Environmental and Risk Factors of Leptospirosis: A Spatial Analysis in Semarang City

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Abstract. Leptospirosis is zoonotic potentially epidemic with clinical manifestations from mild to severe and can cause death. The incidence of leptospirosis in Indonesia tends to increase by the year. The case fatality rate in Semarang was greater than the national's (9.38%). The purpose of this study was to describe the environmental risk factors of leptospirosis in Semarang spatially. The study design was descriptive observational with cross sectional approach. The population and samples in this study were confirmed leptospirosis in Semarang from January 2014 until May 2015, 88 respondents in 61 villages of 15 sub-districts in Semarang. The variables were environmental conditions, the presence of rats, wastewater disposal, waste disposal facilities, the presence of pets, the presence of rivers, flood's profile, tidal inundation profile, vegetation, contact with rats, and Protected Personal Equipment/PPE utilization. Based on the spatial analysis, variables that found in the big half area of Semarang are environmental conditions, the presence of rats, wastewater disposal, waste disposal facilities, contact with rats, and PPE utilization. The presence of pets at risk, the presence of rivers, flood's profile, inundation profile, and vegetation were found only in small half of Semarang area. People are expected to maintain their personal and environmental hygiene to prevent the transmission.

Keywords: Leptospirosis; risk factor; spatial; mapping.

1. Introduction

The risk factors contributing to its perceived re-emergence or fluctuations in prevalence are not completely understood. Some factors that are commonly reported to play a role were living within urban areas [1][2] and peri-urban areas [3], flooding events [3,4], contact with infected wild and peridomestic vectors [3], less than ideal socio-economic conditions in areas where dogs reside [5–7], environmental conditions, the presence of rodents, wastewater disposal, garbage disposal facilities, presence of potential pets as reservoir, the presence of rivers, flood history, a history of tidal inundation, vegetation, history of contact with rats, and use of personal protective equipment [8–11].

Dimentional space picture Information related risk factors for leptospirosis cases will provide benefits for the leader in the Health Service in the planning decisions and the implementation of control programs and the prevention of leptospirosis in the city of Semarang. One way to map risk factors for leptospirosis cases is to use spatial analysis. Spatial analysis is a data analysis technique that refers to the position, the object and the relationship between them in the space of the earth. Spatial analysis of the health sector needs to be done to know the perception of health-related issues or based space and

can help analyze the appropriate control measures and proper treatment [12]. Modern spatial analysis capability of a Geographic Information Systems (GIS) enables us to study the associations of environmental factors with diseases; this, combined with the abundant availability of spatial data in the public domain allows us to assess such associations with more than one perspective. The purpose of this study was to describe the environmental and behavioral risk factors of leptospirosis in Semarang spatially.

2. Method

2.1. Study Design and Minimum Sample Size:

We conducted an explanatory study with cross sectional design. The sample size was calculated by the formula for cross-sectional design. Using $Z_{1-\alpha}$=0,196, $Z_{1-\beta}$=1,282, test value of the population proportion =0.5, and anticipated value of the population proportion=0.3, the minimum sample size was 74 patients.

2.2. Subject of Study:

The subject was confirmed a case of leptospirosis which is suspected persons with clinical symptoms of leptospirosis and laboratory-confirmed diagnosis. For this study, only confirmed cases were included. DHO Semarang uses the same definition recommended by WHO that a case of leptospirosis requires laboratory confirmation which taken consecutively during January 2014-May 2015 (101 cases). The samples were all members of the population study who live in Semarang and willing to become respondents. Exclusion criteria were patients who died. Total samples were 88 subjects.

2.3. Variables:

Variables in this study consisted of the environment, the presence of kinds of rodent, waste water disposal, garbage disposal facilities, the presence of potential pets as reservoir, presence of river, history of flood, history of tidal inundation, vegetation, history of contact with kinds of rodents and habitat of rodents, personal protective equipment.

2.4. Ethics:

Ethical clearance was obtained from the Commission of Ethics of Medical and Public Health Research, Faculty of Public Health, Diponegoro University

2.5. Statistics:

Distribution of data was determined by Kolmogorov-Smirnov test. The risk factors were analyzed by frequencies and percentages. Mapping used GIS software to produce graphic displays of geographical information of cases leptospirosis and the risk factors. Map of Semarang was obtained from *Dinas Tata Ruang Kota Semarang*. Coordinate of cases was obtained from GPS

3. Result and Discussion

Cases of leptospirosis in Semarang City mostly suffered by men with age at most in the range of 51-55 years (19.1%) where the education level was high school graduates as many as 33.0%. A study explored several socio-economic and demographic characteristics of Sao Paulo, Brazil with historical human leptospirosis cases and found significant associations with average monthly income, literacy rate, and some people living in a household, among other factors [13]. Likewise, education, income, housing type, and some people living per household were risk factors for human leptospirosis in a different study from urban Recife in Brazil [14].

Table 1. Risk Factors of Leptospirosis in Semarang City (n=88)

	Variable	f	%
1.	Environment		
	1. Potentially at risk	88	100,0
	2. Not at risk	0	0,0
2.	Presence of rodents		
	1. Yes	88	100,0
	2. No	0	0,0
3.	Waste water disposal		
	1. Potentially at risk	84	95,5
	2. Not at risk	4	4,5
4.	Garbage Disposal facilities		
	1. Potentially at risk	84	95,5
	2. Not at risk	4	4,5
5.	Presence of potential pet as reservoir		
	1. Yes	12	13,6
	2. No	76	86,4
6.	Presence of river		
	1. Yes	32	36,4
	2. No	56	63,6
7.	History of floods		
	1. Yes	20	22,7
	2. No	68	77,3
8.	History of tidal inundation		
	1. Yes	7	8,0
	2. No	81	92,0
9.	Vegetation		
	1. $\geq$ 3 kinds	31	35,2
	2. $<$ 3 kinds	57	64,8
10.	History contacts with rodents		
	1. Yes	67	76,1
	2. No	21	23,9
11.	The use of personal protective equipment		
	1. No	85	96,6
	2. Yes	3	3,4

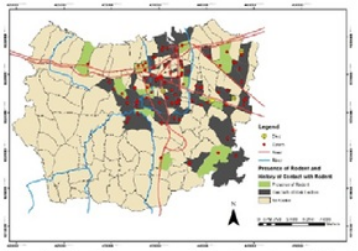

Fig 1. The Presence of Rodent and History of Contact

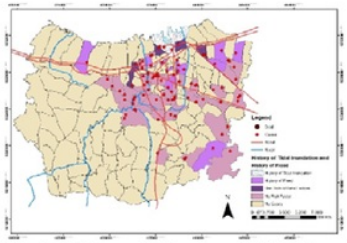

Fig 2. History of Flood and Tidal Inundation

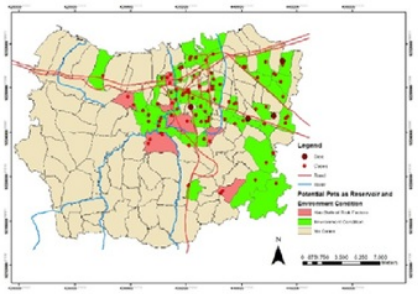

Fig 3. Environment and Presence of Potential Reservoir

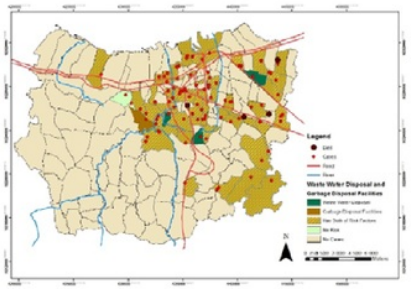

Fig 4. Waste Water l and Garbage Disposal

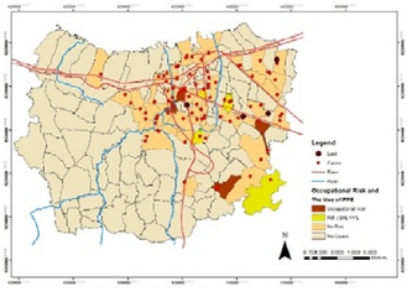

Fig 5. The High Risk Occupation and The Use of PPE

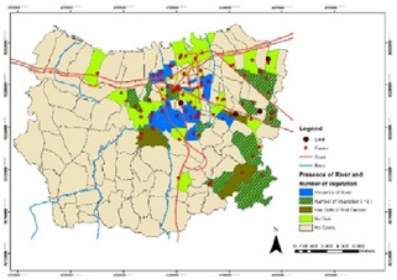

Fig 6. The Presence of River and Vegetation

3.1. The presence of rodent and history of contact

The risk factors existence of rats found in all regions of leptospirosis cases, such as in urban area, rural area as well as in the port area with a history of tidal inundation (Fig. 1). The existence of rodents known from the presence of rat droppings in the home of respondents and the emergence of the rat. Also found a rat hole on the inside and outside of a few respondents. Rats were all over the respondent's house because the environment that supports the life of rats and mice given the reproductive rate was very high.

Indeed, rats are usually considered as the major rodent reservoirs for leptospirosis world wide[15]. Rats reproduce as much as 5-7 times a year with 5-8 tails in the breed, and almost all respondents houses were in densely populated areas causing rats can easily move from one house to another. Rats can get into the house through a small gap and waterways, as well as being able to climb the wall to get into the house through a gap in the roof. Rats move in an area with a radius of 60-80 meters from the nest to the spread follows the pattern of spread of the human. Bacteria of Leptospira lives in the kidneys of mice and can be transmitted through urine and rat tissue, and therefore the presence of a rat is a risk factor of incident leptospirosis [15–17].

Research in Demak and Semarang stated that the presence of the rat is a risk factor leptospirosis [18]. Research in Sleman states of the total 61 respondents there were 54 respondents had the presence of rats inside the house[19]. Similarly, research conducted in France in 2011 which concluded the incidence of leptospirosis is associated with the presence of rodents [20].

History contacts with rodents found in most of the areas with leptospirosis cases (Fig.1). Contact with rodents is one of direct transmission of leptospirosis, from urine or tissues [21–23]. The similar study in Brazil that states contact with rodents was a risk factor for leptospirosis [24]. However, a systematic review of leptospirosis in Indonesia stated that eight out of 13 Indonesian studies and about a quarter of studies from other Asia-Pacific countries had reported a significant association between the

existence of rats near human habitation and the occurrence of human leptospirosis infection or disease. Surprisingly, none of the 11 Indonesian studies showed a significant association between the existence of domestic animals/livestock close to residential premises and leptospirosis infection [11].

3.2. History of flood and Tidal Inundation

Only a relatively small area with leptospirosis who have a history of flooding (Fig.2). Flooding can cause the rats come out of hiding and wandering in a residential neighborhood. The flood waters can be the medium transmission of Leptospira Sp, and can be a place to live Leptospira Sp. Flooding can expand Leptospira transmission so that it can increase the risk of exposure to human [19]. From this study, only a small part of the leptospirosis cases have a history of flooding risk factors, but by previous studies that concluded that flooding is a risk factor for leptospirosis. A study in Jakarta said that the outbreak of leptospirosis occurred after the flood [25].

Reports have suggested an association between canine and human leptospirosis with flooded areas and flood events [4]. These associations are likely due to several factors: leptospiral organisms in the soil (e.g., river banks) deposited there by reservoir wildlife enter the floodwaters; spread of floodwaters and the organism; displacement of infected peridomestic wildlife to dry land; and subsequent increased direct and indirect contact with the organism for dogs [4]. Frequently flooded areas within urban boundaries may include impervious surfaces and stream banks and are especially important in the context of leptospirosis transmission due to the higher density of dogs and peridomestic wildlife that live there. The association of leptospirosis with rain is mentioned in several publications and measured in a few others even large outbreaks have been reported during seasonal periods of heavy rainfall and flooding [24,26–30]

History of tidal inundation occurs only in a small area with leptospirosis (Fig. 2). Tidal inundation occurs along the north side of the north coastlines of Semarang. Semarang had a small area with a history of tidal inundation. *Leptospira Sp* cannot survive in salt water with pH out of the range 6.2 to 8.0. While the tidal water pH range between 8.3-8.5. It is also found at Semarang in 2008, history of tidal inundation is not a risk factor of leptospirosis [8].

3.3. Environment condition and The Presence of Pet as Potential Reservoir

The risk factors environmental conditions were evenly spread throughout the region with leptospirosis cases, among others in urban areas, the center of government and commerce, and in the suburb which was a port area with dense housing (Fig. 3). Environmental conditions in the region at risk, because it had an open sewer and was less than two meters away from the house with stagnant sewer water. Likewise with cases scattered on the outskirts of the city, such as in Sub-districts in Gunung Pati, Tembalang, Pedurungan, Genuk, and Tugu. The area was a rural areas that were not as close to housing in urban areas, but the environmental conditions in the region were also considered at risk because of the distance between home and the sewer less than two meters, with an open sewer, sewer water is stagnant and there were piles of garbage around the house.

Environmental conditions as above were by research in Semarang in 2014 which stated environmental conditions with open sewers, and garbage was a risk factor of leptospirosis in Sleman [31]. Research in 2011 also stated that 47 respondents out of 61 respondents leptospirosis had a ditch around the house[19]. Research in Marseille France in 2011 also concluded that the cause of leptospirosis was a pile of garbage inviting the presence of rodents [20]. Indonesian studies frequently (13; 92.9%) point to flooding, stagnant water surrounding the house, poor sewer condition, and poor sanitation of the house and surroundings as potential environmental risk or modifiable determinants for leptospirosis infection [11]. In developing countries, high infection rates were also found in cities, essentially within disadvantaged urban areas that usually show poor sanitation and where rodents are numerous [6,26,32–34].

The result of spatial analysis known that the presence of a potential pet as reservoir was a risk factor only in a small area, only 13.6% of respondents had potential pets as a reservoir (Fig. 3). Potential pets

owned by respondents include cats and dogs. Cats and dogs can be a reservoir of the bacterium *Leptospira Sp*. A study in Jakarta found several types of the Leptospira serovar from the urine of dogs and cats in Java Island [25]. The similar result was found in Banyumas, out of 13 respondents only three respondents (23.1%) who have pets in their home [9]. However, a systematic review found that none of 14 Indonesian studies showed a significant association between contact with the domestic animal and human leptospirosis infection [11].

3.4. Waste Water Disposal and Garbage Disposal facilities

The results of this study suggest that almost the entire city has a wastewater disposal (Fig. 4) which is at risk (95.5%), as well as with the results of research in Jakarta concluded sewerage is a risk factor leptospirosis [31]. Almost all respondents had Wastewater Disposal Facility is open and cannot be absorbed which causes puddles of water that can be a place to live *Leptospira* bacteria. Urban slums are lacking access to adequate sewage disposal and water treatment infrastructure [6,34–37].

Proximity to open sewer and public waste disposal sites has been associated with human leptospirosis from other countries [14,24,38]. Wastewater disposal is open can be a pathway to enter into houses. A study about leptospirosis outbreaks in dogs primarily occur due to exposure to water contaminated with urine of an infected animal, and in both dogs and humans, exposure to an open body of water is commonly described as a potential risk for leptospirosis [6].

The result of spatial analysis found that almost all regions with leptospirosis cases in the Semarang city had garbage disposal facilities at risk (95.5%) (Fig.4). Landfills/lay still/dumpster in most of the respondent's houses did not have a lid and is ≤500 meters from the residence; so as to trigger the appearance of mice/rat/rodents because they have broad range distance which is affected by some food resources and their population. Rats will migrate with the longest distance of 1-2 km. The lack of adequate sewage systems, trash deposits, and poor housing favor high rodent densities which in turn lead to environmental contamination with pathogenic. Leptospira and high-level transmission of leptospirosis in these communities [6,24,26,27,39,40]. The same thing was found in studies in Jamaica in 2014 which stated that the incidence of leptospirosis occurs in respondents with an open landfills/lay still/dumpster (50%) [41]. Eight out of 13 Indonesian studies and about a quarter of studies from other Asia-Pacific countries have reported a significant association between the existence of rats near human habitation and the occurrence of human leptospirosis infection or disease. Surprisingly, none of the 11 Indonesian studies showed a significant association between the existence of domestic animals/livestock close to residential premises and leptospirosis infection [11].

3.5. The High Risk Occupation and The use of Personal Protective Equipment (PPE)

The personal protective equipment in this study were long shirts, long pants, shoes, and gloves. Almost all respondents did not use personal protective equipment when doing risky activities such as during the flood, tidal inundation, sewage, garbage/disposal treatment, or even contact with rodents or habitat of rodents. This kind of behavior may extend the possibility of the body surface to exposed by *Leptospira Sp*. The similar study found that in Banyumas from 12 out of 13 respondents did not use personal protective equipment [9]. A systematic review of leptospirosis in Indonesia stated that not wearing personal protective equipment was significantly associated with human leptospirosis infection [11]. These findings of systematic review were from studies that investigated specific study sites and activities, such as an outbreaks of leptospirosis after flooding [4], among town service workers [42], in a slum and flood-prone area [37], in an endemic area, occur in disaster situations such as hurricanes and monsoons [43], is increasingly recognized as an emerging infectious disease with cyclic climatic events [44], and in contact with animal excreta [45].The protective benefit of wearing long trousers or long skirts, instead of shorts, in watery places, has been shown in pond-cleaning activities in Thailand [46].

3.6. The presence of river and Vegetation

The presence of the river as a risk factor of leptospirosis was only found in some areas with leptospirosis (Fig. 6).The river water can be medium of transmission of leptospirosis. Distance to the river with the respondent's house closest was one meter. The distance was so close to the river may increase the risk of flooding, the vegetation such as shrubs and bamboo on the outskirts of the river can be a habitat for rodents [9]. The incidence of leptospirosis in this study as well as the incidence of leptospirosis in the city of Banjarnegara in 2013 that occurred in the settlement/residence with the distance radius 50-600 meters from the river [9].

In Semarang, only some areas in Semarang which had three types of vegetations (Fig. 6). However, according to study conducted in Brazil that concluded the positive relationship between the numbers of leptospirosis cases with the existence of vegetation [24]. Any types of vegetation can be habitat for kinds of rodent. Semarang consists of lowland, highland, coastal and hills. Vegetation in the low-land areas in Semarang were shrubs, ornamental plants, and shade trees.

The type of vegetation in the highlands and hills was higher than that in the lowlands. Such as paddy-fields, gardens, bushes, shrubs and shade trees. Shrubs and paddy-fields were the habitats of rodents; knaggy trees make possible of kind of rodents comes into the house by climbing through branches or twigs which adjacent to the house.

3.7. Distribution of leptospirosis cases and risk factors at Semarang

Leptospirosis cases were spread in 15 sub-districts at Semarang (Fig. 1-6). Most cases in downtown which is an urban area, the center of government, commerce, and industrial areas. Sub-district with most cases was South of Semarang, and the fewest cases were in Mangkang and Banyumanik. Sub-district of South Semarang had more cases and the risk factors because of the areas a nice habitat for rodents due to the environment which is a commerce area and a public cemetery which has a variety of vegetation (Fig. 1,3,6). The human behavior–related risk factors included in Indonesian leptospirosis studies were contact with stagnant water (4; 28.6%); contact with river or flood water, muddy areas (4; 28.6%); swimming in a river (2; 14.3%); taking a bath in a river (6; 42.9%); washing in a river (6; 42.9%); contact with animal urine, bodies, or tissues (4; 28.6%); not wearing personal protection equipment (4; 28.6%); walking barefoot (2; 14.3%); and using streams as a source of drinking water (2; 14.3%) [11]. Urban leptospirosis is a consequence of disorganized urbanization and lack of investment in adequate housing, sewage systems and refuses collection services. The most effective interventions will, therefore, be those that directly address the underlying conditions of poverty, such as lack of access to proper sanitation, which is responsible for the emergence of this urban health problem [26,47].

4. Conclusion

The risk factors were found in more than half of the incidence of leptospirosis include environmental conditions, the presence of rodents, wastewater disposal, garbage disposal facilities, history of contact with rats, and use of PPE. The risk factors are found only in less than half the area with leptospirosis include the presence of pets at risk, the presence of the river, history of flood, history of tidal inundation, and vegetation. Districts with the most cases and the risk factor is Southern District of Semarang. Districts with the fewest cases and the risk factor is Sub-district Banyumanik. District Health Office is expected to conduct cross sectorial cooperation to provide personal protective equipment such as gloves and boots for communities. Optimize the role of health workers always to urge people to maintain a healthy environment. The Community is expected to keep the environment clean. To be carried out further studies with variable density of rats.

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