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Relative Risk Estimation of Tuberculosis with Standardized Morbidity Ratio in Malaysia

Ijlal Mohd Diah

School of Quantitative Sciences,
College of Arts and Sciences,
Universiti Utara Malaysia 06010 Sintok,
Kedah, Malaysia.

Nazrina Aziz[1]

School of Quantitative Sciences,
College of Arts and Sciences,
Universiti Utara Malaysia 06010 Sintok,
Kedah, Malaysia.

Nazihah Ahmad

School of Quantitative Sciences,
College of Arts and Sciences,
Universiti Utara Malaysia 06010 Sintok,
Kedah, Malaysia.

Abstract

TB is a widespread disease which is one of several factors that cause millions of death worldwide. The numbers of TB cases reported keep on increasing from year to year. Moreover, this type of disease can become epidemic and also pandemic if it is not controlled. Disease mapping can be used in controlling and as the prevention strategies for a disease as it can give clear picture of the risk areas. It relies on the modeling used to estimate the relative risk to get an accurate disease map. The purpose of this study is to estimate relative risk for TB disease transmission using the most common statistic used in disease mapping that is Standardized Morbidity Ratio (SMR). This relative risk estimation is applied to TB data in Malaysia. Then this value will be displayed in a map to represent TB risk areas. Perlis shows the

[1]Corresponding author.

lowest risk areas of contracting TB while Sabah & Labuan has the highest risk area.

AMS subject classification:
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1. Introduction

Tuberculosis or TB (short for tubercle bacillus) is a bacterial disease caused by Mycobacterium tuberculosis organism which these slow-growing bacteria grow well in the area of the body that has a lot of blood and oxygen [1]. According to [2], in the past, TB was also called consumption, phthisis or phthisis pulmonalis. Tuberculosis usually affects the lung (pulmonary TB or PTB), but also can affect any part of the body, for example bones, kidneys, lymph nodes and brain as the infection can spread via blood from the lung which is called as extrapulmonary tuberculosis (EPT) [3].

TB can be transmitted from a person to another through air [4]; [5]. Tiny droplets released into the air when people with active TB infection sneeze, cough or spit. Even though the droplets dry out quickly, the bacteria can still remain airborne in the air for hours.

General symptoms for those who have active infection include fever, cough with thick, cloudy and bloody mucus from the lungs for more than two weeks, chest pain, fatigue, weight loss, shortness breath and night sweats [1]. According to [4], there are many factors related with an increased risk for being infected and further developing the disease such as migrants from high TB prevalence countries, healthcare workers, patients with HIV infection, diabetes mellitus, chronic renal failure, infancy and also people of older age. Even though it takes a long process, treatment is often successful [1]. TB treatment usually takes about six to nine months. However some TB infection cases should be treated for up to two years. A single antibiotic is usually used for latent TB treatment, while combinations of several antibiotics are used to treat active TB disease. This can help to decrease the threat of the bacteria developing antibiotic resistance.

1.1. Tuberculosis Scenario in Malaysia

In Malaysia, TB has emerged as the number one killer in Malaysia between 1945 and 1957. At that time, most of the beds in the hospital were filled with patients [6]. In 2001, it was the second highest communicable disease in Malaysia [7]. TB is among the top 5 communicable diseases [8]. This disease was first detected in Malaysia when British returned to Malaya at the end of the World War II as TB recorded the highest single killer and the most suffering cause in Malaysia. TB continued to be the biggest health problems the next 15 years [6]. According to [6], usually TB is a disease of urban communities but in Malaysia, at that time, this disease affected in the rural areas as seriously as the towns.

According to [10], the numbers of reported cases of TB and HIV co-infection have increased from 6 cases in the year 1990 to 933 cases in 2002. Based on Table 1, the

Table 1: Number of TB Cases in Malaysia (Source: [9])

Year	**No. of Cases**	**% of Change**
2003	15,853	
2004	115,429	−2.67
2005	15,991	3.64
2006	16,665	4.21
2007	16,918	1.52
2008	17,496	3.42
2009	18,102	3.46
2010	19,337	6.82
2011	20,666	6.87
2012	22,710	9.89
2013	24,071	2.43
2014	24,711	6.23

[9] stated that the number of TB cases had increase 8858 cases from the year 2003 until year 2014 which is about 55.88 %. In 2011 to 2012 recorded an increase in the number of cases of the most high of 9%. In 2013, the number of cases notified is 23, 262 and in 2014, it increase to 24, 711. This new cases had increase 1, 449 from the year before which is increase about 6.23 % (refer to Table 1).

It is necessary to look into this problem as TB is the number one infectious disease in Malaysia [6]. Based on Table 2, the number of deaths due to TB disease in Malaysia is still high despite a drop from 1,644 deaths in 2011 to 1,414 deaths in 2012. This number is tally with the HIV cases which also drop in 2012. However the number of deaths due to TB infectious increase to 1,597 in 2013 and 1603 in 2014. This represents an increase of 0.38 % (refer to Table 2) or 6 cases.

According to Director of the Institute of Respiratory Medicine and Senior Medical Consultant, Datuk Dr Abdul Razak Muttalif, TB is a prime cause of death from infectious disease in Malaysia and it is the second highest disease among infectious disease [10]. Hence, there is still a long way to achieve Stop TB Partnership target. In Malaysia, the current method used to estimate the high-low areas is still by using traditional approach by monitoring based on the total number of TB cases for each region that have been reported. This method only showed general information without considers the area of disease transmitted. Before we mark the area as high or low risk area for disease transmission, we need to consider the number of people in population, gender and age.

According to [11], disease mapping can be used in controlling and as the prevention strategies for a disease. Disease mapping can help to show a clear picture of the risk area. However it relies on the accurate value of relative risk estimation to get a good disease mapping. Relative risk estimation for disease mapping is still ongoing studies as it is an important issue that need to consider when investigate geographical distribution [12]. Since relative risk estimation for disease mapping are important as it can helps to

Table 2: The Number of Deaths due to TB Cases in Malaysia (Source: [9])

Year	**No. of Cases**	**% of Change**
2003	1,029	
2004	1,318	28.09
2005	1,437	9.03
2006	1,431	−0.42
2007	1,504	5.10
2008	1,523	1.26
2009	1,582	3.87
2010	1,557	−1.58
2011	1,644	5.59
2012	1,414	−13.99
2013	1,597	12.94
2014	1,603	0.38

detect the critical areas of disease, there is a need to study the best method. In the study of TB disease, SMR has been used as the conventional way to estimate relative risk.

1.2. Standardized Morbidity Ratio

In disease mapping, SMR has been a common statistic method used to estimate the relative risk. [13] described that the SMR method essentially compares the observed incidence with the expected incidence which has been used traditionally for the analysis of counts within tracts and calculated as

$$\widehat{\theta_i} = \frac{O_i}{E_i} \tag{1.1}$$

where O_i is the observed number of deaths or incident cases of disease in the area and E_i is the expected number of cases.

In disease mapping, suppose that the study area to be mapped is divided into M mutually exclusive states ($i = 1, 2, \ldots, M$). Each state has its own observed number of cases O_i and expected number of cases,E_i. Using O_i and E_i as obtained based on the available data, we can calculate one of the most common indices to estimate the relative risk for state i, which is the SMR model defined as follows:

$$r_i = \widehat{\theta_i} = \frac{O_i}{E_i} \tag{1.2}$$

The observe number could be found from other resource such as health indicator from the Ministry of Health Malaysia which is under disease control department. For the expected value, it could be count by using a particular formula as below for the study

region. In the purpose of this research, the expected number of cases, E_i is calculated as

$$E_i = N_i \frac{\sum O_j}{\sum E_j} \tag{1.3}$$

$$r_i = \frac{\sum O_j}{N_i \sum E_j} \tag{1.4}$$

$$= O_i \times \frac{\sum N_j}{N_i \sum O_j} \tag{1.5}$$

$$= \frac{O_i}{N_i} \times \frac{\sum N_j}{N_i \sum O_j} \tag{1.6}$$

$$= \frac{(\frac{O_i}{N_i})}{(\frac{\sum O_j}{\sum N_j})} \tag{1.7}$$

$$\tag{1.8}$$

where N_i is the population of region i and the summations ($\sum$) are for $j = 1, 2, \ldots, M$. Here, standardization is completed by the total population at risk, assuming everybody is equally at risk. Consequently, we estimate the relative risk using formula;

$$r_i = \widehat{\theta_i} = \frac{(\frac{O_i}{N_i})}{(\frac{\sum O_j}{\sum N_j})} \tag{1.9}$$

which defines it as the probability that a person within the state contracts the disease is divided by the probability that a person in the population contracts the disease.

2. Experimental

SMR method is used to estimate the relative risk of TB disease using TB data of Malaysia. WinBUGS software is used in this study to compute the relative risk. WinBUGS software is a program designed to implement Bayesian inference on statistical problem using Markov chain Monte Carlo (MCMC) computations [12]. All of these results are presented in table and graph. Based on the relative risk results, map of the TB risk is constructed.

Data set used in this study was provided by Ministry of Health, the Institute for Medical Research and the Department of Statistics in Malaysia. This SMR method are applied to TB data in the form of counts of cases within 14 states in Malaysia that are Perlis, Kedah, Penang, Perak, Federal Territory of Kuala Lumpur and Putrajaya, Selangor, Negeri Sembilan, Melaka, Johor, Pahang, Terengganu, Kelantan, Sabah and Sarawak. In this analysis, TB data refer to observed new infective TB cases which were observed from year 2008 until year 2015.

3. Results

The results of the relative risk estimation for all states of Malaysia are displayed in Fig. 1. The graph shows that most states have relative risk below one from year 2008 until 2015. This is a necessary consequence of the positively skew distribution inherent of the positive valued relative risk. The relative risk in this analysis is defined to be the conditional probability that a person within a region contracts the disease divided by the conditional probability that a person in the population contracts the disease. In this analysis, a value for the relative risk is close to 1. Hence, that refers to no real difference between the conditional probability of a person within the specific region and the general population to contract with the disease. This means that there is no significant difference in terms of the likelihood that the people affected with TB disease in a region and within the whole population. If the value of relative risk is less than 1, it shows that there is a decrease in likelihood of getting the disease, which means that the people within the region are less likely to endure from this disease compared with people in the population. Conversely, for a value of relative risk increase above 1, this indicates that people within the region are tending to suffer from this disease compared with people in the population.

Table 3 shows the numerical values for the relative risk based on SMR method for year 2015. From Table 3, when compared with people in the overall population, it can be seen that Perlis has the lowest risk of contracting TB with 0.667 while Sabah (including Labuan) has the highest risk of contracting TB with corresponding value of relative risk approximately 1.585.

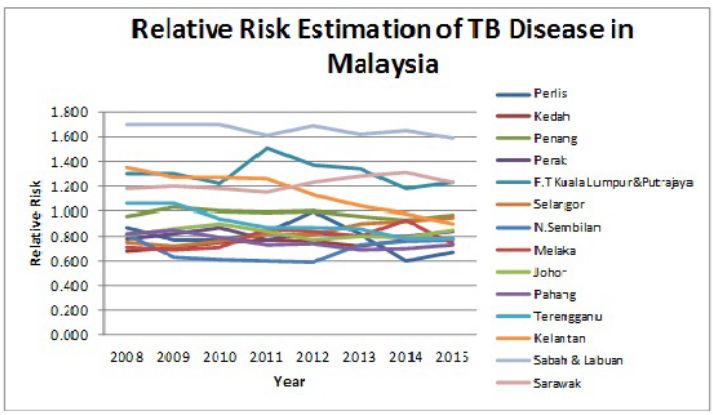

Figure 1: Time series plots of the relative risk estimation based on the SMR method for different states in Malaysia.

In order to show a clear picture of the risk areas, choropleth map with single-hue progression colours is used to display and differentiate between high and low risk areas of TB cases occurrence for each state in Malaysia. Each state is assigned one of five different levels of relative risk which are very low, low, medium, high and very high risks with respective interval of $[-\infty, 0.67)$, $[0.67, 0.78)$, $[0.78, 0.90)$, $[0.90, 0.97)$ and $[0.97, \infty)$. The lightest shade represents the very low risk while the darkest shade

Table 3: Relative Risk Estimation of TB Disease for Year 2015.

States	Relative Risk
Perlis	0.667
Kedah	0.778
Penang	0.972
Perak	0.842
Kuala Lumpur & Putrajaya	1.234
Selangor	0.950
N.Sembilan	0.765
Melaka	0.740
Johor	0.854
Pahang	0.726
Terengganu	0.775
Kelantan	0.904
Sabah & Labuan	1.585
Sarawak	1.230

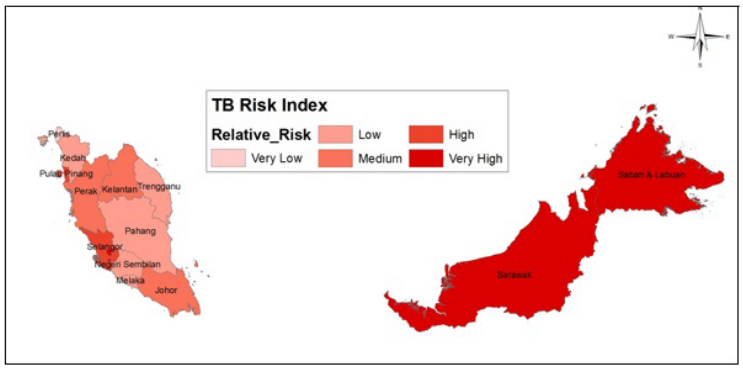

Figure 2: Dsease nap of relative risk estimation based on SMR method for year 2015.

represents the very high risk area for different levels of relative risk.

Fig. 2 shows the SMR map that the state of Pulau Pinang, Kuala Lumpur& Putrajaya, Sarawak and the state of Sabah & Labuan have very high risk areas. The state of Selangor is identified as high risk area. Perak, Johor and Kelantan showed medium risk areas. This is followed by low risk by other states except Perlis with very low risk areas.

4. Conclusion

In controlling spreading of TB, it is necessary to estimate the relative risk. In this study, in order to find the relative risk estimation, SMR method has been used which this is the most common statistic method used to estimate the relative risk. The results of the

relative risk are present in graph, table and also map which this map shows clear picture of high-low risk areas. In conclusion, Pulau Pinang, Kuala Lumpur & Putrajaya, Sarawak and Sabah show the highest risk areas while Perlis is the lowest risk area of contracting TB. However, according to [12] and [14], direct use of SMR may not be worthy as it cannot detect the small areas as it does not take into consideration the high diversity of different regions and the spatial patterns of the areas under study. Since SMR is based on ratio estimators, the used of SMR can yield large changes in the estimate, and relatively small changes in expected value [12]. Therefore, the disadvantages of this method have motivated many researchers to propose others alternative methods to estimate the relative risk.

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