

# Hot-spot and cluster analysis on legal and illegal dumping sites as the contributors of leptospirosis in a flood hazard area in Pahang, Malaysia

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## Abstract

**Background:** Leptospirosis is one of the zoonotic diseases which pose major public health issues worldwide. The spread of leptospirosis depends on the climate conditions as well as environmental conditions.

**Methods:** The cases of leptospirosis were determined by using database obtained from Ministry of Health, Malaysia. Case cluster and hot spot analysis within Geographical Information System (GIS) were done using ArcGIS version 9.3. Level of significance was set at  $\alpha = 0.05$ .

**Results:** Most of the cases were at the centre Pahang located along the flood hazard stream. Cluster analysis indicated that cases were mostly clustered near illegal and legal dumping sites. The outliers were Jerantut, Maran, Pekan, and Rompin in both maps ( $p < 0.05$ ). The hot spot analysis obtained an obvious trend in the legal dumping compared to the illegal dumping. The hot spot area was found in the middle of Pahang such as in Jerantut, Temerloh, Maran, Pekan, and Rompin.

**Conclusions** Increasing flood risk, poor sanitation and abundance of rats are conditions that trigger leptospirosis outbreaks. Interventions are therefore needed, targeting at environmental sources of transmission namely open legal and illegal dumping sites as well as flooding in flood hazard areas. A refined waste management system is needed to control the spread of the disease.

**Keywords:** Illegal and legal dumping sites, flood hazard areas, hot spot analysis, cluster analysis

## Introduction

Zoonotic disease such as Leptospirosis has been recognized for many centuries as a major public health problem worldwide (World Health Organization [WHO], 2015a). The disease gives a serious health impact on human beings and their trends growing continuously (Ambu, 2014; WHO, 2015b). Leptospirosis causes significant morbidity and mortality in populations (Skouloudis and Rickerby,

2015). Although Leptospirosis has been discovered for many years before, the infection is still difficult to control due to its multiple transmission modes, several hosts and complex and dynamic nature of the diseases (Skouloudis and Rickerby, 2015). The spread of leptospirosis depends on the global distribution, climate condition, land elevation, presence of domestic animals and its environmental conditions (Ko et al., 1999). Climate severity such as flooding, high temperature, high humidity can worsen the



severity of an outbreak of leptospirosis. Since the rodent is the major mode of transmission of leptospirosis, the control of rodents in the environment is essential for the maintenance of health condition in the population (Brown, 2004). Their infected droppings and urine are the major routes of many diseases which spread among populations (Ambu, 2014). The increase in rodent population in many countries is due to poor sanitation and an inadequate waste management process that creates a big challenge to the environment and health status of Malaysian residents (Saeed et al., 2009). It was reported that 17,000 tonnes of solid waste are produced daily in Malaysia, and this trend will shoot up to 30,000 tonnes per day in 2020 (MHLG, 2005) due to increasing trend of population in Malaysia. This has led to the increase in generation of solid waste disposal either legal or illegal in Malaysia (Badgie et al., 2012). Moreover, there is a very limited study done on the leptospirosis transmission related to the waste disposal either illegal or legal in Malaysia. Given this issue, this paper discussed the environmental condition involving illegal and legal solid waste disposal which is avoidable or controllable, related to cases of leptospirosis during flooding in Pahang state.

## Materials and Method

Case cluster and hot spot analysis within Geographical Information System (GIS) were used in this study using ArcGIS version 9.3. The case cluster analysis consists of a z-score, p-value, and cluster/outlier type (COType) and Local Moran's I index value. A high z-score indicates intense clustering. A z-score near zero signifies no apparent spatial clustering.

## Results

There were 118 cases that were affected by leptospirosis from all states of Pahang from January 2014 until March 2015. The cases were described by their distribution according to the three environmental factors, namely, flood risk area, illegal and legal dumping sites areas.

### (i) Flood Risk Areas

Figure 1 shows the distribution of cases by flood hazard area. The flood hazard area that contributes the flood calamity is the deep part of the Pahang river basin, which is Sungai Kuantan. A combination of slow movement of the water current, poor drainage system and heavy rainfall contributes to the flooding. Most of the cases were distributed at the center Pahang which is located along the flood hazard stream.

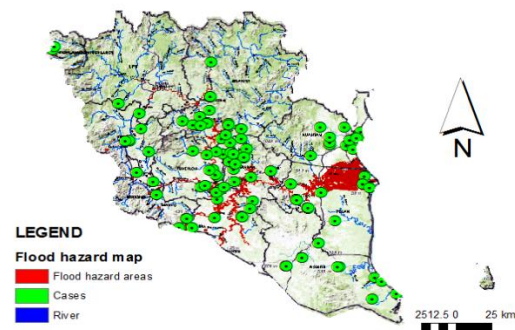
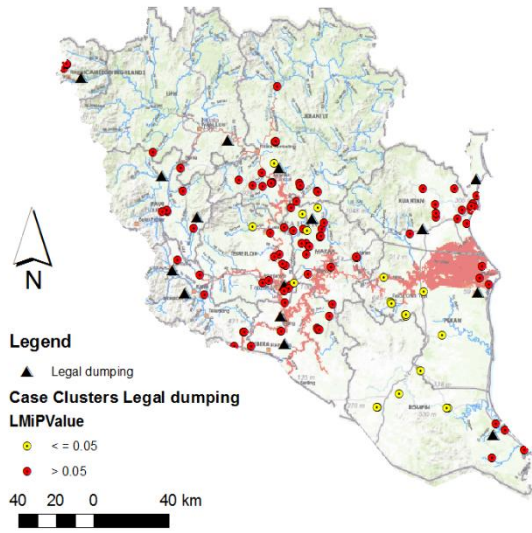


Fig 1. Distribution of cases by flood hazard

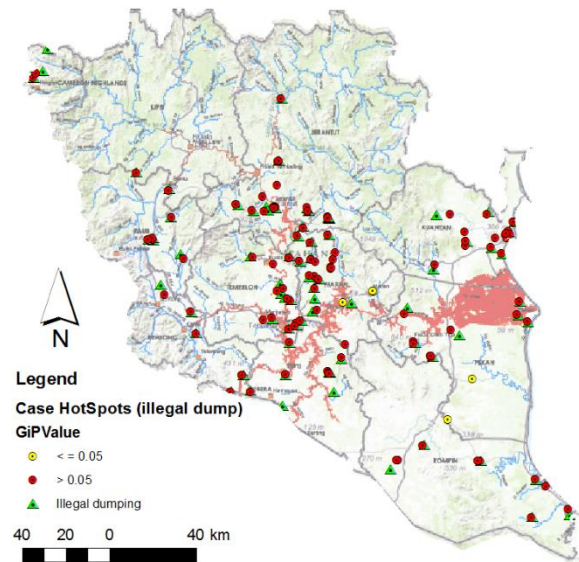
### (ii) Waste Disposal site

Figure 2a and 2b show the case cluster and outlier analysis of leptospirosis cases by dumping sites. The case cluster indicates that most of the cases were clustered within or at proximity to illegal and legal dumping sites. There were some points (with  $p < 0.05$ ) were highlighted as outliers in the map. The outlier was obtained in Jerantut, Maran, Pekan, and Rompin in both maps.

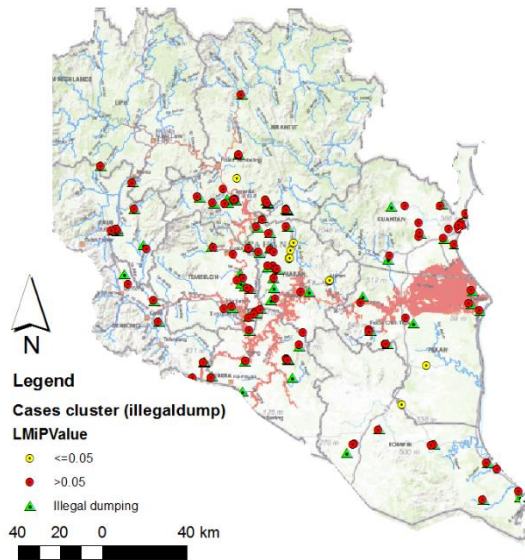
The hot spot analysis obtained an obvious trend in the legal dumping and illegal dumping (Figure 3a and 3b) whereby most of the cases were significantly distributed within the legal dumping sites. The hot spot area for leptospirosis cases was observed in the middle of Pahang such as in Jerantut, Temerloh, and Maran and at some parts of in the south (Pekan and Rompin).



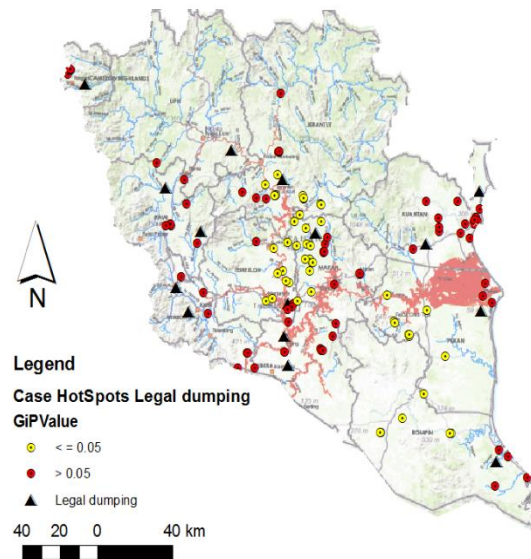
**Fig 2a.** The case cluster and outliers analysis of leptospirosis cases by legal dumping sites.



**Fig 3a.** The hot spot analysis of leptospirosis cases by illegal dumping sites.



**Fig 2b.** The case cluster and outliers analysis of leptospirosis cases by illegal dumping sites.



**Fig 3b.** The hot spot analysis of leptospirosis cases by legal dumping sites.

## Discussion

Flooding poses a big problem towards the worldwide population, and the incidence is expected increase exponentially due to global warming (Patz and Kovats, 2002). In an area which is flood-prone, most of the leptospirosis cases were distributed at the centre of the state along the flood hazard stream. Although the flood hazard area that contributes the flood problem is the main outlet of the river basin in Pahang, which is Sungai Kuantan, most of the cases were concentrated towards the adjacent of the river. This was possibly due to the overflow of river water that may be influenced by the volume of rainfall which causes to disseminate the leptospirosis around the environment (Senior, 2008).

According to Ghani (2012), the river basin has an average annual rainfall of 2470 mm and the mean annual discharge is 37.7m<sup>3</sup>/s. Head area of the basin contributed more influence to the production of flood flow compared to the lower plain area of the basin. Also, the head basins of the study area have great potential to give more flood water to downstream receiving sub-basins (Sungai Pahang) (Ghani et al., 2012). The association between heavy rainfall and human leptospirosis has been concluded as a temporal relationship in Salvador (Ko et al., 1999; Sarkar et al., 2002, Chennai, India (Muthusethupathi et al., 1995) and Mumbai (Karande et al., 2003) as well as in other tropical countries (Ko et al., 1999; Marotto et al., 1997; Trevejo et al., 1998). Flooding is the medium of transport for leptospire-infected animal urine, which exposes the danger towards humans who are in contact with it (Anon, 1981). A lot of clinical cases were diagnosed during heavy downpour seasons due to the inadequate and inefficient flood mitigation system. Flooding helps in the survivability of leptospires excreted from rodent urine such as from *Rattus Norvegicus*. The higher the concentration of leptospire-infected urine in contact with a human, the more severe the leptospirosis manifestation (Dias et al., 2007).

The proximity of residence to open sewers and accumulated refuse and intense rat infestation areas prove to be the key factors of leptospirosis infection (Barcellos and Sabroza, 2000; Maciel et al., 2008; Reis et al., 2008). These factors are caused by improper solid waste disposal which is due to the rapid increase in population. In Pahang, waste management system was found to be inadequate, and several sanitary landfills are nearly filled up (Romali et al., 2013).

Another possible reason is that the waste management systems in rural areas might be probably not as efficient as that of urban areas in Pahang regions. Although the regular municipal waste collection is regular in the urban areas, the sanitation service is difficult to reach to the high land elevation and slum areas, causing an increase in illegal dumping sites and poor sanitation in the environment (Barcellos and Sabroza, 2000). In urban, leptospirosis is seen as a disease of the poor population because it affects communities that lack adequate sewage systems and the refusal of collection services in a disproportionate way (Reis et al., 2008). Seasonal rainfall or flooding in cities with lackluster drainage and waste management system makes matters worse (Ganoza et al., 2006; Sarkar et al., 2002).

## Conclusion

This study reported that a combination of improper waste management, flooding, and infected rodents led to the increase cases of leptospirosis in Pahang. Since the management of illegal and legal dumping sites is controllable, it is important to conduct future research to find out the new dumping sites in both urban and rural areas of Pahang. Health education program should be carried out to educate public about the hazards and consequences of improper waste disposal, rodent infection, and flooding hazards. In conclusion, this research will suggest a direction for future development of waste management practice which is important for control of leptospirosis.

## Ethical Considerations

Ethical approval was obtained from UPM Ethics Committee for Research Involving Human Subjects, referenced as FPSK (Exp15) P060.

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