Leptospirosis in Si Sa Ket, Thailand: Incidence and Factors of Death during 2010-2019

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Abstract

Leptospirosis is an emerging public health problem in Thailand especially Si Sa Ket. The aims of this study were to determine the leptospirosis incidence and factors of death among leptospirosis patients in Si Sa Ket. This study was performed during 2010-2019 from the 506-surveillance report of leptospirosis to the Sisaket Provincial Public Health Office and the National Disease Surveillance System, Bureau of Epidemiology, Ministry of Public Health, Thailand. The data was using the definition of leptospirosis patient for disease surveillance. Multiple logistic regression analysis was performed to evaluate factors of death. A total of 3,988 cases were reported from 22 districts, mainly in rural settings. The incidence rate for leptospirosis was 27.15 per 100,000 population. The dramatic phenomenal of epidemiological characteristics of leptospirosis in Si Sa Ket include a peak incidence in August and October in association with the rainy season. Seventy-four point eight percent of subjects were male, 24.5% were aged 45-54 years and 78.3% were agricultural workers. A total number of 86 deaths were registered in 19 districts. Mortality was higher in males (80.2%). The fatality rate was 2.16%. Significant factors of death found on multiple logistic regression analysis were agricultural workers (Adjusted OR=2.51, 95% CI: 1.15-5.49) and the duration of seeking for medical care >3 days after onset (Adjusted OR=2.45, 95% CI: 1.30-4.61). To reduce the burden disease, the promotion of preventive health behavior, early recognition and treatment of patients have been shown to reduce the severity of illness and death.

1. Introduction

Leptospirosis is an important public health problem in many countries of the world, including Thailand. This disease is caused by infection with pathogenic bacteria called *leptospires*, which can survive in the environment for months. Humans become infected through direct contact with the urine of infected animals or with a urine-contaminated environment. The bacteria enters the body through cut wounds, abrasions on the skin, the oral cavity mucous membranes, nose and eyes. Human-to-human transmission is rare. It often peaks seasonally, sometimes in outbreaks, and is often linked to climate changes, to poor urban slum communities, to occupation or recreational activities (WHO, 2003). The people who are most at risk of leptospirosis infection are involved with activities that require to be exposed to water for a long time, work outdoors or with animals. Leptospirosis can have a broad range of symptoms and clinical signs, from a mild flu-like illness to severe with hemorrhage, multi-organ failures associated with high mortality (WHO, 2003 and DDC- MOPH, 2019). Leptospirosis is found throughout the world, but higher prevalence found in tropical regions with high rainfall (Allwood et al., 2014, Carvajal and Fagerstrom, 2017, Sánchez-Montes et al., 2015 and Santos et al., 2017).

It was estimated that there are annually 1.03 million clinical cases and 58,900 deaths due to leptospirosis worldwide, resulting in 2.90 million DAILYs lost each year. Most of the deaths are in areas that lack critical care capabilities (WHO, 2019). In Thailand, leptospirosis incidence was 5.3 per 100,000 population. It was endemic in the most rural area. The ratio between male to female was 4:1. The most frequently found age group was 45-54 years. Most patients were agricultural. Thailand, the highest incidence rates were found in Si Sa Ket, the

morbidity rate was 52.80 per 100,000 population, the fatality rate was 2.0% (DDC-MOPH, 2019). Si Sa Ket, leptospirosis can be found throughout the year. The highest rates occur in the rainy season during June to November which the highest in October coincides with the monsoon season (Carvajal and Fagerstrom, 2017, Sánchez-Montes et al., 2015 and Santos et al., 2017). Although the morbidity rate in Si Sa Ket is reduced, the number of deaths was still high, an annual outbreak of leptospirosis still occurs (DDC-MOPH, 2020 and Sisaket Provincial Public Health Office, 2020). The purposes of this study were to determine the leptospirosis incidence and factors of death among leptospirosis patients in Si Sa Ket during 2010-2019. The data generated by this study will help in the provision of baseline information and understanding epidemiological patterns could assist in the prevention and control of leptospirosis for local populations.

2. Methods

2.1 Study Design

A retrospective study was conducted among 3,988 cases of leptospirosis in Si Sa Ket during 2010-2019 from the 506-surveillance report, Sisaket Provincial Public Health Office and the national disease surveillance system, Bureau of Epidemiology, Department of Disease Control, Ministry of Public Health, Thailand.

2.2 Statistical Analysis

Statistical analysis was used frequencies and percentages to describe cases of leptospirosis. The relationships between risk factors and death by multiple logistic regression analysis. The first step, rough data analysis was performed using Chi-square test or Fisher's exact test then the case that 20% of all cells had the expected value less than 5, all variables were taken into the model by univariate analysis was performed using odds ratio (OR) and 95% confidence intervals (CI) and second step taken variables with rough analysis results P-value<0.25 were selected into an initial model of multivariate analysis. From the initial model to the last model (the best model was analyzed by backward elimination procedure. The variables that remained significant (P-value<0.05) were kept in the model, using adjusted OR and 95% confidence intervals (CI) were also calculated.

2.3 Ethics Statement

The study protocol was reviewed and approved on March 28, 2020 by the Ethics Committee of Mahasarakham University, Thailand (registration number 132/2020). Informed written consent was obtained from all the respondents.

3. Results

A total of 3,988 cases of leptospirosis were reported during 2010-2019 across all 22 districts in Si Sa Ket. The incidence rate for leptospirosis was 27.15 per 100,000 population. The dramatic phenomenal of epidemiological characteristics of leptospirosis in Si Sa Ket include a peak incidence between August to October in association with the rainy season. The Highest morbidity rates per 100,000 population were found in Phu Sing (63.79), Khukhan (55.65), khun Han (53.83), Prang Ku (43.96) and Phrai Bueng (35.43) respectively. There were 86 deaths during 2010-2019, most of the death cases were from Khukhan (15.12%), Prang Ku (13.95%) and Uthumphon Phisai (11.63%) respectively (Figure 1). The overall case mortality rate was 0.58 per 100,000 population and fatality rate was 2.16% (Table 1).

Most cases of leptospirosis were male (74.8%), the ratio of male to female cases was 2.97: 1, aged 45-54 years (24.5%), aged 35-44 years (20.7%), aged 55-64 years (18.0%), marital status (69.6%), agricultural (78.3%), laborer (11.7%), student (5.4%). More leptospirosis cases came from rural areas (83.3%) and the rest from urban areas (16.7%). Most of the leptospirosis death cases were male (80.2%) more than female (19.8%), aged ≥ 45 years (74.4%), single status (88.4%), agricultural (87.2%), live in rural areas (95.3%) and came to seeking medical care ≤ 3 days after onset was 86.0%. Leptospirosis cases came to seeking medical care ≤ 3 days after onset was 83.4% and come seeking for medical care > 3 days after onset was 16.6%. The median period between the date of onset and date of seeking medical care was 8 days (range 0-20 days), while the median duration between the date of onset and the date of death was 10 days (range 0-28 days) (Table 2). The altitude from sea level, the loamy sand are important variables for leptospirosis cases spreading (Figures 3-4). The distribution of leptospirosis shows that the high incidence area is located at agricultural land and rice farming area, the low-risk area is located in a forestry area (Figure 5). There are increasing infection during rainfall and still occurred during low rainfall, most of the clusters were around a body of water of some sort which is near the river and the rice field (Figures 6-7). The higher population density is contributing the leptospirosis incidence, it also the higher population density at that location, the higher potential for leptospirosis incidence will happen in that location (Figure 8).

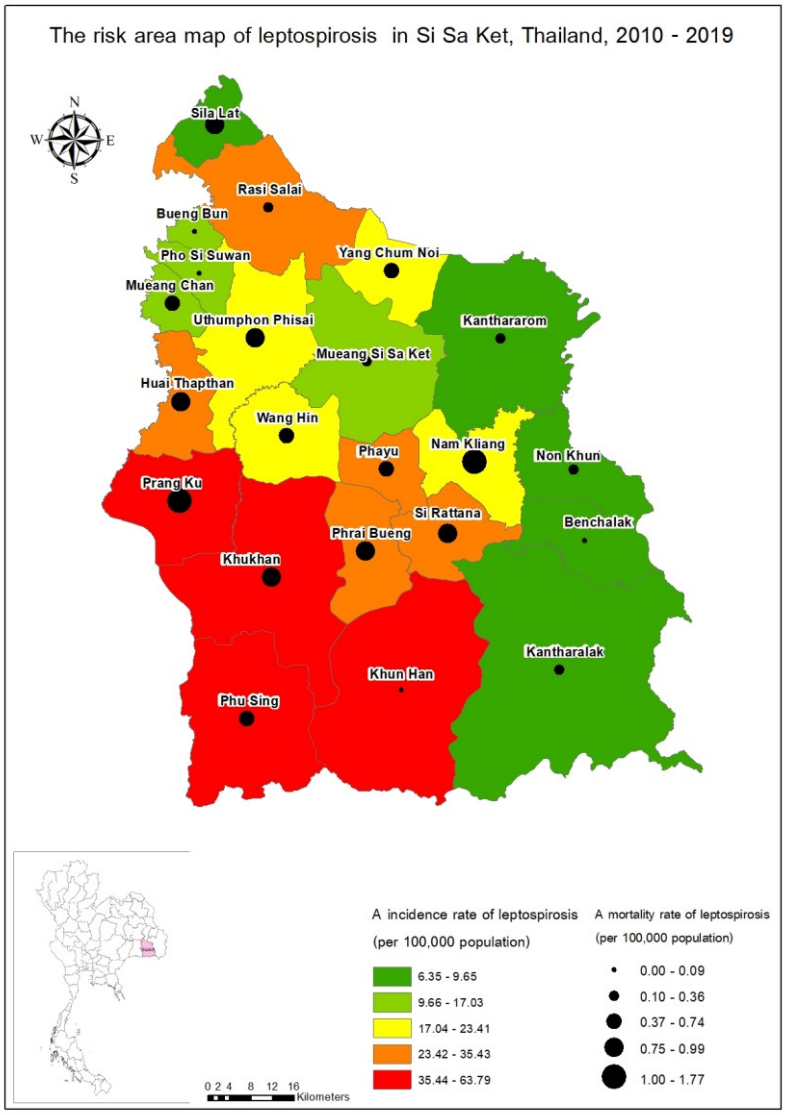

Figure 1: Morbidity rate and mortality rate of leptospirosis in Si Sa Ket during 2010-2019

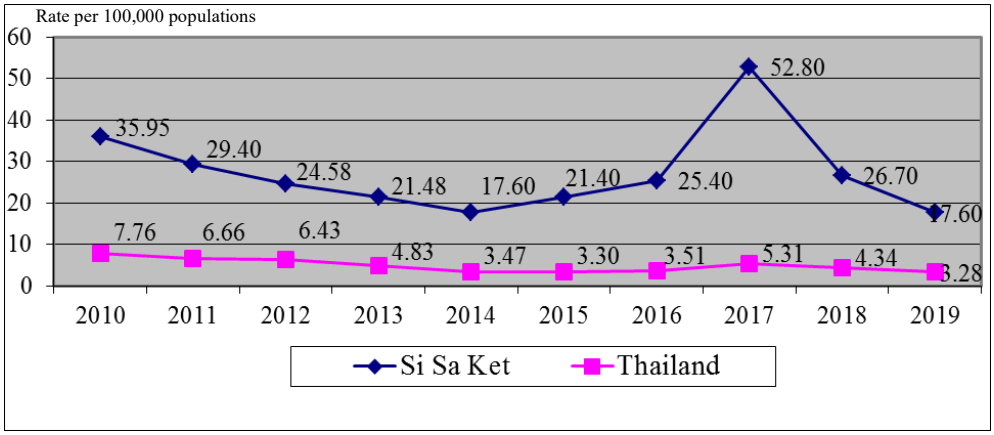

Figure 2: Morbidity rate of leptospirosis in Si Sa Ket and Thailand during 2010-2019

Table 1: Incidence, mortality and fatality rate of leptospirosis in Si Sa Ket, 2010-2019 (N=3,988)

District	Incidence rate (per 100,000)	Number of dead cases (%)	Mortality rate (per 100,000)	Fatality rate (%)
Muang Si Sa Ket	14.50	5 (5.81)	0.36	0.13
Yang Chum Noi	23.36	2 (2.33)	0.54	0.05
Kanthararom	9.65	2 (2.33)	0.20	0.05
Kantharalak	8.62	7 (8.14)	0.35	0.18
Khukhan	55.65	13 (15.12)	0.86	0.33
Phrai Bueng	35.43	4 (4.65)	0.83	0.10
Prang Ku	43.96	12 (13.95)	1.77	0.30
Khun Han	53.83	1 (1.16)	0.09	0.03
Rasi Salai	26.97	2 (2.33)	0.25	0.05
Uthumphon Phisai	21.20	10 (11.63)	0.93	0.25
Bung Bun	17.03	0 (0.00)	0.00	0.00
Huai Thap Than	27.18	4 (4.65)	0.94	0.10
Non Khun	8.29	1 (1.16)	0.25	0.03
Sri Ratana	30.47	5 (5.81)	0.94	0.13
Nam Kliang	23.41	6 (6.98)	1.35	0.15
Wang Hin	23.09	3 (3.49)	0.60	0.08
Phu Sing	63.79	4 (4.65)	0.74	0.10
Muang Chan	14.50	1 (1.16)	0.55	0.03
Benchalak	6.35	0 (0.00)	0.00	0.00
Phayu	28.50	2 (2.33)	0.55	0.05
Pho Si Suwan	15.27	0 (0.00)	0.00	0.00
Sila Lat	9.04	2 (2.33)	0.99	0.05
Total	**27.15**	**86 (100.00)**	**0.58**	**2.16**

Table 2: Characteristics of leptospirosis cases in Si Sa Ket, 2010-2019

Variables	Number of cases (%) (N=3,988)	Number of dead cases (%) (N=86)
Gender		
Male	2,984 (74.8)	69 (80.2)
Female	1,004 (25.2)	17 (19.8)
Age (years)		
< 10	61 (1.5)	0
10-14	99 (2.5)	0
15-24	334 (8.4)	2 (2.3)
25-34	516 (12.9)	6 (7.0)
35-44	825 (20.7)	14 (16.3)
45-54	978 (24.5)	25 (29.1)
55-64	717 (18.0)	23 (26.7)
≥ 65	458 (11.5)	16 (18.6)
Marital status		
Married	1,214 (30.4)	10 (11.6)
Single	2,774 (69.6)	76 (88.4)
Occupation		
Agricultural	3,121 (78.3)	75 (87.2)
Student	215 (5.4)	4 (4.7)
Government	124 (3.1)	0
Laborer	467 (11.7)	7 (8.1)
Personal career	43 (1.1)	0
Priest	18 (0.4)	11 (12.8)
Residence		
Urban	667 (16.7)	4 (4.7)
Rural	3,321 (83.3)	82 (95.3)
Duration between the date of onset & Date of seeking for medical care (days)		
≤ 3	3,327 (83.4)	74 (86.0)
> 3	661 (16.6)	12 (14.0)

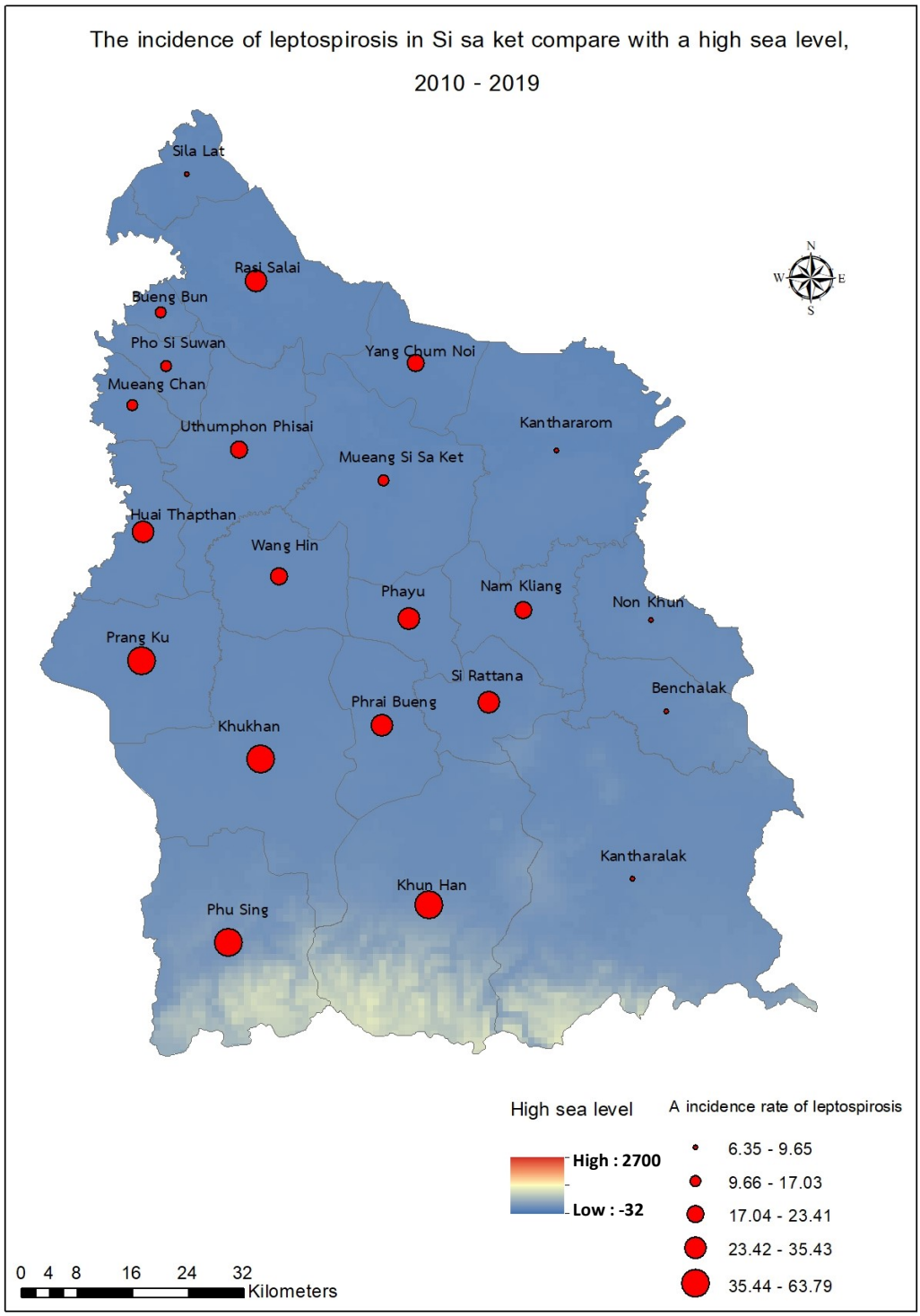

Figure 3: Incidence of leptospirosis compare with a high sea level (2010-2019)

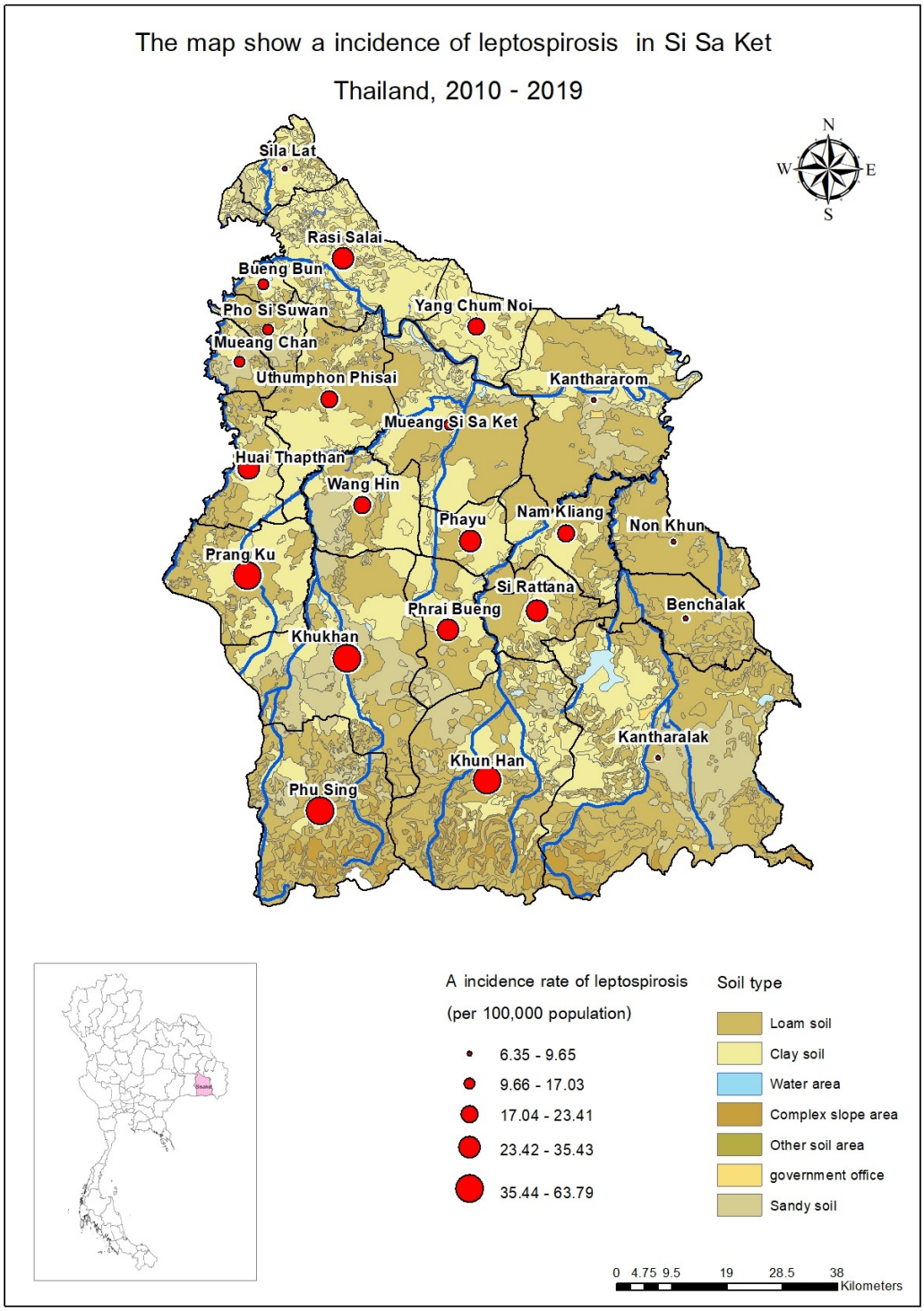

Figure 4: Incidence of leptospirosis compare with soil type (2010-2019)

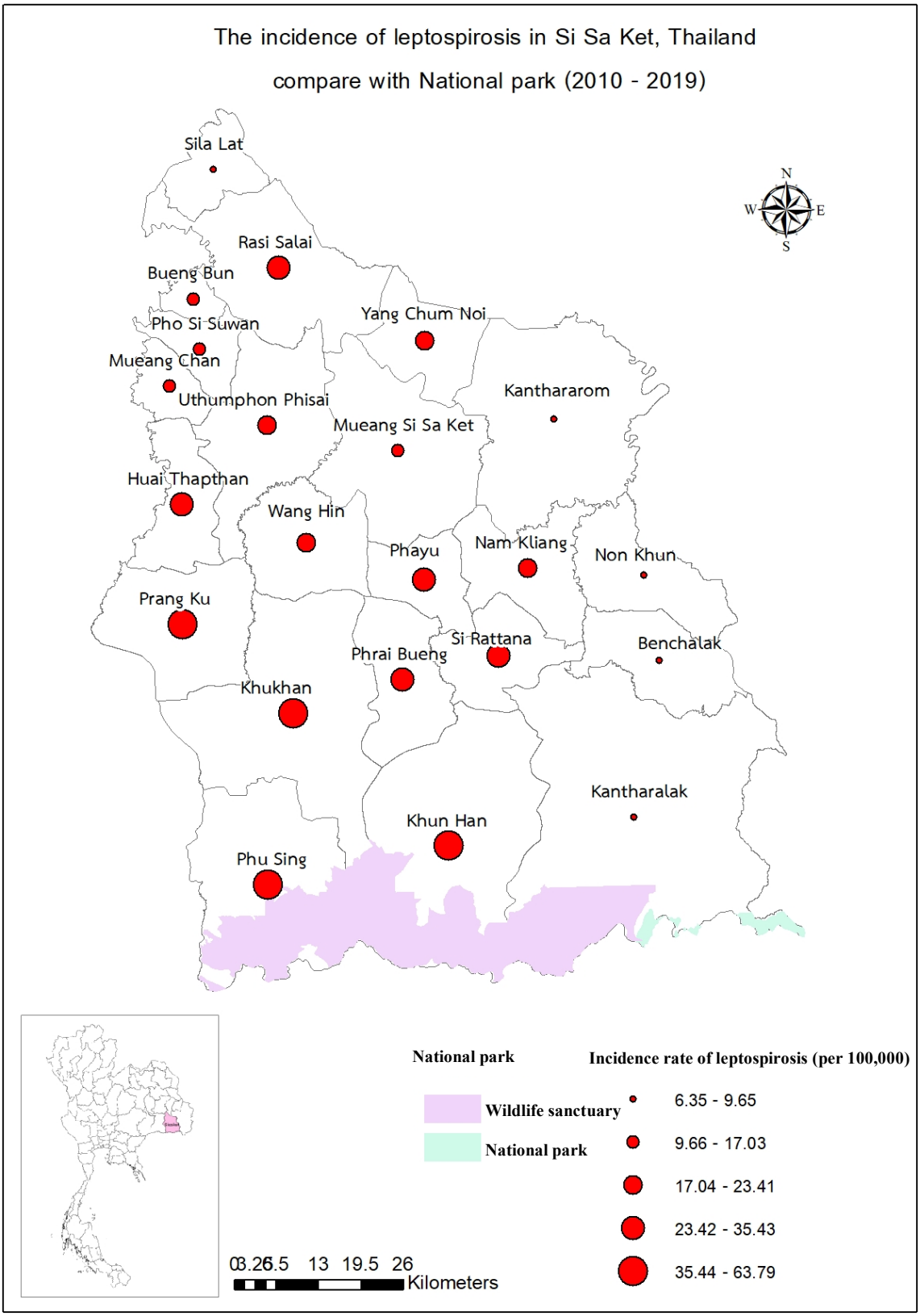

Figure 5: Incidence of leptospirosis compare with National park (2010-2019)

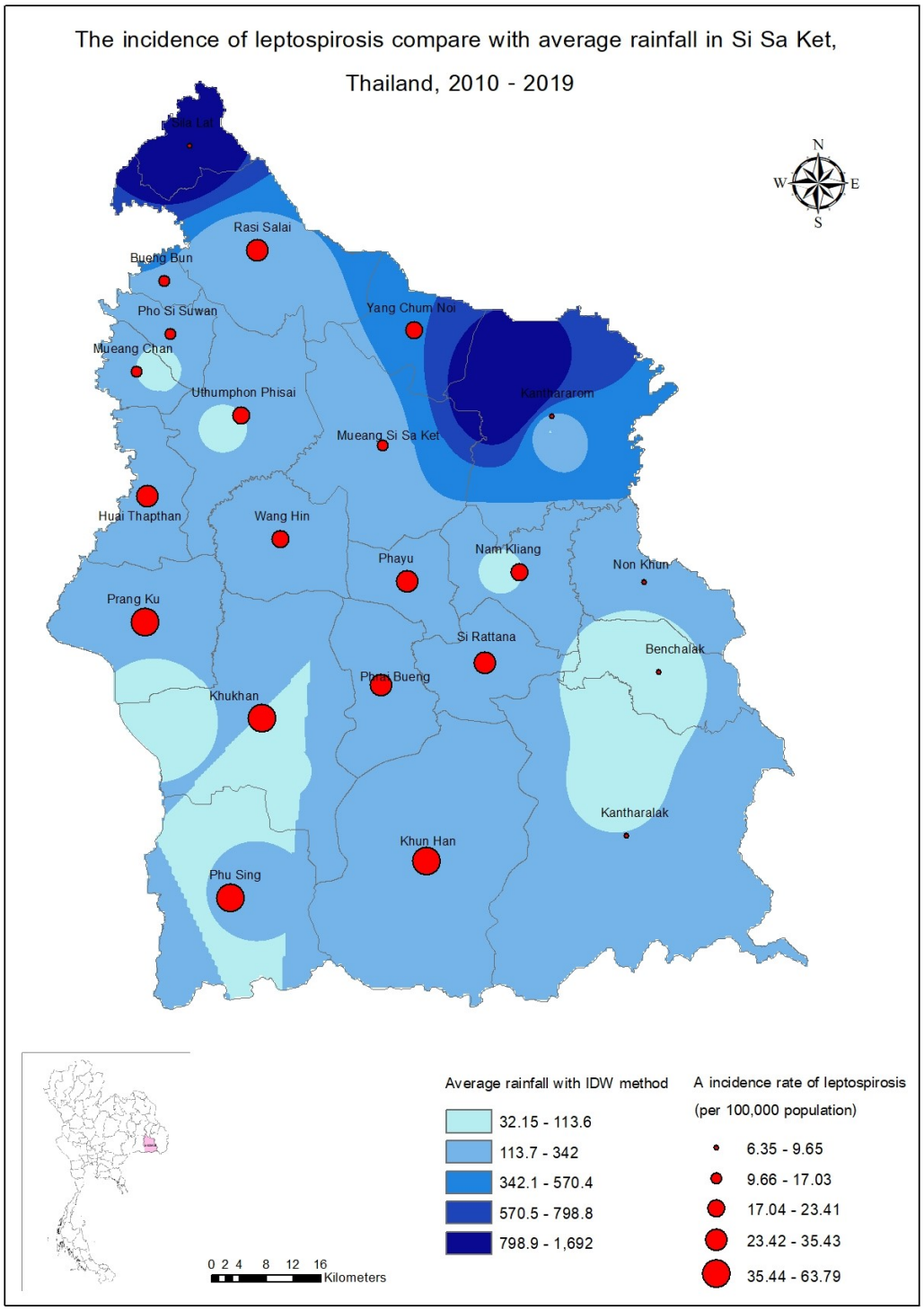

Figure 6: Incidence of leptospirosis compare with average rainfall (2010-2019)

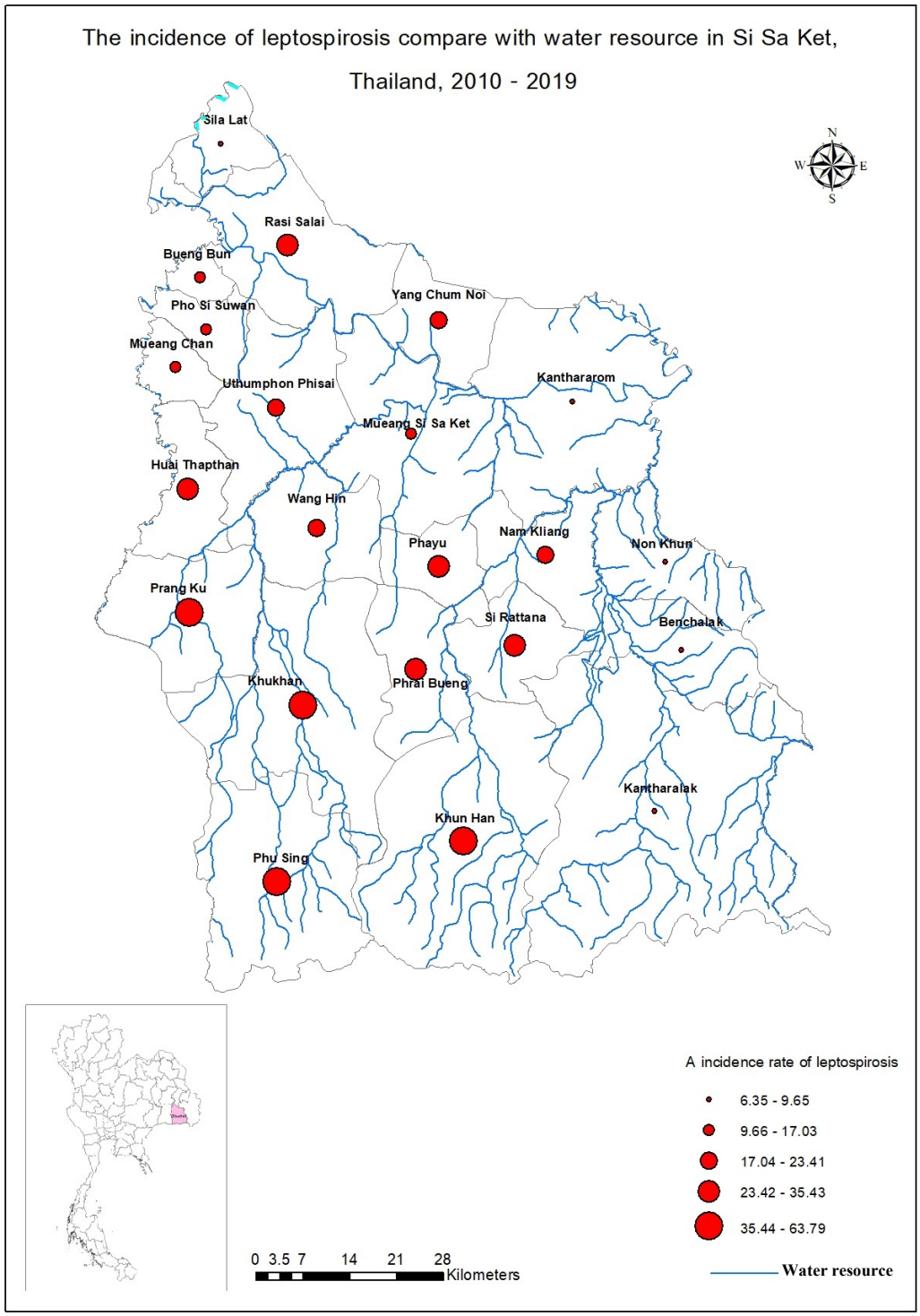

Figure 7: Incidence of leptospirosis compare with water resource (2010-2019)

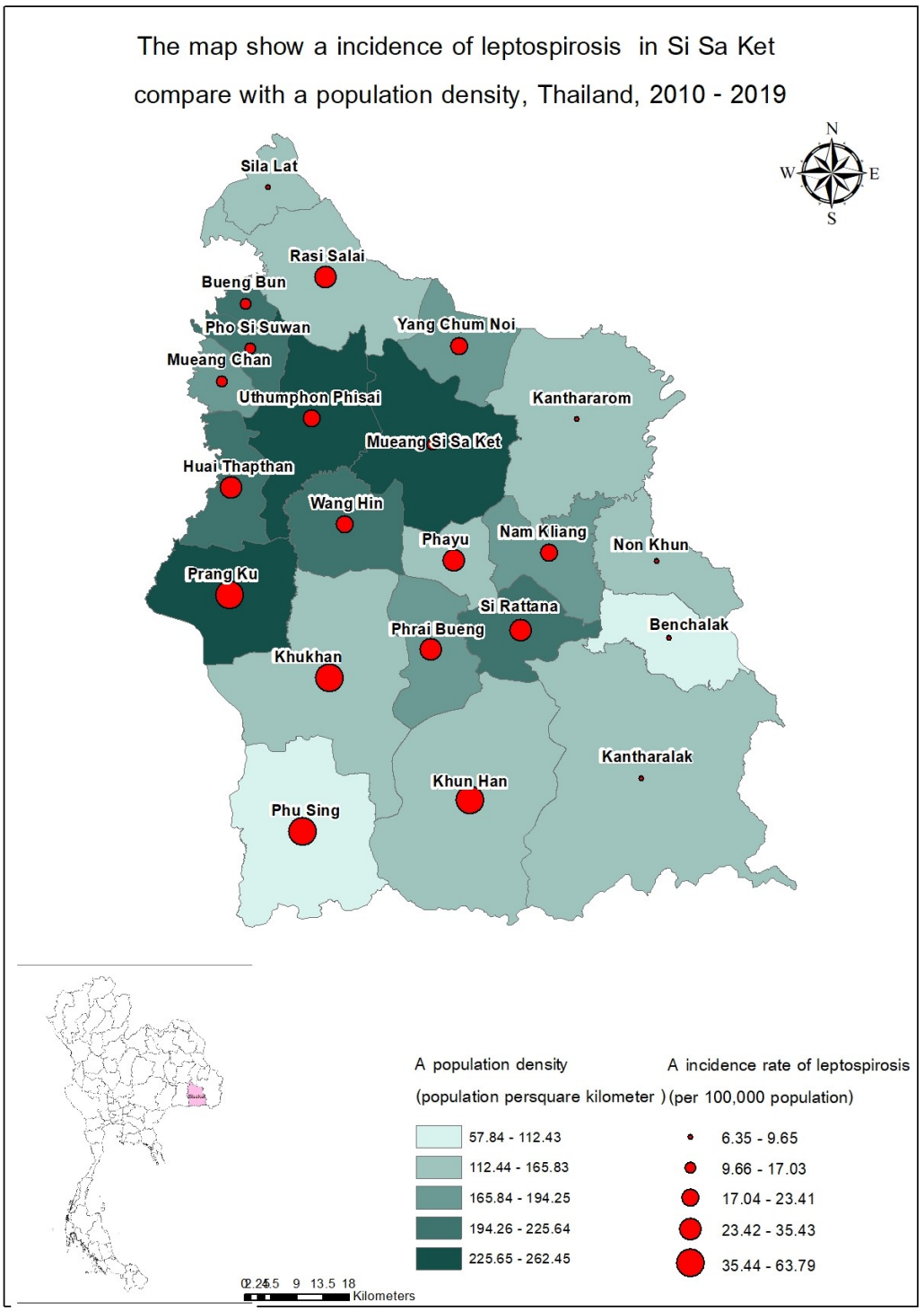

Figure 8: Incidence of leptospirosis compare with a population density (2010-2019)

Table 3: The factors of death among leptospirosis patients in Si Sa Ket during 2010-2019

Variables	Number of cases (%) (N=3,902)	Number of dead case (%) (N=86)	Crude OR (95% CI)	Adjusted OR (95% CI)	P-value
Age (years)					
< 45	1,813 (46.5)	22 (25.6)	1.0	1.0	
≥ 45	2,089 (53.5)	64 (74.4)	2.22 (1.36-3.62)	1.47 (0.86-2.51)	0.164
Marital status					
Married	2,698 (69.1)	76 (88.4)	1.0	1.0	
Single	1,204 (30.9)	10 (11.6)	0.40 (0.21-0.77)	0.64 (0.31-1.33)	0.229
Occupation					
Other	856 (21.9)	11 (12.8)	1.0	1.0	
Agriculturist	3,046 (78.1)	75 (87.2)	3.55 (1.71-7.38)	2.51 (1.15-5.49)	0.021*
Duration between date of onset & Date of seeking for medical care (days)					
≤ 3	3,253 (83.4)	74 (86.0)	1.0	1.0	
> 3	649 (16.6)	12 (14.0)	2.48 (1.33-4.65)	2.45 (1.30-4.61)	0.006**

There were no the significant factors of death among cases who survived and died, gender, age, marital status and residence. The factors significantly of death among leptospirosis patients on multiple logistic regression analysis were patients with agricultural occupation [Adjusted Odds Ratio (ORadj) = 2.51; 95% Confidence Interval (CI): 1.15-5.49] and Leptospirosis cases came to seek for medical care > 3 days after onset [Adjusted Odds Ratio (ORadj) = 2.45; 95% Confidence Interval (CI): 1.30-4.61] (Table 3).

4. Discussion and Conclusion

The average incidence of leptospirosis trends in Si Sa Ket during 2010-2019 period was 27.15 per 100,000 population (range=6.35-63.79), which was relatively stable, not show any change in disease pattern or distribution unless an outbreak in 2017 was rose from 25.4 per 100,000 population in 2016 to 52.8 per 100,000 population in 2017 and then decreased to 26.7 per 100,000 population in 2018. The incidence of leptospirosis in Si Sa Ket during 2010-2019 has a nature of the regular outbreak continues every year. The global incidence of leptospirosis was ranged from approximately 0.1 to 10 per 100,000 per year (WHO, 2019). Thailand report of leptospirosis incidence in 2010-2019 period was 4.89 per 100,000 population (DDC-MOPH, 2020). The incidence of leptospirosis in Si Sa Ket was higher than the national level and global averages (Figure 2). Similar to a study from Kandy district, Sri Lanka reported that the incidence of leptospirosis is above national and global averages, despite an active health ministry preventive program (Ehelepola et al., 2019). In the same period with Si Sa Ket, Thailand. This consistent a study from Zakarpattia Oblast, a region of western Ukraine reported that the incidence generally declined from 4.10 per 100,000 population in 2005 to 0.88 per 100,000 population in 2015 (Markovych et al., 2019).

A study from Ireland reported that the incidence of leptospirosis in 2010-2017 period represented a slight decrease from 2010 to 2013, after that there was a fluctuation until 2017. In Europe, 2016, Ireland reported the fifth highest incidence rate after the Netherlands, Lithuania, Slovenia and Portugal (HSE Health Protection Surveillance Centre, 2018). The study is different from a study from China; Zhang et al., (2020) reported that the incidence of leptospirosis has a slow downward trend from 0.0660 per 100,000 population in 2007 to 0.0113 per 100,000 population in 2018 and Dhewantara et al., (2018) reported that the burden estimates of leptospirosis in 2005-2015 period have shown a declining trend across the country, both were lower than in Si Sa Ket province and Thailand. A study from Malaysia reported that the incidence was continued increasing from 6.99 per 100,000 population in 2010 to 30.20 per 100,000 population in 2015 (Disease Control Division, Ministry of Health, Malaysia, 2015). A study from Thrissur district, Kerala, India which showed the highest cases in 2014 followed by 2016 and the least number of cases was reported in 2017 (Premdas et al., 2019). A study from Mumbai, India reported that the incidence of leptospirosis was rose from 207 cases in 2012 to 512 cases in 2016 (Mavatkar et al., 2017). A study from Bulgaria reported that the incidence of leptospirosis in 2010-2014 was the most common in 2014. Following heavy rainfall and floods in 2014, a 5-times increase in leptospirosis cases was observed in comparison with 2013. Water was found as the main source of infection (Christova and Taseva, 2016).

It was estimated that there are 3,988 clinical cases and 86 deaths due to leptospirosis in Si Sa Ket during 2010-2019 period. The fatality rate was 2.16%. The mortality and fatality rate that began to

be reported in 2011 was higher than the national level since 2012 continued to the present. Similar to a study from Bulgaria reported that despite, Bulgaria is located in the temperate climate region of southeastern Europe, is endemic with low incidence but significant case fatality rate (Christova and Taseva, 2016). This difference a study from Malaysia reported that the mortality rate has lower than Si Sa Ket province and Thailand. The average mortality rate during 2010-2015 period in Si Sa Ket and Thailand was higher than Malaysia approximately 11.50 times and 7.01 times respectively compared with the same period (Disease Control Division, Ministry of Health, Malaysia, 2015).

Location: The incidence of leptospirosis in Si Sa Ket during 2010-2019 period had a nature of disease distribution covered all areas in Si Sa Ket. The morbidity rates were most commonly reported from Phu Sing, Khukhan, Khun Han, Prang Ku and Phrai Bueng respectively. The altitude from sea level was an important variable for leptospirosis cases spreading in Si Sa Ket, most of the area is a plateau alternating rice fields with mountains and forests in the south. The area will gradually slope down to the north and the west, which is full of creeks, canals, swamps, various marshes throughout the distance that the Mun River and the Chi River flow through. Similar to the previous study that the average slope was significantly associated with leptospirosis occurrence in each area (Viroj et al., 2021 and Rahayu et al., 2018). A study of Silva (2020) reported that the incidence of leptospirosis was associated with particularly low altitude.

The distribution of leptospirosis in Si Sa Ket shows that the high incidence area is located in lowland areas with sandy loam, agricultural land, rice farming area, and low-risk area is located in a forestry area. Which consistent with a study of Hassan and Tahar (2016) reported that the high-risk area is located at the agricultural area. A study of Rood et al., (2017) found that land use is an important variable for leptospirosis cases spreading. Different from the previous study found that the forestry area was high-risk of leptospirosis (Hassan and Tahar, 2016). A study of Rood et al., (2017), the leptospirosis transmission was higher in areas with high coverage of sabulous clay soils.

The distribution of disease was found at the location near the natural source, Huai Samran which flows from Prang Ku to Mun River at Muang Si Sa Ket, Huai Sala has upstream from Huai Phanom Dong Rak and flows from Huai Samran. Which consistent with the previous study that found the puddles that were contaminated by rat's urine were risk factors of leptospirosis cases (Rahayu et al., 2018). Most leptospirosis cases came from rural areas. This is consistent with previous studies that a high village prevalence of leptospirosis was observed in open habitats near rivers (Della Rossa et al., 2016). Leptospirosis cases that report contact with mud in the environment were significant environmental exposure for infection. Additionally, there was a nearly significant linear relationship between higher household elevation and lower infection risk for each 10 meters increase in elevation (Hagan et al., 2016). Different from a study in Brazil reported that the local profile of human leptospirosis was predominantly associated with urban areas (Santos et al., 2017 and Silveira et al., 2020).

Time: The incidence of leptospirosis was found throughout the year. It's often peak incidence between August to October in association with the rainy season and precipitation (Cunha et al., 2019 and Deshmukh et al., 2019). Flooding is known to promote leptospirosis transmission, which correlates with the amount of rainfall (Rahayu et al., 2018, Hinjoy, 2014, Carvajal and Fagerstrom, 2017 and Santos et al., 2017). It is during farming season, the agriculturist who had activities, frequent exposure to environmental risk factors such as contact with wet soil, mud or natural water sources have a long time were high risk for leptospirosis (Hinjoy, 2014). The rainy season had a temperature is also a major factor influencing the potential reproduction of rodents which tends to increase in rodent populations. Therefore, humans may have more chance of exposure to water contaminated with the urine of infected rodents (Hinjoy, 2014 and Perez et al., 2011). Similar to a study from Santa Catarina, Brazil showed the highest rates occurring in periods with higher rainfall indexes (Ghizzo Filho et al., 2018). A study from China reported that morbidity rates increased beginning in May, remained at high levels in August and September, and decreased after November (Zhang et al., 2020), a study from Thrissur district, Kerala, India showed the peak of cases between June to October. A study from Brazil found that the increase in soil moisture and precipitation, acted as risk factors of leptospirosis (Baquero and Machado, 2018). In contrast to the previous study reported that outbreak of leptospirosis in the relatively dry zone (Sanjeewani, 2017 and Agampodi et al., 2014). A study from Sri Lanka found that rainfall did not have a significant correlation with leptospirosis incidence (Plouffe, 2016). Normally leptospirosis is endemic within wet zone areas since most favorable conditions for transmission of leptospirosis like paddy farming activities, high rainfall, and moist soil, year-round water retention in paddy fields, the use of buffalo in

agriculture and peri-domestic animal farming in rural areas can be seen in common in these regions zone (Sanjeewani, 2017). Flooding after rainfall can force humans and rodents into closer contact, which can result in further contamination of surrounding water (Premdas et al., 2019). There were differences from the previous study that flooding had a low influence on leptospirosis infection (Suwanpakdee et al., 2015). Therefore, prevention and control of leptospirosis will be more effective in the event that rodent control should be performed before the rainy season and should be focusing on people to against contact with wet soil, mud or contaminated water by wearing personal protective equipment, especially boots and gloves (Hinjoy, 2014).

Person: The majority of leptospirosis cases were male, the ratio of male to female cases was 2.97: 1, males are more likely to have activities or occupation exposure compared to females (Hagan et al., 2016, Hinjoy, 2014, Carvajal and Fagerstrom, 2017 and Yu et al., 2019). The aged group with the highest incidence was those aged 45-54 years followed by those aged 35-44 years and 55-64 years respectively. Consistent a study from Netherlands reported that those aged 45-64 years were found to be significantly associated with leptospirosis incidence (Rood et al., 2017). Similar to a study from Brazil that showed that the most cases of leptospirosis occurred in individuals aged from 20-39 years old, followed by those aged 40-59 years old (Silveira et al., 2020), a study from Malaysia reported that the most cases of leptospirosis found in aged 30-39 years (Benacer et al., 2016), a study from Mexico reported that the most cases occurred in aged 25-44 years (Sánchez-Montes et al., 2015). These age groups are at increased risk due to occupational exposure (Silveira et al., 2020), which is the working-aged was probably due to a frequent exposure with environmental risk factors for leptospirosis higher than other age group, which the study from Kuantan, Malaysia reported the aged 18-29 years had a preventive practice of leptospirosis better than the other age group (Aidid et al., 2018). Different a study from China reported that older people (aged 60-75 years) were high-risk populations (Zhang et al., 2020). More than 78% of cases were agricultural (Hinjoy, 2014), there are probably due to being exposed soil or water contaminated with the urine of rodents or other reservoir animals. This consistent a study from Kandy district, Sri Lanka reported that working in rice paddies is considered as the main risk factor for contracting leptospirosis in Sri Lanka (Ehelepola et al., 2019). This affirms to previous studies that a person who had an activity related to contact with contaminated surface water are risk factors frequently associated with leptospirosis infection (Sakundarno et al., 2014), contact with mud in the environment was 1.57 times more likely for leptospirosis infection (Hagan et al., 2016), animal handlers compared with other occupations were 11 times more likely to come down with leptospirosis than others (Abiayi et al., 2015). There are differences from a previous study in Malaysia that reported the highest incidences of cases by occupation is student, maybe exposed during outdoor extra-curricular or recreational activities (Yu et al., 2019 and Tan et al., 2016). In Si Sa ket, the population density at that location, the higher potential for leptospirosis incidence will happen on that location. Similar to previous studies reported that population size was positively and significantly associated with leptospirosis (Rahayu et al., 2018, Hassan and Tahar, 2016 and Viroj et al., 2021). A study of Rood et al., (2017) reported that the percentage of the population between 45–64 years of age were found to be significantly associated with leptospirosis incidence rates. In contrast to a study from Brazil found that the decrease in the proportion of urban households was a risk factor of leptospirosis (Baquero and Machado, 2018).

The majority of death cases of leptospirosis were males, aged ≥ 45 years and agricultural workers. Similar to a previous study (Tem-eiam, 2020 and Hinjoy, 2014). More leptospirosis death cases came from rural areas. This affirms a previous study (Hinjoy, 2014). The majority of death cases were a single status. Contrary to a study of Hinjoy (2014) found that a majority of death cases were a married status.

The majority of leptospirosis cases were come to seek for medical care ≤ 3 days after onset was 83.4%. Factors significantly of death on multiple logistic regression analysis included agricultural workers were 2.51 times more likely for mortality than others that may be due to most of the cases working in agricultural and duration to seek for medical care >3 days after onset were 2.45 times more likely for mortality than duration to seek for medical care ≤3 days after onset. This affirms to previous studies that delay in seeking for treatment, which was beyond three days after onset, significantly increased the risk of death (ORadj = 1.83; 95% CI: 1.53-2.19] (Hinjoy, 2014). A study from New Calendonia found that the delay > 2 days between the onset of symptoms and the initiation of anti biotherapy were 2.78 times more likely to come down with severe leptospirosis (OR = 2.78; 95% CI: 1.31-5.91] (Tubiana et al., 2013). Early recognition, diagnosis and treatment will reduce the incidence of severe illness and deaths (Lau et al.,2010). The public relation communication to perception and

awareness of leptospirosis should be the promotion of preventive health behavior, early recognition and treatment of patients have been shown to reduce the duration severity of illness and death.

The strength of this study was a review of all reported leptospirosis cases in Si Sa Ket during 2010-2019, there have been no other published studies for this area and during the time period. A limitation of this study was a review of individual cases and data of leptospirosis cases from Si Sa Ket Provincial Public Health Office and the national surveillance system. The data from passive surveillance that's also a problem of incomplete data.

In conclusion, leptospirosis remains a major endemic environmental disease and occupational disease in Si Sa Ket. The incidence of leptospirosis in Si Sa Ket during 2010-2019 period was relatively stable, not show any change in disease pattern or distribution unless an outbreak in 2017 rose from 25.4 per 100,000 population in 2016 to 52.8 per 100,000 population in 2017 and then decreased to 26.7 and 17.6 per 100,000 population in 2018 and 2019 respectively. The study of leptospirosis incidence and factors of death. Including, early recognition, diagnosis and treatment of patients have been shown to reduce the severity of illness and mortality of leptospirosis. These data can inform leptospirosis prevention programs for the local area. To reduce this disease burden, enhanced surveillance, control, prevention, environmental management and further study are required to understand the environmental drivers of infection, to build capacity for preventive behaviors of leptospirosis, strengthen perception and awareness of the disease and promote people and community for adaptation to a changing climate.

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