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ORIGINAL ARTICLE

The association of climatic pattern and leptospirosis cases in Malaysia from 2013 to 2021

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Abstract

Introduction: Leptospirosis is an emerging infectious disease exemplified by frequent outbreaks worldwide with more than one million cases and 50,000 deaths annually. A high number of cases have been reported in Southeast Asia, including Malaysia. This study aims to identify the relationship between climatic patterns and leptospirosis cases in Malaysia from 2013 to 2021. *Materials and Methods:* The climatic data comprising temperature, humidity, and rainfall from 2013 to 2021 were obtained from the Malaysian Meteorological Department. Data was collected from five states in Malaysia: Kelantan, Perak, Selangor, Negeri Sembilan, and Sarawak. A Spearman correlation test was used to determine the relationship between the climatic pattern and Leptospirosis cases. *Results:* In general, Leptospirosis cases fluctuated, with a maximum number of 8291 cases in 2015 and the lowest number being 1761 cases in 2021. The rainfall (mm) exhibited a fluctuating pattern from 2013 to 2021, with the highest total rainfall of 1938.5 mm in 2017. Temperature patterns varied from 2013 to 2021 with the highest temperature recorded was 27.60 degrees Celsius (°C) in 2016. The humidity increased steadily from 2017 to 2021, with the highest humidity recorded at 83.7% in 2020. A significant relationship was identified between the rainfall (mm) and Leptospirosis cases ($p<0.05$). *Conclusion:* The findings imply that the amount of rainfall has a significant relationship with leptospirosis cases and the highest cases of leptospirosis of 8291 cases, occurred in the year 2015 with a temperature of 27.3°C, a humidity of 82.4 %, and a total rainfall of 1559.1mm.

Keywords: Leptospirosis, humidity, rainfall, temperature, Malaysia

INTRODUCTION

Leptospirosis is estimated to cause 58,900 deaths a year.[1,2] The disease is a zoonosis with ubiquitous distribution, caused by the Leptospires bacteria.[3] The bacteria are grouped into 250 recognised serovars according to their antigenic relationship. Some pathogenic serovars can infect many species of wild and domestic animals.[3] Small mammals, such as rodents, act as the major reservoir host in the transmission of Leptospirosis.[4] Leptospires also can survive in rivers, ponds and other forms of surface water, which refers to water that is collected above ground, such as in streams, lakes and flooded areas, thus facilitates the transmission.[5] People can get infected via direct contact with infected animals or indirect contact with leptospires in moist soil, and surface water.[6] Leptospirosis is an endemic disease in the tropical region including Malaysia. The highest incidence of Leptospirosis was reported in Malacca, with an average of 11.12 cases per 100,000 population, followed by Pahang, Terengganu, Kelantan and Perak. Meanwhile, the lowest incidence was recorded in Johor (1.79 cases per 100,000).[7] The case fatality rate (CFR) was reported to be the highest in Perak (6.81 %), followed by Sarawak (6.42 %) and Perlis (6.25 %) from 2004 to 2009.[8] Environmental factors such as soil moisture, surface water, temperature, and humidity can influence the transmission and survival of Leptospirosis. Leptospirosis also can spread through flood water and waterways.[9] Based on the previous study, the transmission rates of Leptospirosis depend on flooding and temperature where a high degree of flooding leads to a higher number of infected people.[10]

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The peak of Leptospirosis incidence was also associated with rainfall and temperature, and it shows that the climate is conducive to leptospirosis transmission.[11] In 2014, a heavy and continuous rainfall that hit eastern states in Peninsular Malaysia, especially in Kelantan caused a rise in the incidence of infectious diseases including Leptospirosis.[12] A total of 1,229 leptospirosis cases were identified and the cases doubled in the post-flood period. This study shows that changes in the environment after flooding cause increased interactions between humans and carrier animals and increased leptospirosis cases.[12] The increasing incidence of leptospirosis is worrying because it can lead to kidney damage, meningitis, liver failure, respiratory distress, jaundice, abdominal pain, diarrhoea, mental confusion, psychosis, and even death.[13] There are reports on Leptospirosis cases in Malaysia, which collectively report incidence and patterns of leptospirosis in the country from 2004 to 2014.[7,13,14] These earlier studies focused mainly on socio-demographic data (gender, ethnicity, age and occupation) and very limited environmental factors were included for data mapping and analysis.[7] Therefore, for a better understanding of the epidemiology of leptospirosis and climatic predictors in Malaysia, this study aimed to identify the climatic pattern that comprised temperature, humidity and rainfall and its relationship with leptospirosis cases in Malaysia from 2013 to 2021.

MATERIALS AND METHODS

This cross-sectional study used secondary data as a method for data collection. The climatic data, which consisted of temperature (°C), humidity (%) and rainfall (mm) was obtained from the Malaysian Meteorological Department.[15] The five states in Malaysia, representing the five main locations for weather observation stations in Malaysia, provided the climatic data from 2013 to 2021. The states were Kelantan, Perak, Selangor, Negeri Sembilan and Sarawak.

The number of leptospirosis cases was gathered from published reports by the Ministry of Health of Malaysia for the same five states and time frame.[16–24] According to the guidelines provided by the Ministry of Health, reported leptospirosis cases were confirmed using the Microscopic Agglutination Test (MAT), which is considered as the gold standard for diagnosing leptospirosis. Other confirmatory diagnostic methods including polymerase chain reaction (PCR), culture method and rapid diagnostic tests were employed to support case identification.[25] Statistical analysis was performed using SPSS version 27. Spearman correlation test was used to assess the relationship between climatic variables and leptospirosis cases. A p-value ≤ 0.05 was considered statistically significant.

RESULTS

A total of 45150 leptospirosis cases were recorded from five states in Malaysia: Kelantan, Perak, Selangor, Negeri Sembilan and Sarawak throughout the ninth-year study period. The number of cases varied from year to year, with the highest number occurred in 2015 at 8291 and the lowest number occurred in 2021 at 1761 (TABLE 1).

The trend of rainfall from 2013 to 2021 demonstrated varying patterns, with some years experienced higher levels of rainfall compared

TABLE 1: The average rainfall, temperature, humidity, and total leptospirosis cases from 2013 to 2021 of five states in Malaysia

YEAR	RAINFALL (mm)	TEMPERATURE (°C)	HUMIDITY (%)	LEPTOSPIROSIS CASES
2013	1658.9	27.1	83.1	4457
2014	1575.4	27.0	81.6	7806
2015	1559.1	27.3	82.4	8291
2016	1466.1	27.6	81.5	5285
2017	1938.5	27.1	83.3	4365
2018	1902.5	27.1	83.4	5056
2019	1466.3	27.4	83.0	5217
2020	1869.0	27.3	83.7	2912
2021	1720.4	27.1	82.8	1761

to others. Notably, 2017 experienced a peak in rainfall with 1938.5 mm, and the number of leptospirosis cases in this year is 4365 (FIG 1). The temperature patterns from 2013 to 2021 also fluctuated, with the highest recorded temperature being 27.60°C in 2016. Interestingly, this year saw a higher number of leptospirosis cases at 5285. From 2019 to 2021, both temperature and leptospirosis cases showed a persistently decreasing trend (FIG 2). Humidity levels showed a fluctuating pattern from 2013 to 2016 but then increased steadily from 2017 to 2021. The peak humidity level was 83.7% in 2020, a year that recorded 2912 cases of leptospirosis (FIG 3).

There was a significant, negative, and strong relationship between rainfall and leptospirosis cases, with a p-value < 0.05 and an r-value of -0.67 (TABLE 2). This indicates that as the amount of rainfall increases, the number of leptospirosis cases decreases. However, there was no significant relationship between leptospirosis cases with temperature and humidity.

DISCUSSION

Leptospirosis has been consistently present in Malaysia, posing a substantial public health concern due to its wide range of clinical symptoms and potential for severe consequences, including liver failure, respiratory distress, kidney damage and death.[26] In this study, the number of leptospirosis cases shows significant variability, peaking in 2015 (8291 cases) and reaching a low in 2021 (1761 cases). A sharp decline of the cases from 2019 to 2021 were likely influenced by behavioural changes of the COVID-19 pandemic such as reduced exposure to high-risk environments, improved hygiene practices, and changes in healthcare dynamic.[27] This trend corresponds with global observations, where reduced case rates during the pandemic were also reported in Europe, India, and China, associated with similar factors.[28–30]

This study found a significant negative relationship between leptospirosis cases and heavy rainfall, suggesting that the cases decreased when there was a higher amount of rainfall. This finding contradicted with traditional understanding of leptospirosis epidemiology, where increased leptospirosis cases are always associated with higher rainfall, lower temperatures and higher humidity.[11,31,32] Previous studies found a positive relationship between rainfall and leptospirosis cases in tropical regions, as flooding caused by heavy rainfall creates a stagnant water environment that is conducive for *Leptospira* proliferation, and enhances human exposure to the contaminant thus causing leptospirosis outbreak.[10,33] Such trends were observed in Malaysia in 2015 and 2014, where relatively higher rainfall corresponded with increased cases.

However, the negative relationship observed in this study can be explained by the dilution effect, where heavy rainfall reduces the concentration of *Leptospira* in water bodies to a level that is no longer infectious.[34] Rapid water flow during heavy rainfall also may wash away contaminated water before it can lead

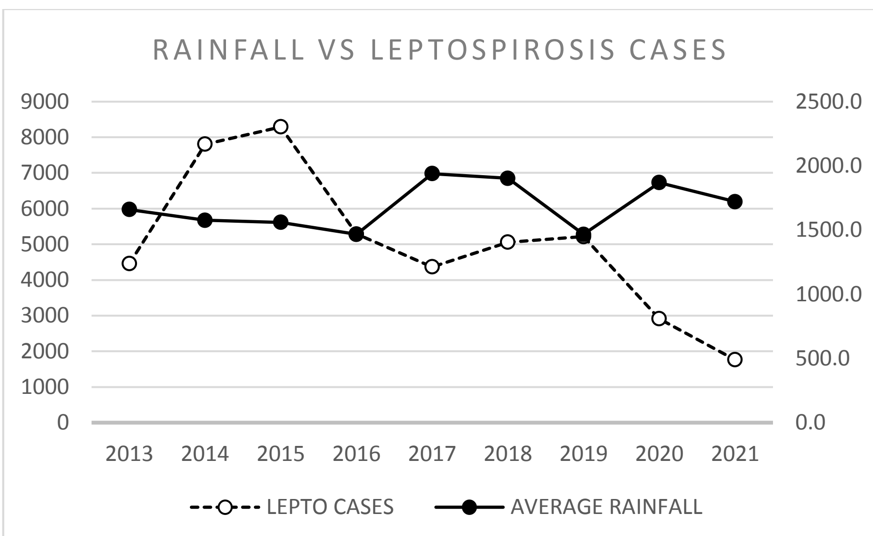

FIG. 1. The average rainfall with a total of leptospirosis cases from 2013 to 2021.

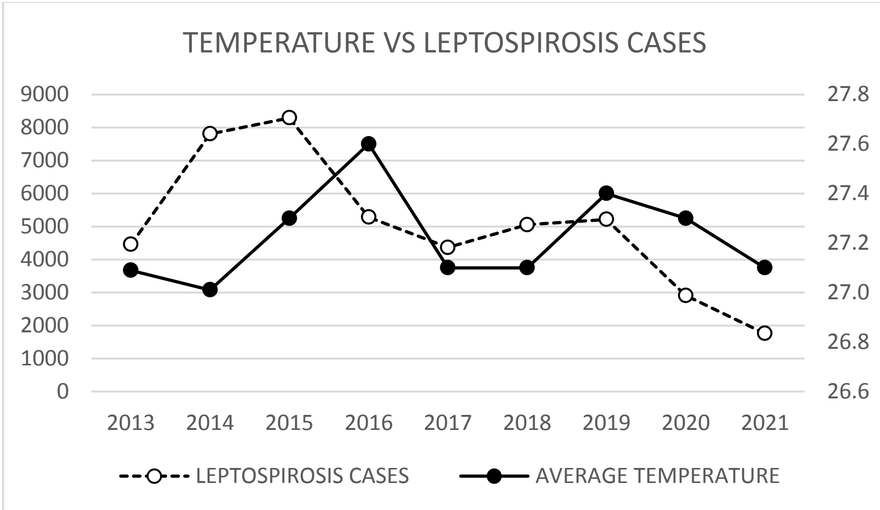

FIG. 2. The average temperature with a total of leptospirosis cases from 2013 to 2021

to significant human exposure.[35] In addition, behavioural changes such as using protective measures and avoiding waterlogged areas during rainfall may further decrease exposure to contaminated environments.[36] This highlights the intricate relationship between rainfall intensity, duration, and human behaviour, implying that rainfall does not serve as a simple linear determinant of leptospirosis cases.

The relationship between leptospirosis cases and temperature or humidity was not significant in this study, even though these factors are known to play a crucial role in Leptospira survival and transmission. Pathogen Leptospira favours warm temperatures and humid environment to survive.[37] This is consistent with the relatively stable warm temperature and high humidity in this study. Higher humidity levels enhance the survival and proliferation of Leptospira bacteria in the environment, thus potentially increasing infection rates.[38] For example, the increase in leptospirosis cases in 2020 coincided with elevated humidity. Malaysia possesses these conditions all year long, however, the lack of statistically significant relationship could indicate the influence of multiple environmental variables, including the combined impact of rainfall, temperature, and humidity, as well as other unaccounted factors like soil conditions and patterns of human activity.[39,40]

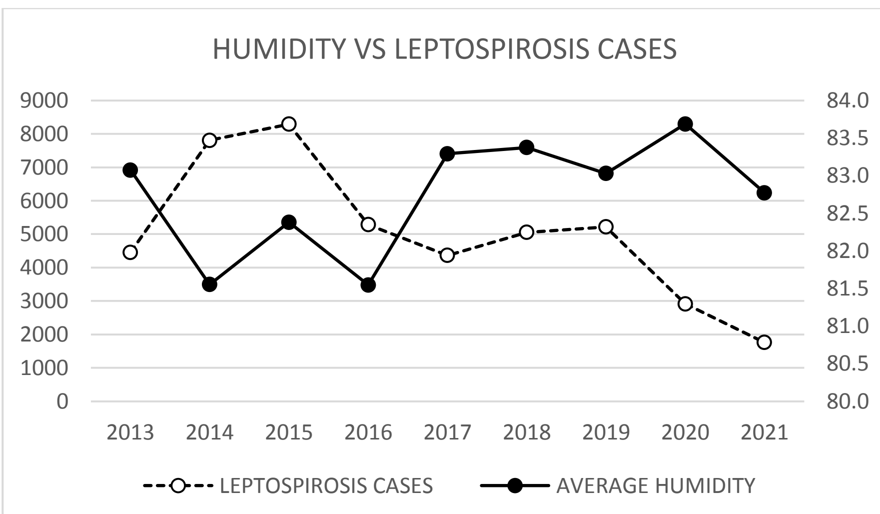

FIG. 3. The average humidity with a total of leptospirosis cases from 2013 to 2021.

TABLE 2: Relationship between rainfall, temperature and humidity with leptospirosis cases (n=9)

Climatic factors	leptospirosis cases	
	r-value[a]	*p*-value[b]
Rainfall (mm)	-0.67	0.04*
Temperature (°C)	0.19	0.62
Humidity (%)	-0.63	0.06

a: Correlation coefficient, b: Spearman's correlation test *significant at p-value ≤0.05

Previous studies suggested that there were periods when fluctuations in temperature and humidity were associated with leptospirosis cases, but these associations were not consistently significant across different seasons and years.[41] The influence of temperature on leptospirosis is more pronounced when combined with high humidity and rainfall.[42] For instance, warmer and more humid conditions during rainy seasons can promote *Leptospira* survival in floodwaters, potentially resulting in greater transmission.[11] On the other hand, a study found that humidity plays a less significant role, as its effects are often mediated by other environmental factors.[43] Similarly, research from Korea found that the correlation between leptospirosis and temperature or humidity was weaker compared to rainfall. Although the lag effect of climatic variables showed some correlations, it was not strong enough to establish a reliable predictive model.[44]

Based on the observed relationship between leptospirosis cases and climatic factors, several prevention measures could be considered to reduce the disease transmission. Public awareness campaigns should be prioritised, focusing on improving knowledge about leptospirosis risks, especially during the rainy season. These initiatives should deliver targeted messages to high-risk groups, including agricultural workers and urban communities in flood-prone areas.[45] The campaigns should emphasise the importance of protective measures such as wearing waterproof boots, gloves, and suitable clothing. In addition, vaccination programmes should be explored as a long-term strategy to reduce leptospirosis incidence. The vaccines should be prioritised for high-risk groups including those in flood-prone areas, agriculture and livestock.[46] Flooding, on the other hand, is a significant factor contributor to leptospirosis outbreaks. To prevent such occurrences, human exposure to contaminated floodwaters must be reduced. This can be achieved by reinforcing systematic flood management systems, particularly in regions where flooding occurs frequently. The drainage system should be constructed efficiently to prevent debris accumulation and ensure smooth water flow.[47] Setting up early flood notification systems and providing temporary relocation assistance for individuals living in flood-vulnerable zones during significant rainfall events are additional strategies to consider. Rodents serve as primary reservoirs for *Leptospira*, are commonly associated with unsanitary environments. Improving sanitation and implementing effective rodent control measures are important for limiting rodent populations and reducing the risk of disease transmission. These measures include improving waste management systems, minimising accessible food sources for rodents, and promoting cleanliness in residential and urban areas.

However, the efficiency of these prevention measures encounters significant challenges due to the rising of global temperatures and the increasing frequency of extreme weather events such as heavy rainfall and flooding.[48,49] The significant climatic changes provide conditions that favour survival and transmission of *Leptospira*. The rise in global temperature could expand the geographic range of *Leptospira*, introducing the pathogen into new regions and escalating outbreaks in tropical and subtropical areas.[50,51] More frequent and intense flooding could worsen transmission dynamics, particularly in urban areas with inadequate drainage systems. Without effective intervention, leptospirosis cases are likely to rise substantially in the coming decades. To manage this emerging threat, public health authorities must prioritise climate change adaptation in their strategies and focusing community-based interventions. Furthermore, collaborating with international organisations to share data and develop predictive models is crucial in understanding and justifying the impact of leptospirosis globally under changing climatic conditions.

CONCLUSION

The findings show that rainfall has a negatively significant relationship with leptospirosis cases, while the other two climatic variables – temperature and humidity do not have any significant relationship with leptospirosis cases. The highest case of leptospirosis occurred in 2015 with 8291 cases, a temperature of 27.3°C, humidity of 82.4 %, and a total rainfall of 1559.1mm. The results contradict the fundamentals of the disease and factors, even though there are acceptable arguments. Improvement shall be made in future research to obtain a convincing result. This research project will bring together the leptospirosis cases and climatic patterns in Malaysia from year 2013 to 2021. This will allow for designing effective awareness programmes, preparation of support needs for medical attention, and governing authorities and health-related agencies to take appropriate measures (e.g., orderly evacuations or stockpile medication during onset flooding from heavy rainfall). Findings from this research once published, will also stimulate the generation of similar datasets from other countries and in return should provide large-scale datasets for studying risk factors associated with this endemic disease. Study on pathogen and reservoir dynamics between *Leptospira* bacteria, reservoir populations and environmental conditions can be done. Understanding the relationship between these factors and their evolution over time can provide insight into the emergence and spread of disease. A public health interventions study is also important to evaluate the effectiveness of past interventions or policies in reducing leptospirosis outbreaks. Identifying the gaps and proposing new strategies based on changing environmental dynamics and disease patterns can help in overcoming this situation.

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