR is 0 and for Poisson-Gamma is 0.077, where the standard deviation for SMR is 0.992 that is reduced to 0.857. This shows that the relative risk estimation using Poisson-Gamma model can overcome the problem of SMR when there is no observed data in certain region.

Table 2 Comparison of the relative risk estimation for Chronic Hepatitis B in January

STATES	Relative Risk based on SMR Method	Relative Risk based on Poisson-Gamma Model
Perlis	1.000	0.999
Kedah	0.000	0.077
Pulau Pinang	0.167	0.249
Perak	0.333	0.376
Kelantan	0.750	0.764
Terengganu	0.2	0.296
Pahang	1.333	1.289
Selangor	1.364	1.226
Kuala Lumpur	0.400	0.470
Negeri Sembilan	0.750	0.773
Melaka	1.000	0.989
Johor	0.143	0.182
Sarawak	0.900	0.891
Labuan	0.000	0.662
Sabah	4.000	3.642
Mean	0.000	0.077
Standard Devition	0.992	0.857

Consequently, a disease map is used to represent the high-low risk area of Acute and Chronic Hepatitis B for all 15 states in Malaysia. Figures 5 to 8 show the thematic risk maps for Acute and Chronic Hepatitis B based on SMR method and Poisson-Gamma method. The darkest shade in map shows the very high risk area while the lightest shade shows the very low risk area.

Figure 5 shows the area which have a very high risk of Acute Hepatitis B occurrences, which are Melaka and Labuan. Whereas, by using the Poisson-Gamma models in Figure 6, the very high risk area is only in Labuan. Figure 7 shows that the high risk area for Chronic Hepatitis B is Perlis, in contrast to using the Poisson-Gamma method (Figure 8) where Perlis is a low risk area for Chronic Hepatitis B. Thus, if we compare the risk areas of Acute and Chronic Hepatitis B, we can see that for each state the risk for Acute and Chronic are different. It also shows that Sabah is a very low risk area for Acute Hepatitis B, but a high risk area for Chronic hepatitis B.

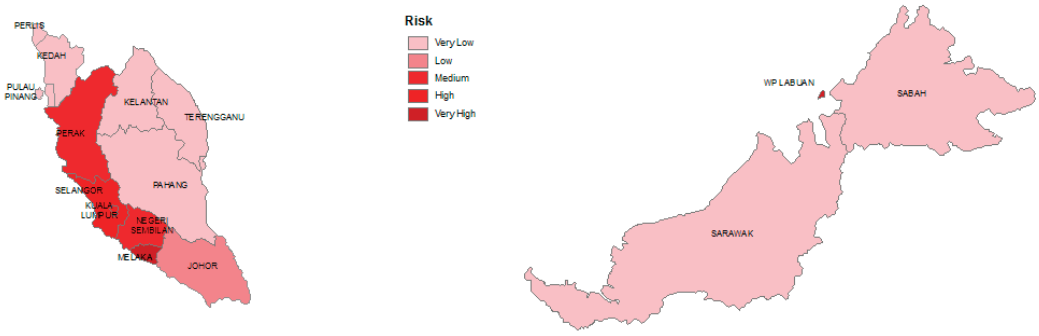

Figure 5 Disease map of estimated relative risk for Acute Hepatitis B based on SMR method

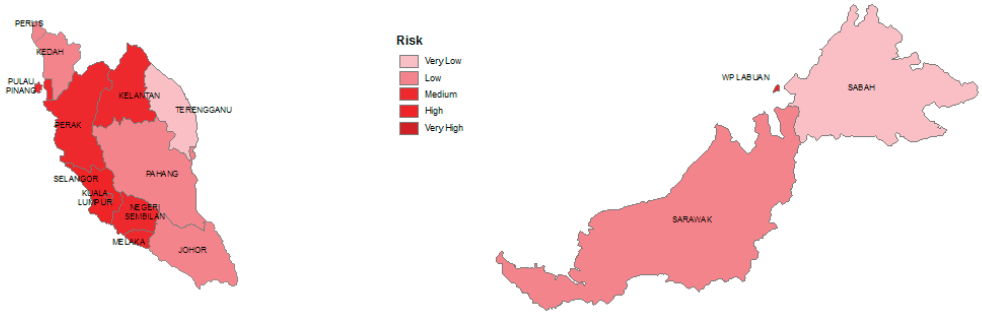

Figure 6 Disease map of estimated relative risk for Acute Hepatitis B based on Poisson-Gamma model

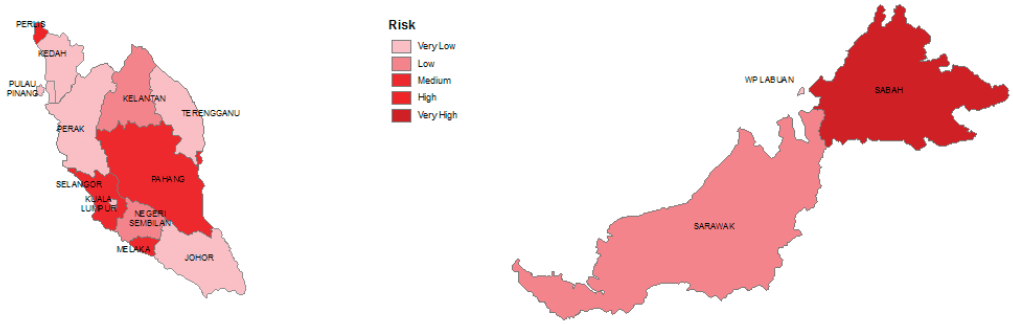

Figure 7 Disease map of estimated relative risk for Chronic Hepatitis B based on SMR method

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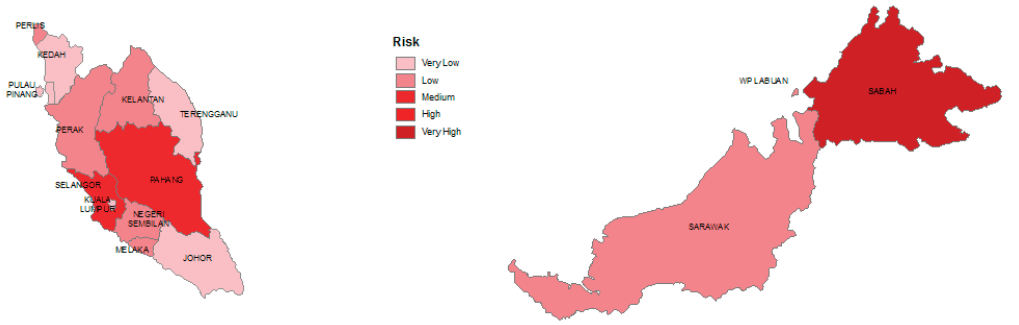

Figure 8 Disease map of estimated relative risk for Chronic Hepatitis B based on Poisson-Gamma model

CONCLUSION

The Poisson-gamma model has been clarified as a better model to estimate the relative risk compared to the traditional model in disease mapping which is the standardized morbidity ratio (SMR). This study shows the Poisson-gamma model can overcome the drawbacks of SMR when there is no observed data for Acute and Chronic Hepatitis B in certain regions. However, the primary problem of Poisson-gamma is the count data which are usually over-dispersed, where, the means equal to the variance (Anselin, 2002). The model is also difficult and does not allow spatial correlation between risks of adjacent areas (Samat & Percy, 2012). Therefore, a new alternative method for estimating the risk can be studied in the future.

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