The Impacts of Climate Change on Cholera Disease in Malaysia

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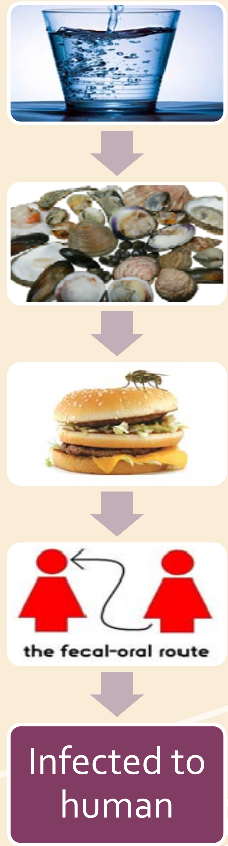
Seminar on Climate Change and Health: Exploring the Linkages

INTRODUCTION

- Cholera is one of the climate sensitive diseases that remain a global threat to human health because of its fatality and endemic nature.
- It is estimated that there were 1.4 to 4.3 million cholera cases, and caused 28,000 to 142,000 deaths worldwide (Ali et al. 2012).
- *Vibrio cholerae* can survive up to two weeks in fresh water and eight weeks in salt water (WHO 2014).
- Cholera has short incubation period of 2 hours to 5 days.
- Cholera is commonly related to water, sanitation and hygiene problems.
- Changes in rainfall, ambient temperature, and relative humidity are believed to play a role (Hashizume et al. 2008).
- This study is an attempt to quantify climate-induced increases in morbidity rates of cholera.



Methodology

Study Design
- Ecological study

Study Area
- All states in Malaysia

Sampling Method
- Universal Sampling

Climate projection

•Climate projections using PRECIS model data from NAHRIM.

•The domain of the study encompasses a region of 95°E to 122°E and 6°S to 13°N with a grid resolution of 0.22° × 0.22°

•SRES A1B

Cholera projection

•Analysis using Poisson generalized linear models (El-fadel 2012)

$$Yi \sim Pois(u_i\lambda_i) \quad (1)$$

$$\log(u_i\lambda_i) = \log(u_i) + \log(\lambda i) \quad (2)$$

$$\log(\lambda i) = Xi\beta \quad (3)$$

$$\text{Expected no. of cases}_i = u_i e^{Xi\beta} \quad (4)$$

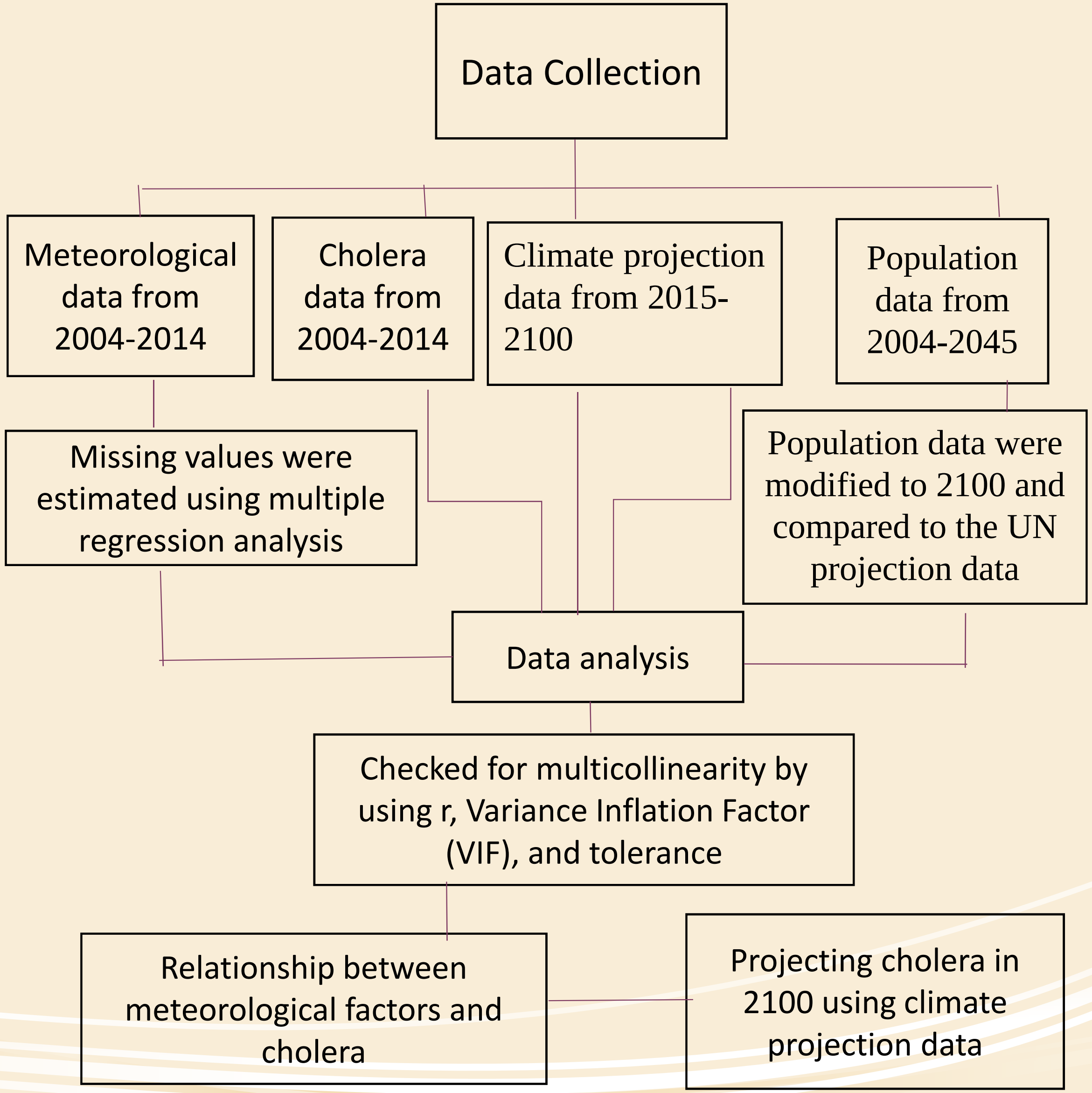


Figure 1 : Flowchart of the research

Result

Table 1: Demographic Data

Demographic information	Cholera, N = 3841(%)
Gender	
Male	1923 (50.07%)
Female	1918 (49.93%)
Age	
Mean±SD	21±19 years old
<12 years old	1704 (45.12%)
13-24 years old	745 (19.72%)
25-59 years old	1102 (29.18%)
>60 years old	226 (5.98%)
Nationality	
Malaysian	2700 (70.30%)
Non-Malaysian	1141 (29.70%)
Death	32 (0.80%)

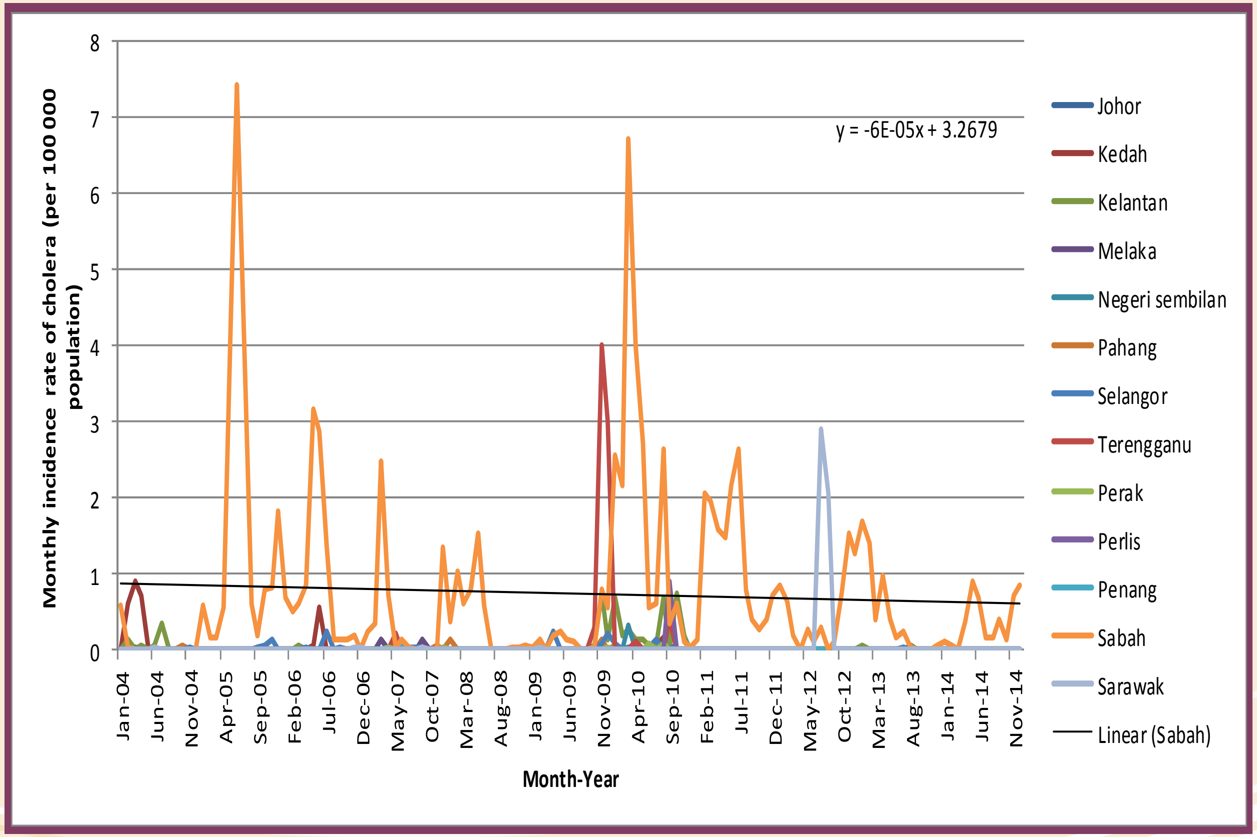


Figure 2: Cholera distribution from 2004-2014

Results

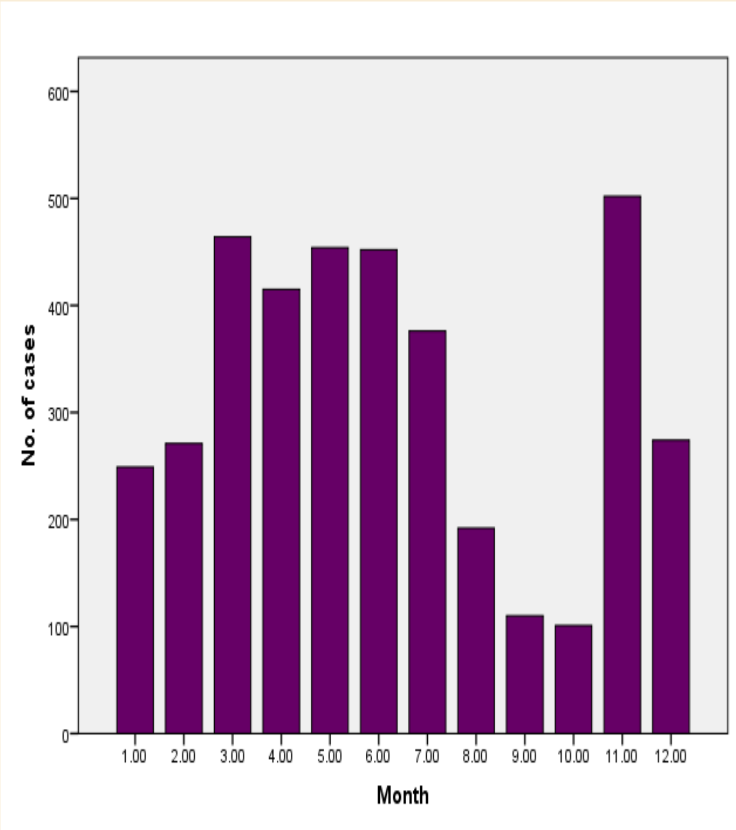


Figure 3: Cholera distributions by month

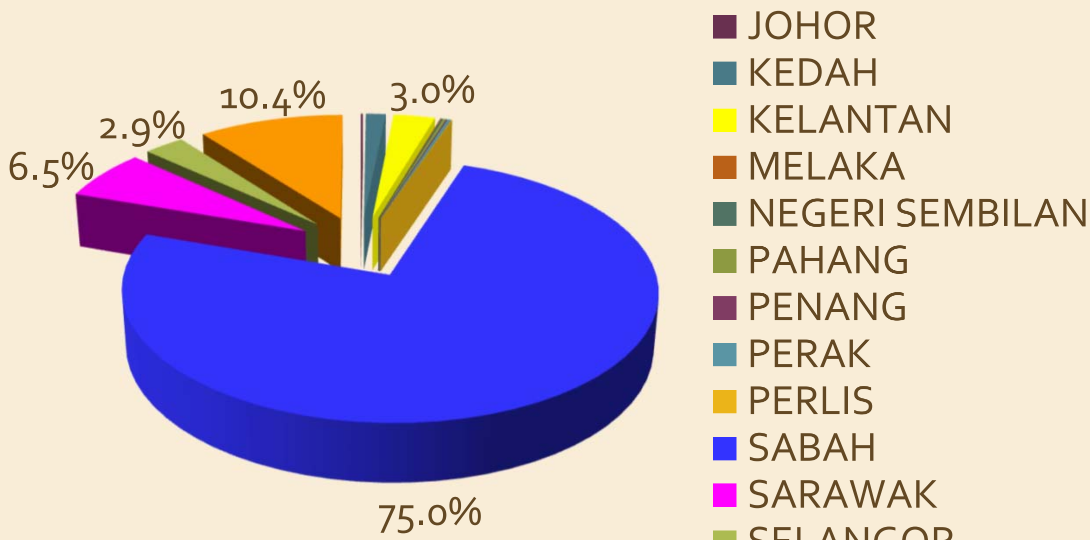


Figure 4: Cholera distributions by states

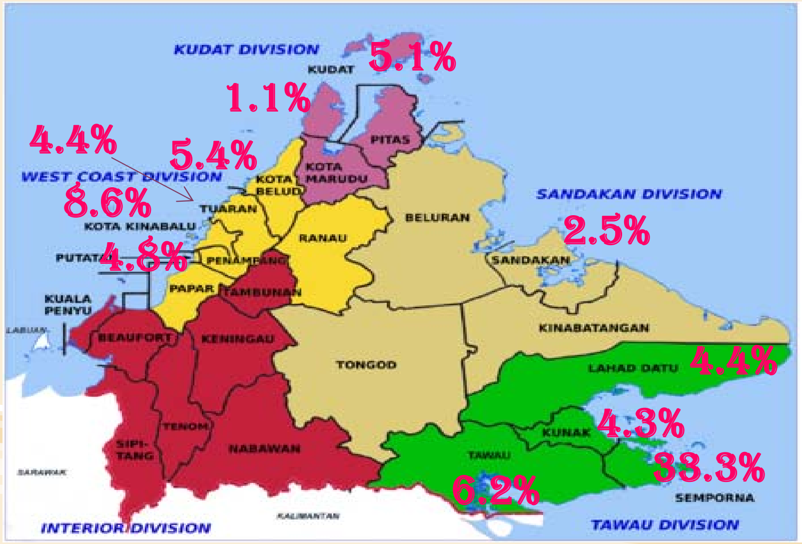


Figure 5: Sabah divisions

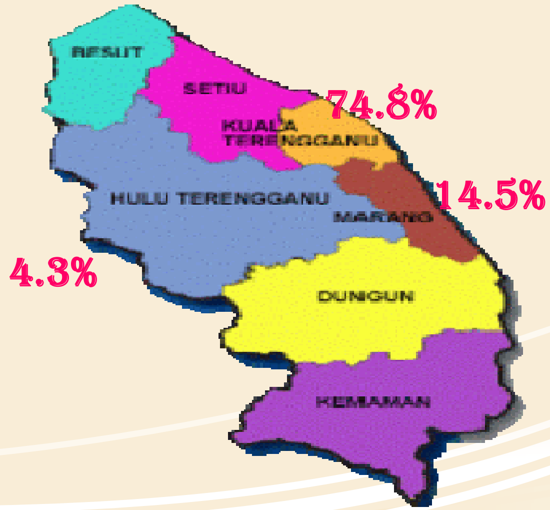


Figure 6: Terengganu districts

Temperature and precipitation from 2004-2014

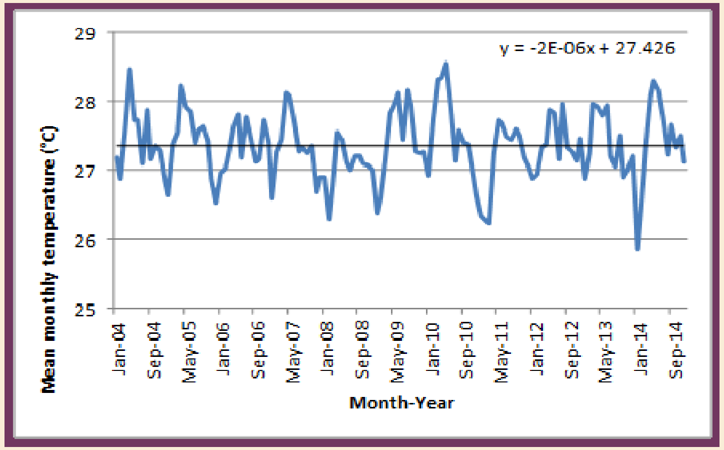


Figure 7: Temperature in Sabah

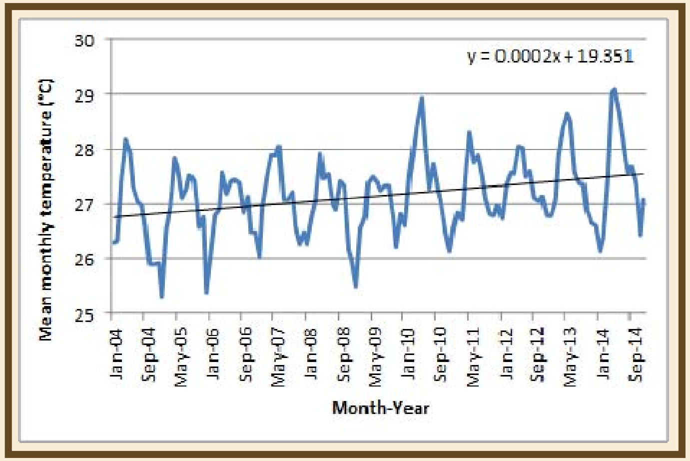


Figure 9: Temperature in Terengganu

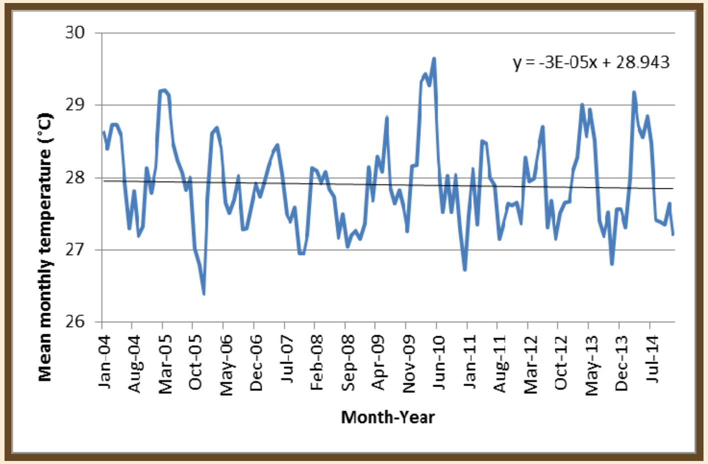


Figure 11: Temperature in Kedah

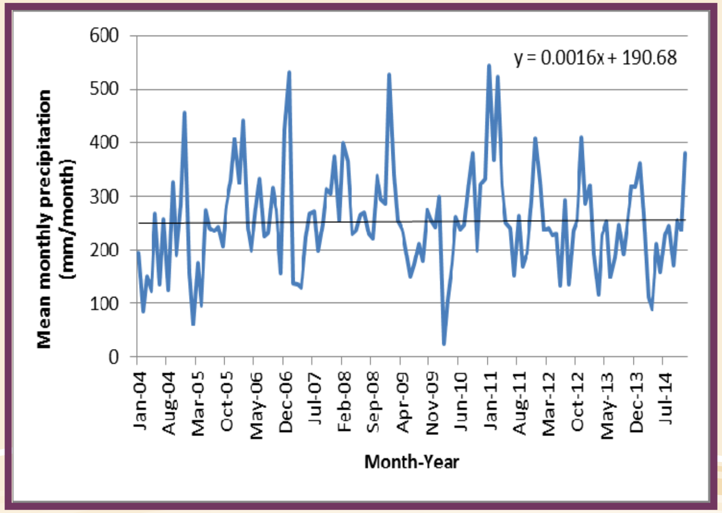


Figure 8: Precipitation in Sabah

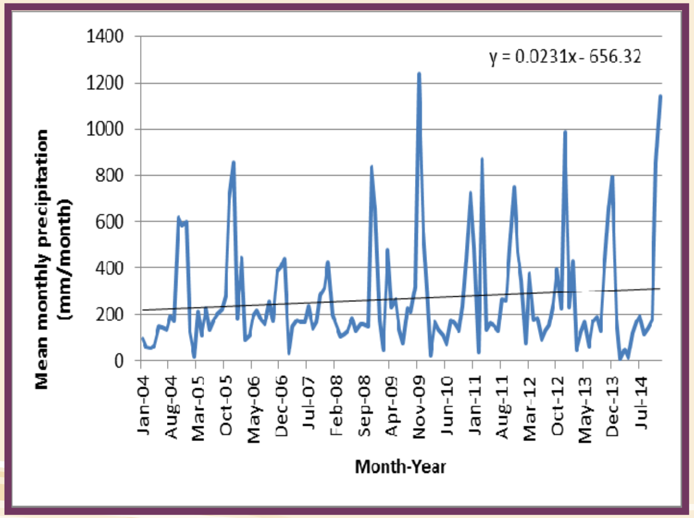


Figure 10: Precipitation in Terengganu

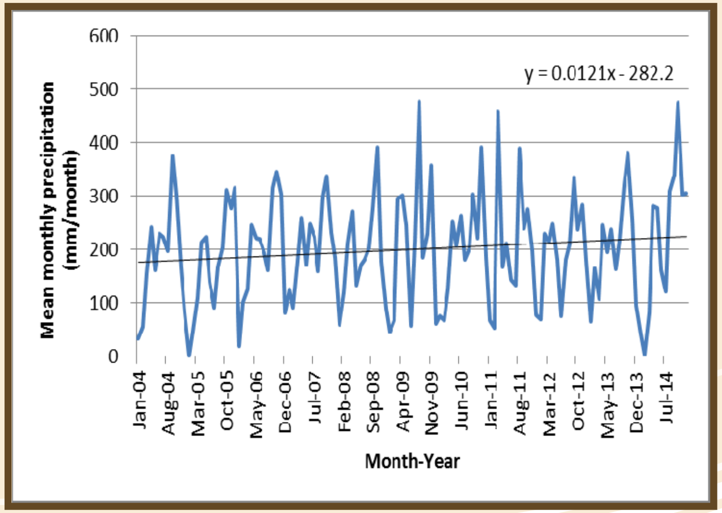


Figure 12: Precipitation in Kedah

Table 2: Estimated model coefficients for cholera

Coefficients	Model value	Confidence Interval	RR	p-value
Sabah				
Intercept	-23.888	2.132E-12 to 8.364E-06	0.000	0.001*
Temperature	0.462	1.425 to 2.017	1.587	<0.001*
Precipitation	0.003	1.001 to 1.006	1.003	0.022*
Seasonality	0.415	1.110 to 2.066	1.514	0.001*
Long term trend	-0.015	0.933 to 1.039	0.985	0.575
Terengganu				
Intercept	-18.588	3.882E-09 to 0.003	0.000	0.004*
Temperature	0.618	0.703 to 4.899	1.855	0.072
Precipitation	0.005	1.004 to 1.007	1.005	<0.001*
Seasonality	-0.388	0.294 to 1.565	0.678	0.063
Long term trend	-1.386	0.059 to 1.058	0.250	0.060

Cont.

Coefficients	Model value	Confidence Interval	RR	p-value
Kedah				
Intercept	-17.724	9.293E-08 to 0.041	0.000	0.050*
Temperature	-0.658	0.258 to 1.039	0.518	0.064
Precipitation	0.005	1.001 to 1.008	1.005	0.014*
Seasonality	2.084	3.509 to 18.393	8.034	0.001*
Long term trend	-7.590	0.001 to 0.004	0.001	<0.001*

Sensitivity Testing

- Lag data were used due to unavailability of minimum and maximum temperature data and small variations in the temperature range in Malaysia.
- The result showed that both factors were still significant although one of the independent variables had been replaced.
- For every 1.0 °C increase in temperature in a month, 1.55 (1.42 to 1.69) or 55.2% of the cases occurred, whereby a statistically significant result, p= <0.01 was obtained.
- For the precipitation, after the lag 1 month of temperature was introduced, the result indicated that for every 1mm increase of precipitation in a month, 1.003 (95% CI, 1.001 to 1.007) or 0.3% of the cholera cases occurred.

Final model for cholera projection

Sabah

$Log(\lambda i)=-23.888+0.462*(temperature)+0.003*(precipitation) +0.415*(seasonality)-0.015*(long\ term\ trend)$

Expected number of cases= $\mu i e^{-23.888+0.462*(temperature) +0.003*(precipitation) +0.415*(seasonality)-0.015(long\ term\ trend)}$

Terengganu

$Log\ (\lambda i)= -18.588+0.618*(temperature)+0.005*(precipitation)-0.0388*(seasonality)-1.386*(long\ term\ trend)$

Expected number of cases = $\mu i e^{-18.588+0.618*(temperature)+0.005*(precipitation)-0.0388*(seasonality)-1.386*(long\ term\ trend)}$

Kedah

$Log(\lambda i)=-17.724-0.658*(temperature)+0.005*(precipitation)+2.084*(seasonality)-7.590*(long\ term\ trend)$

Expected number of cases = $\mu ie\text{-}17.724^{-0.658*(temperature)+0.005*(precipitation)+2.084*(seasonality)-7.590*(long\ term\ trend)}$

Temperature and precipitation from 2015-2100

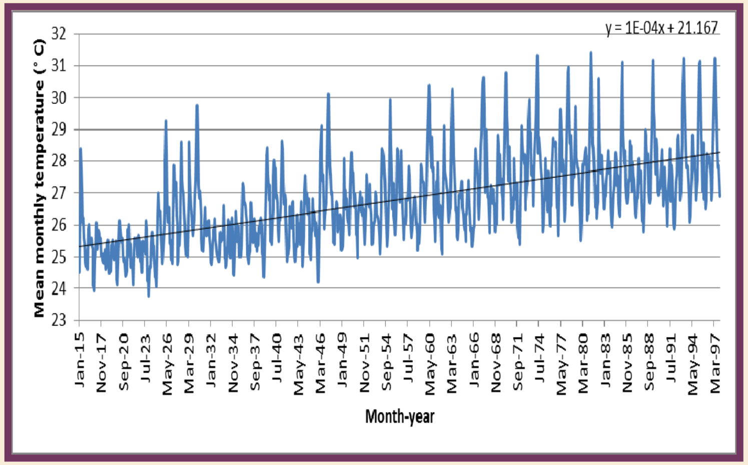


Figure 13: Temperature in Sabah

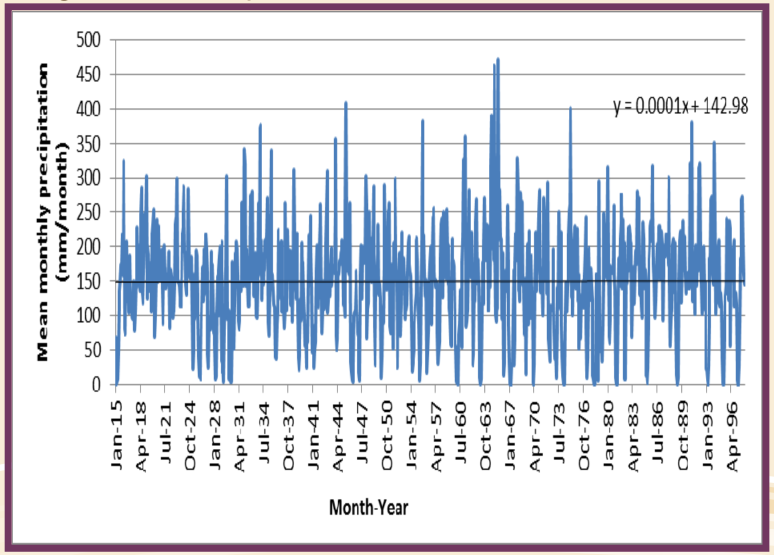


Figure 14: Precipitation in Sabah

Table 3: Correlation between mean monthly temperature and time

States	r	p-value
Sabah	0.622	<0.001*

Table 4: Mean monthly temperature (°C)

States	Baseline	2041-2070	2041-2070	2071-2100	High Temperature	Low Temperature
Sabah	28.55	29.74	30.78	31.41	March to June	November, December, January

Table 5: : Correlation between monthly precipitation and time

States	r	p-value
Sabah	0.019	0.865

Table 6: Maximum annual precipitation (mm/year)

	Maximum Annual precipitation (mm/year)			
States	Baseline	2015-2040	2041-2070	2071-2100
Sabah	3725.85	2544.87	2785.15	2415.42

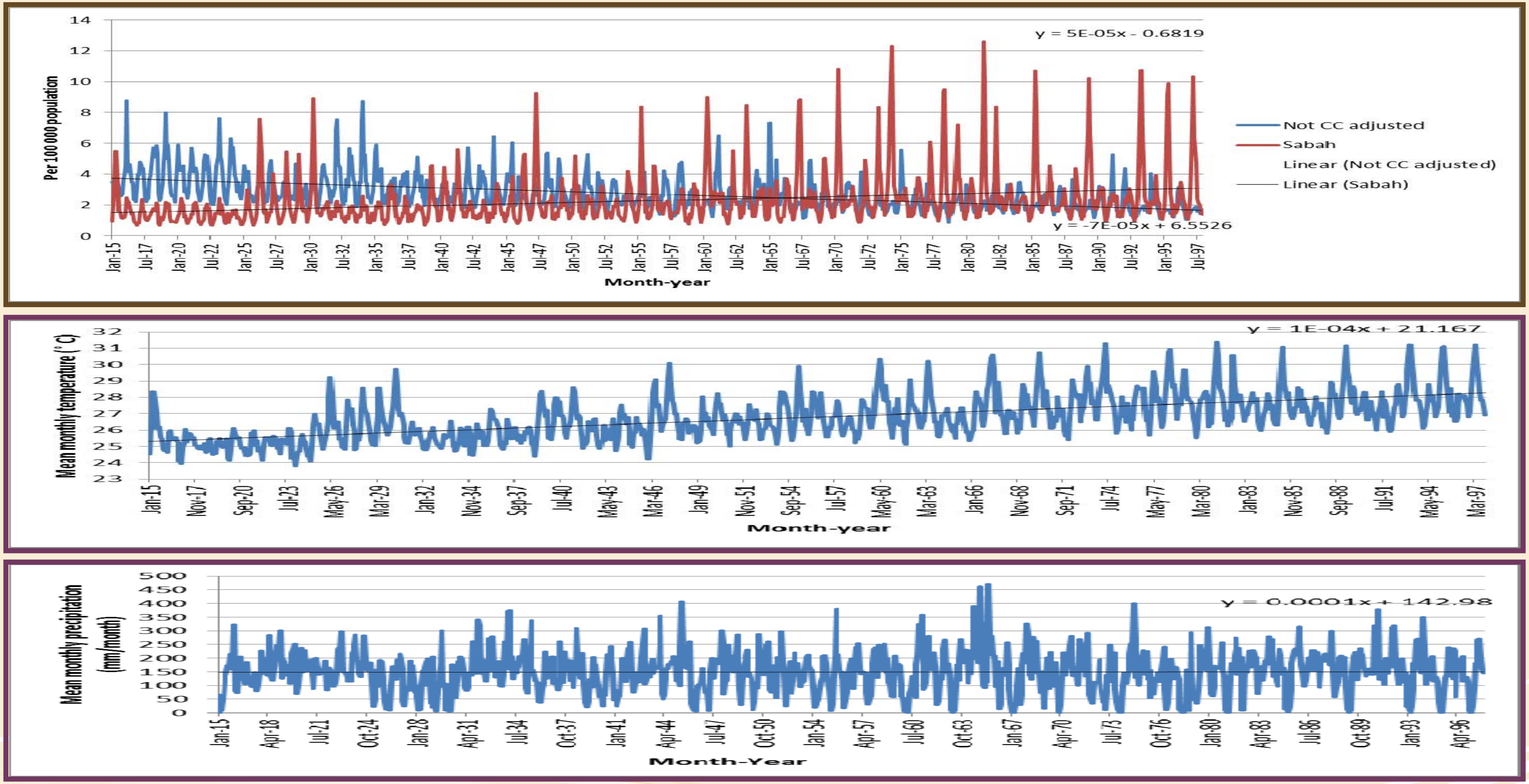


Figure 7: Cholera incidence projection in Sabah from 2015 to 2100

Table 4:Monthly incidence rates of cholera in Sabah

	Monthly incidence rates											
State	Minimum (B)	2015-2040	2041-2070	2071-2100	Mean (B)	2015-2040	2041-2070	2071-2100	Maximum (B)	2015-2040	2041-2070	2071-2100
Sabah	0.03	0.664	0.74	0.88	0.98	1.74	2.31	3.16	7.44	8.93	10.83	12.61

Table 5: Correlation between monthly incidence rates of cholera and time

States	r^1	p-value	r^2	p-value
Sabah	0.277	<0.001*	-0.537	<0.001*

Table 6 :High incidence rates and low incidence rates months

	High incidence rates				Low incidence rates			
State	Baseline	2015-2040	2041-2070	2071-2100	Baseline	2015-2040	2041-2070	2071-2100
Sabah	April to July	April to June	March to May	April to May	November to December	August, October and November	October to November	August, October and November

Discussion

- Different states have different climatic factors which contributed to cholera cases.
- Temperature and precipitation gave significant impact on cholera cases in Sabah ($p<0.001$).
- The study revealed that most of the cholera cases in Malaysia were from the coastal areas .
- The bacterium is strongly associated with plankton , and forming commensal or symbiotic relationship with copepods (Colwell et al. 2003) .
- Warmer temperature blooms algae species (Hunter 2003).
- Temperatures ranging from 25.0 °C to 30.0 °C and salinity of 15.0% have been proven to be important in influencing the attachment of *Vibrio cholerae* to copepods (Constantin 2009).
- Algae and copepods were consumed by fish, mollusc and crustacean, a heavy intrusion of carriers infected with *Vibrio cholerae* were generated and distributed into multiple coastal communities.

- A study done on muddy and sandy sediments in Kok Lawi beach, Sabah found that there were 2632 copepods in the samples taken. It was found in 5 to 15cm depth of the sand (Shabdin and Othman 1999).
- A study conducted in Bangladesh showed that the cholera cases were reduced by 48.0% when they filtered the copepods and particulates of more than 20µm from the water before use (Colwell et al. 2003) .
- Some parts of Sabah is still dependent on rain and surface water for daily activities (Zin et al. 2015).
- The Association of Water and Energy Research Malaysia (AWER 2011) investigated the water coverage of states in Malaysia and the findings show that, in 2010, only 79.0% of houses in Sabah used the water provided by *Jabatan Bekalan Air (JBA).*
- Climate change will alter the marine ecosystem, higher temperature will provide more reservoir for *Vibrio cholerae.*
- *At the end of the 21st century*, the maximum monthly incidence rate of cholera in Sabah would increase by 41.0% compared to baseline.

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