ENVIRONMENTAL RISK FACTORS ASSOCIATED WITH PLASMODIUM KNOWLESI IN SABAH, MALAYSIA.

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INTRODUCTION

• Malaria is still a major public health concern worldwide.

• WHO estimated 300-500 million malaria cases per year & causing 1 million deaths due to this disease and its complications. (Yusuf et al 2013)

• In Malaysia, the number of malaria cases has declined from 12 thousand to 4 thousand from 2000 to 2012. (MOH, 2014)
  • MOH targets to eliminate malaria by the year 2020.

• Despite the successful malaria control program, the prevalence of *P. knowlesi* cases is still alarming in Sabah. There is still limited studies to identify the environmental risk factors associated with *P. knowlesi* infection in Sabah.

• In 2010-2011, almost half of fatal malaria cases were caused by *P. knowlesi* infection (Rajahram et al. 2016)
DISTRIBUTION *P. KNOWLESI* in SEA

(Shearer et al. 2016)
OBJECTIVE

General Objective :

- To analyze the factors associated with *P. knowlesi* infection for Sabah, Malaysia.

Specific Objective

1. To explore the prevalence and characteristics of *P. knowlesi* cases in Sabah for the year 2013 and 2014.

2. To explore the characteristics of environmental factors (climate factors and non-climate factors) related to the occurrences of *P. knowlesi* cases in Sabah.

3. To evaluate the spatial distribution of malaria density areas in Sabah.

4. To examine the factors associated with *P. knowlesi* density areas in Sabah.

5. To develop a model for *P. knowlesi* occurrence for Sabah.
Latitudes of 4° to 7° north of the equator and longitudes of 115° to 119° east.
METHODOLOGY

- Study Design
  - Retrospective, ecological study from the period of 01 January 2013 – 31 December 2014.

- Study subject
  - Districts in Sabah
<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>SOURCE OF DATA</th>
<th>RESOLUTION</th>
<th>FREQUENCY</th>
<th>NUMBER OF IMAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Malaria</td>
<td>Vekpro, MOH</td>
<td></td>
<td>Daily</td>
<td>104 images</td>
</tr>
<tr>
<td>2. Satellite data</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LST</td>
<td>MOD11A</td>
<td>1 km</td>
<td>Every 6 days</td>
<td>90 images</td>
</tr>
<tr>
<td>Rainfall</td>
<td>TRMM</td>
<td>30 km</td>
<td>Daily</td>
<td>730 images</td>
</tr>
<tr>
<td>NDVI</td>
<td>Landsat 8</td>
<td>250 m</td>
<td>Weekly</td>
<td>137 images</td>
</tr>
<tr>
<td>Elevation</td>
<td>STRM</td>
<td>1 km</td>
<td></td>
<td>12 images</td>
</tr>
<tr>
<td>3. Topographical data</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Population density</td>
<td>ESRI Malaysia</td>
<td></td>
<td></td>
<td>1 images</td>
</tr>
<tr>
<td>River density</td>
<td>JUPEM</td>
<td>1:50,000</td>
<td></td>
<td>1 images</td>
</tr>
<tr>
<td>Swamp</td>
<td>JUPEM</td>
<td>1:50,000</td>
<td></td>
<td>1 images</td>
</tr>
<tr>
<td>Lake</td>
<td>JUPEM</td>
<td>1:50,000</td>
<td></td>
<td>1 images</td>
</tr>
<tr>
<td><strong>TOTAL IMAGES</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>1077 images</strong></td>
</tr>
</tbody>
</table>
Malaria data
(indigenous)

Satellite data

Topographical Data

Pre-processed Image

Processed Image

LST
Rainfall
NDVI
Elevation

Malaria density
- Kernel density

Population density

Swamp
Lake
River Density
Malaria density

Satellite data

Topographic data

Resample into 5 x 5 km fishnet

Spatial analysis
- Pattern of disease monthly using Moran’s I
- Hotspot area using Getis-Ord

Modeling using ANN
- Using Alyuda neurointelligent version 2.3
Run analysis for 8 parameter
  • Feature selection: Stepwise
  • Select best fit model
    • 6 parameter fit model

Pre-processing - scaling of data

Model design
  • best fit design (6-15-1) (fitness: 4852)

Training the data
  • Test selected: Quick propagation
    • Correlation 0.70

Testing result-paired sample t-test between observed & predicted
RESULTS AND DISCUSSION
Characteristics of malaria cases in Sabah, 2013-2014

<table>
<thead>
<tr>
<th></th>
<th>2013</th>
<th>2014</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Total no. of cases</td>
<td>1608 (47.48%)</td>
<td>1779 (52.52%)</td>
<td>3387</td>
</tr>
<tr>
<td>2. Case classification</td>
<td>1513 (46.9%)</td>
<td>1712 (53.1%)</td>
<td>3225</td>
</tr>
<tr>
<td>Indigenous</td>
<td>88 (57.9%)</td>
<td>64 (42.11%)</td>
<td>152</td>
</tr>
<tr>
<td>Imported</td>
<td>3 (100%)</td>
<td>0 (0.0%)</td>
<td>3</td>
</tr>
<tr>
<td>Induced</td>
<td>1 (50%)</td>
<td>1 (50%)</td>
<td>2</td>
</tr>
<tr>
<td>Introduced</td>
<td>1 (33.3%)</td>
<td>2 (66.77%)</td>
<td>3</td>
</tr>
<tr>
<td>Relapse</td>
<td>1513 (46.9%)</td>
<td>1712 (53.1%)</td>
<td>3225</td>
</tr>
</tbody>
</table>
Distribution of malaria species in Sabah, 2013-2014
Characteristics of *P. knowlesi* cases

- **Males** (83.5%), **mean age** 36 years old, **Malaysians**, Bumiputera Sabahans (82.3%).

- **Agricultural sector** contributes the highest no. of cases (82.2%), followed by forest-related activities such as lodging and collection of forest products (17.5%).
Moran’s I – *P. knowlesi* cases occur in clusters.
- Moran index is between 0.22 - 0.24
- Z-score 15-16
- P-value is significant (<0.001)
DECEMBER 2014
MODELING USING ANN

- Alyuda neurointelligent 2.2 software was used.
- Based on feature selection; forward stepwise model with a smoothing factor of 0.1 was selected.
  - 6 predicted factors were selected based on the best fit model
    1. Rainfall
    2. LST
    3. NDVI
    4. Elevation
    5. River
    6. Population density
- Neuron 6-15-1 design was selected.
Based from the model, 6 out 8 parameters were used to predict the occurrence of malaria in Sabah.

From the model, the p value of paired sample-t test shows no significance, which explained that there was no difference between the mean observed and predicted malaria cases.
Rainfall

Case density (10 x 10 km)

Average weekly rainfall (mm)
Case density (10x10km) vs. Average weekly LST (°C)
NDVI
River density
Population

Case density (10 x 10km)
DISCUSSION

- District located at Kudat division, West coast and some part of interior part of Sabah showing clustering of *P. knowlesi* infection, compare that other division.

- Subdistrict located at the west coast and interior part of Sabah such as in Ranau, Tambunan, Kota Marudu have slightly higher elevation as they located nearby the Sabah Range Croaker.

- A study was done in Kapit, Sarawak, found that An. Latens prefer to feed human and macaques at ground level however, they prefer to feed macaques at higher elevation (Tan CH. 2008). Human who lives at nearly mountain area are higher risk to get infected.
DISCUSSION

- Sabah is known for its preserved nature and tropical rainforest which provide a good natural habitats for both the vector as well as the macaques reservoir.
  - Close proximity to the forest could bring humans into contact with the macaques and vector (Collins WE., 2012, Barber BE., 2013).
  - Most of the traditional villages in Sabah are located near the forest edge and the source of income usually related to forest products. This will increase the chances of human-vector-animal contacts.
DISCUSSION

- There are various factors which play a role in *P. knowlesi* transmission particularly in Sabah, and management and control programme could be challenging for MOH.
- Sabah have a combination of topographical regions, with the addition of climate suitability which makes its population susceptible to malaria.
- As the main vector for *P. knowlesi* is *An. balabacensis* which breeds mostly in ground pool water, rainfall and temperature play an important role in *P. knowlesi* transmission. This study addresses the role of LST and rainfall, and a similar study done in Kudat, Sabah also showed strong correlations between these two factors and the incidence of *P. knowlesi* in Sabah. (Barber B.E 2012).
- However, excess rainfall also can flush the breeding site of the Anopheles (Gbenga J.,2016).
CONCLUSION AND RECOMMENDATIONS

- *P. knowlesi* infection in Malaysia differs from *P. knowlesi* infection in other regions such as Thailand and Laos as in Malaysia, *P. knowlesi* infection do cause fatal outcome (WHO, 2017).
- Active case detection is one of the major strategies for the identification and early treatment of malaria, as it causes rapid parasitemia.
- However, topographical area in Sabah, would be a major challenge for MOH.
- It is important to identify high risk areas in Sabah, and ACD and entomological survey could be done effectively in monitoring this infection.
- The accessibility to health region is also one of the major challenges in Sabah. Therefore high risk areas should be given priorities for treatment of *P. knowlesi*, as early treatment can prevent mortality.
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Thank you