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SPATIAL ANALYSIS OF LEPTOSPIROSIS DISEASE IN BANTUL REGENCY YOGYAKARTA

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Abstract

Leptospirosis has still become a public health problem in the world, especially in developing countries which have tropical and subtropical climate such as in Indonesia. This research aims at investigating the spread and analyzing the cluster of Leptospirosis cases by using GIS. This research was conducted in 2015 using descriptive qualitative method. The total cases were 35 cased during May-Dec 2014 in Bantul Regency, Yogyakarta. The data consisted of secondary and primary data collected by using GPS. Univariate and spatial analysis were performed through SaTScan, QGIS desktop 2.4.0 and ArcGIS 1.1.0. The result shows that the distribution of Leptospirosis case in Bantul Regency is equally distributed in all districts with plain topography. The highest case occurs in May (12 cases). Clustering pattern is significant with p value= 0,001 with 11 cases in the cluster.

Introduction

Leptospirosis is a disease which becomes a public health problem in the world, especially in developing countries that have tropical and subtropical climates. On most issues, leptospirosis happens in tropical countries and is associated with a subtropical climate as well as environmental conditions that allow leptospira bacteria, the cause of the leptospirosis disease, to live and breed. Leptospirosis cases cannot be predicted precisely, given the misdiagnosis in some parts of the world and no sufficient recorded data. Meanwhile, leptospirosis in Indonesia is like an iceberg phenomenon; the case happened on the surface seems to be small, but an intensive search will find that the number of cases can be surprisingly high, especially in endemic regions (Hariastuti, 2011). Even in 2010, Indonesia ranks third in the deaths of leptospirosis (Ramadhani, 2010).

The increase of leptospirosis cases in Yogyakarta happened in 2011 so it was declared as an extraordinary incident (*Kejadian Luar Biasa*-KLB) by the Government of Yogyakarta Special Region (DIY). The areas which are designated for an outbreak of leptospirosis are Bantul, Kulon Progo and Gunung Kidul regencies (Hariastuti, 2011). Reported cases of leptospirosis in Bantul Regency in 2008-2011 continued to increase, but in 2012 there were 63 reported cases with 6 deaths cases. The number of cases declined sharply from 2011 which reached 626 cases with the 43 deaths (Dinas Kesehatan Daerah Istimewa Yogyakarta, 2013). Leptospirosis cases deserve attention since most of the population in DIY works in agriculture. Paddy farmlands as the habitat of mice cause leptospirosis transmission.

One of the risk factors for leptospirosis is outdoor occupation types or those which require people to be in direct contact with animals, such as ranchers, farmers, veterinarians, field workers, and military personnel (Haake, 2015). Transmission of infectious leptospirosis disease

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in general occurs through direct contact with infected animals such as the bites of animal like rodent and the open wounds which are exposed to urine or body fluids from infected animals. The disease can also be transmitted through direct contact with the water environment and soil contaminated with the Leptospira bacteria (Chua 2010; Sumanta, 2015). The diagnosis of leptospirosis is done through confirmation of laboratory results to determine the cause of the infection in the suspected source of infection and the reservoir containing leptospirosis bacteria (Chua, 2010).

Different types of animals can be sources of leptospirosis transmission, especially mammals. Mammals which are considered to play a major role in the transmission of leptospirosis are small mammals such as rodents and large mammals such as cattle, pigs, dogs, goats (rare), horses, buffalo, and sheep. Leptospirosis is no longer a disease that only affects the rural population, but also can attack the urban population. WHO describes the transmission of leptospirosis as shown in the below figure. From the illustration it is shown that complications can happen to some organs if leptospirosis attacks. Therefore, leptospirosis cannot be considered as a mild disease.

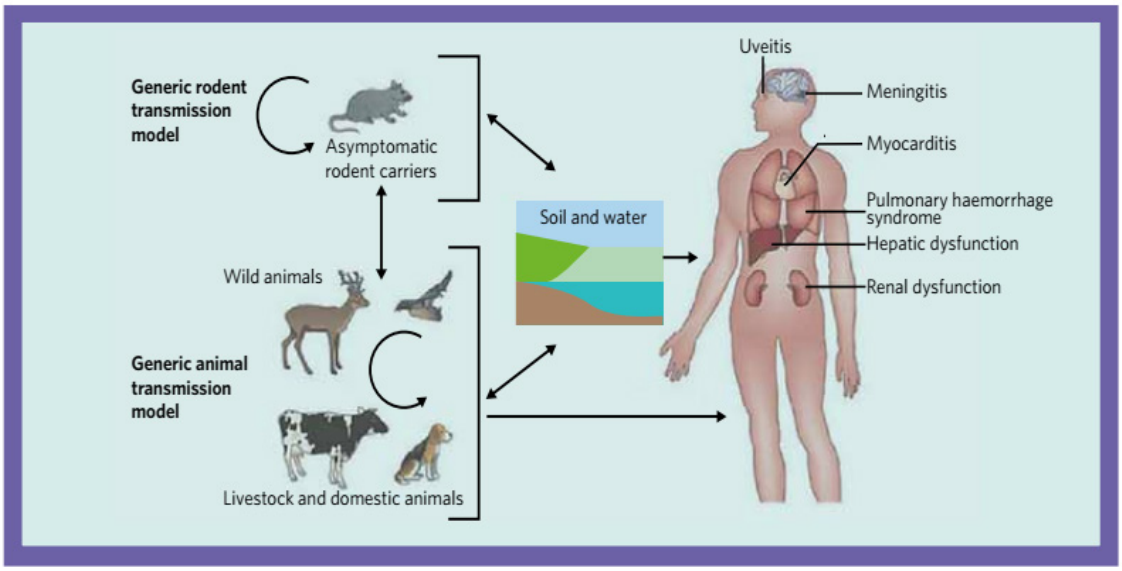

Figure 1. The Chain of Transmission of Leptospirosis
Source: (World Health Organisation 2010)

Leptospirosis cases of in Bantul Regency, Yogyakarta started to be reported in 2009 with the number of 10 cases and Case Fatality Rate (CFR) of 10%. Then, in 2010 and 2011, there was an increase of cases in each case amounted to 116 cases with a CFR of 16.37% in 2010 and 154 cases with a CFR of 7.79% in 2011. In 2012, the case was declined as many as 48 cases with a CFR of 2.3% and then in 2013, there was an increase to 74 cases with the CFR of 0%, and in 2014, there were 77 cases of leptospirosis with CFR of 9.09% (DKK Bantul, 2014).

Epidemiological spread of leptospirosis bacteria is influenced by environmental and socio-demographic aspects (Gracie, 2014). Some associations with the environment, including temperature and topography are thought to affect the incidence of leptospirosis. Spatial analysis is an analysis of the territorial aims to determine the association of an event toward the aspects of space. Spatial analysis area can be used to determine the deployment, to cluster and to predict the occurrence of leptospirosis in the region, as well as to evaluate risk factors for leptospirosis disease which is associated with environmental and social aspects (Sumanta, 2015; Soares, 2010).

Spatial analysis using GIS (Geographic Information Systems) has become one of the important methods in disease surveillance.

GIS is able to compile the data into multiple layers which is commonly referred as "overlay" and gives real benefit in disease surveillance. Additionally, SIG provides an overview of temporal and spatial dat. Several studies outside leptospirosis have implemented GIS as a research tool. In the study of malaria in Purworejo, GIS is used as an overlay between the incidence of malaria and population density (Sulistyawati, 2012). It is also used in the incidence of malaria in Kulonprogro by overlaying rock and slope formations (Murhandarwati, 2014). Another study is about the distribution of illegal garbage dumping ground which is also performed using SIG (Mulasari, 2014). All the studies that have been done suggest that GIS is a real contribution in the study of public health.

GIS is a tool that can be used for decision support, including in the control of vector-related diseases, such as multiple studies on the use of GIS as a tool of policy making in Malaria in Zambia (Chanda, 2012). Likewise, the mapping of leptospirosis cases can be used as a guide for decision making control programs and also treatment of leptospirosis, primarily to determine the priority of handling area. GIS analysis has been widely used in various studies to control the leptospirosis disease. One of the benefits of GIS analysis is to detect the spread of leptospirosis cases as early as possible so that it can be used as a control strategy in terms of areal and to identify areas at risk by assigning a pattern of disease as the location of the disease source as well as to measure the risk factors (Sumanta, 2015 ; Jontari, 2014).

This study aims to determine the distribution of leptospirosis cases by level of education and type of occupation, leptospirosis cases mapping, and clustering analysis (grouping cases) using GIS (Geographic Information Systems). Generally, this research is expected to be useful for policy makers in terms of planning and implementation of the elimination program of leptospirosis cases in Bantul Regency, Yogyakarta.

Method

This research was conducted in Bantul Regency Yogyakarta consisting of 17 districts, namely Dlingo, Imogiri, Pleret, Piyungan, Banguntapan, Sewon, Pity, Sedayu, Displays, Bantul, Jetis, Pandak, Bambanglipuro, Pundong, Kretek, Sanden, and Srandakan Districts. The populations in this study were the community in Bantul Regency, Yogyakarta. The samples in this study were obtained from secondary data consisting of people who were diagnosed as leptospirosis positive and recorded in D.I.Yogyakarta Bantul District Health Office from May to December 2014 and were still alive. Sampling technique used totality sampling. The number of sample cases of leptospirosis in May-December 2014 as many as 35 cases. Latitude and longitude coordinates were obtained by plotting the location or the homes of people using the Global Positioning System (GPS) of Garmin e-Trex.

This study was a descriptive quantitative research using the approach of GIS or Geographic Information System. Spatial analysis was done by using SaTScan with multinomial model. SaTScan was used to analyze the results spatially and temporally. The purposes of analysis using SaTScan were to do surveillance of disease geographically, to detect spatial disease clusters and to see a statistically significant value. Statistical scan multinomial model was used to make observations on any case that had several different categories for each case. In the model multinomial, this statistical scan was conducted jointly to look for high or low cluster on one group study areas that were tailored to the overall distribution of the disease. The information required to perform analysis using statistical Scan Multinomial Model was the location of any cases of the disease, the individual categories (this study using the level of education), and the latitude and longitude coordinates, as well as the period of occurrence of the disease. The analysis of spatial data was further processed by using a geographic information system application namely QGIS desktop ArcGIS 2.4.0 and 1.1.0 which has the ability to visualize, explore, sort and analyze data spatially (Mau, 2011).

Results and Discussion

Bantul Regency is located in the southern part of Yogyakarta Special Province. This regency is bordered directly with Yogyakarta and Sleman regencies in the north, Indonesian Ocean in the south, Gunung Kidul Regency in

Figure 2. The Study Area

the east and Kulonprogro Regency in the west. Bantul Regency is located between 07 ° 44 '04 "- 08 ° 00' 27" south latitude and 110 ° 12 '34 "- 110 ° 31' 08" East Longitude. Furthermore, to the area of Bantul is 506.85 km2 (15.90%) from the total area of DIY (3185.80 km2) with low-lying topography 40% and 60% areas are less fertile hilly areas.The topography of Bantul on West side is less sloping area and hills, stretching from North to South direction covering an area of 89.86 km2, or 17.73% of the entire region. Central part is a flat area and also ramps which are fertile agricultural areas covering an area of 210.94 km^2 or 41.62%. The east side is the area of ramps, sloping and steep but the situation is still better than the western region, covering an area of 206.05 km^{2}or 40.65%. Meanwhile, the southern part is actually part of the Central part of the natural state of sand and also a little bit lagoon, lying on the South Coast of Srandakan, Sanden and Kretek. Bantul consists of 17 districts, 75 Villages, 933 Hamlets (BPK, 2015).

Topography distribution which consists sloping area makes this district has vast agricultural areas, such as fields and other water trap which become potential as a breeding area.

Table 1 shows the result of the frequency distribution according to the demographic characteristics of the sample. The highest gender percentage is male with 27 cases (77.1%) while the lowest is in women with 8 cases (22.9%). The results of the frequency distribution of educational level shows that the highest percentage of patients are primary school graduates with 17 cases (48.6%) and the lowest percentage of high school graduates with only 1 case (2.9%). The results of the frequency distribution according to the type of work the majority of the population still work as farmers with the highest percentage of 22 people (62.9%) and the lowest percentage of people as trader with a percentage of 1 (2.9%).

The results of the frequency distribution by districts reports that there were 35 cases of leptospirosis from May to December 2014, spreading across all districts in Bantul Regency,

Table 1. The Distribution of Leptospirosis Cases by Demographic Characteristics

No	Characteristic		Number (n)	Percentage (%)
1	Gender			
		Male	27	77,1
		Female	8	22,9
2	Educational Level			
		Uneducated	10	28,6
		SD	17	48,6
		SMP	7	20,0
		SMA	1	2,9
3	Occupation			
		Laborer	8	22,9
		Trader	1	2,9
		Farmer	22	62,9
		Unemployed	2	5,7
		Becak Rider	2	5,7

Sources: Primary data

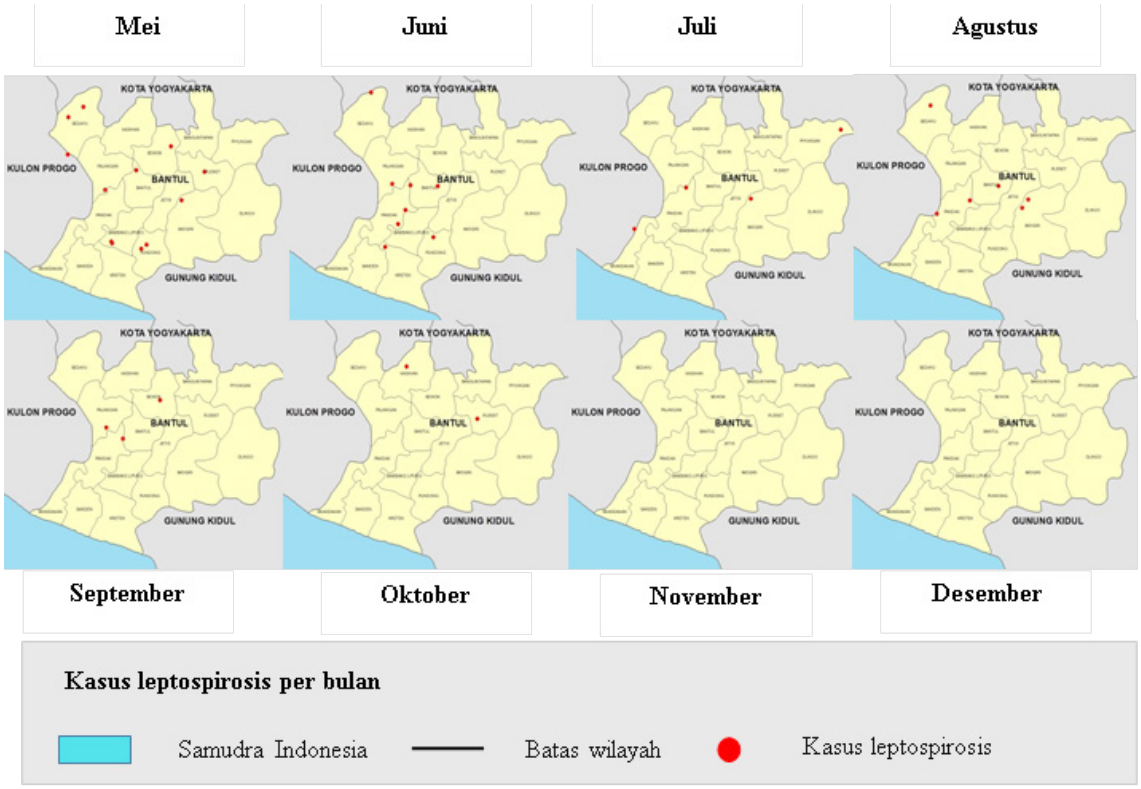

Figure 3. The Map of Temporal Case from May to December 2014 Bantul Regency Yogyakarta

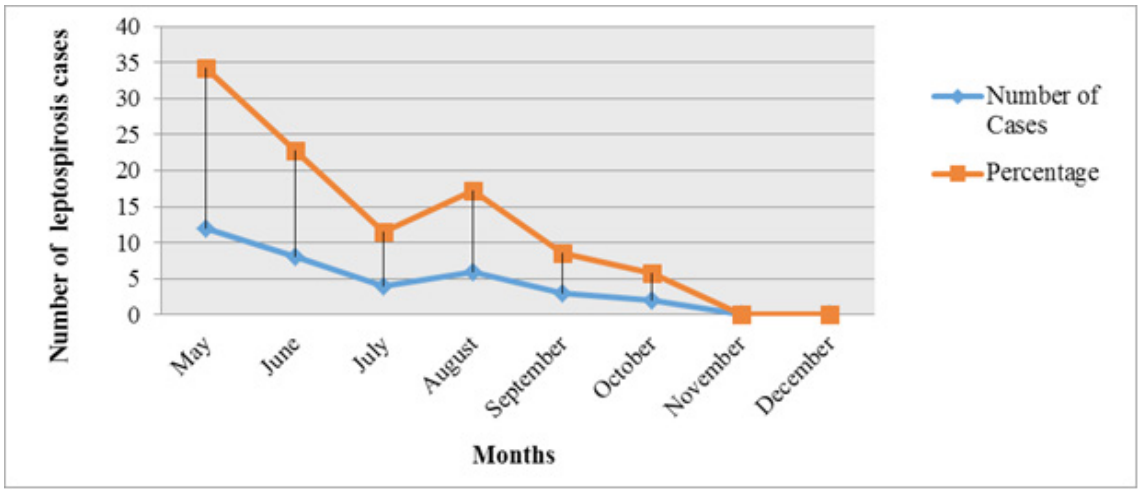

Figure 4. The Number of Leptospirosis Cases from May to December 2014 in Bantul Regency

The highest incidence was found in Bantul City 6 cases (17.14%) and the lowest in Jetis District with no case (Bantul Health Office, 2014). Figure 3 shows the distribution of leptospirosis cases in the period from May to December 2014. Cases of leptospirosis occurred in May 2014 in 12 cases (34.3%) and continued to decline until July 2014 as many as four cases (11.4%), but in August 2014, it increased again to 6 cases (17.1%) and steadily declined until in November and December 2014 (0%) with no detected cases of leptospirosis.

The identification of the cluster pattern is based on SaTScan analysis using Multinomial model. The analysis shows that case of leptospirosis has occurred in several

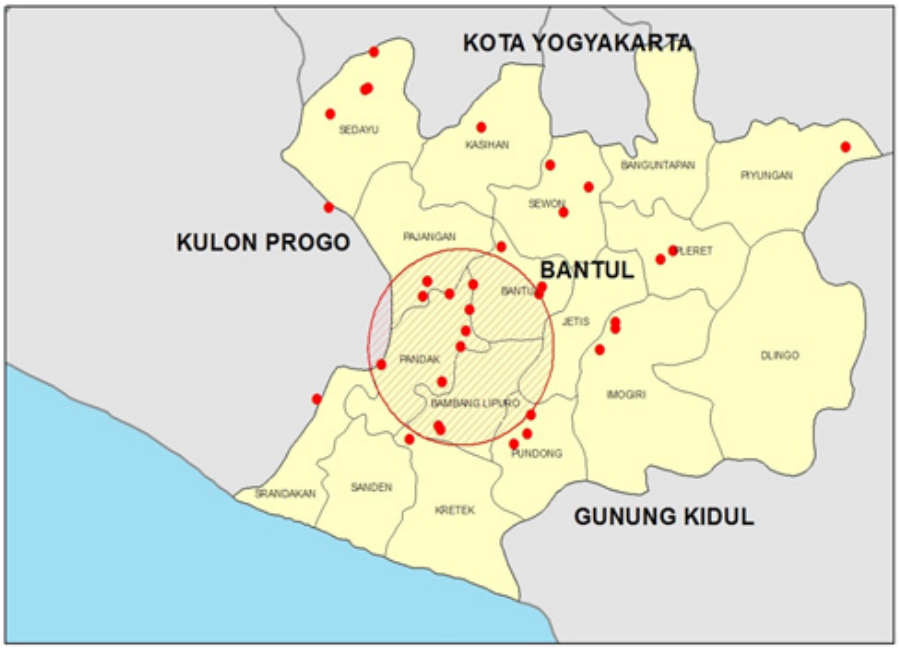

Figure 5. Map of Cluster Cases of Leptospirosis in Bantul Regency Yogyakarta Spatial Distribution of Leptospirosis Cases.

sub-districts in Bantul Regency. Cluster center is in a position coordinates 7.919055 SL and 110.314643 NL with a radius of 4600 meters located in the area of Bantul City, Bambanglipuro District and Pandak District. These clusters are statistically significant with a significance value is 0.001. The numbers of cases coming into the cluster are 11 cases (31.42%).

Leptospirosis is a disease transmitted by animals (zoonosis) caused by the Leptospira bacteria. During May to December 2014, the proportion of cases of leptospirosis is prevalent in the male population with 27 cases or with percentage of 77.1% as compared to the female population with only 8 people or with percentage of 22.9%. This shows that male population is more at risk of contracting leptospirosis as compared to female population. A research in Semarang on the proportion of leptospirosis cases in 2004-2006 shows that male population (66%) is at higher risk as compared to females (34%). This is because men do the jobs that may be a risk factor for transmission of leptospirosis (Widiastuti, 2008). A research conducted in Jakarta also shows the same results in the majority of patients with leptospirosis domination by men (53.7%) as compared to women (46.3%) (Okatini, 2007). Similar result is delivered in a study conducted by researchers in USA that the proportion of Leptospirosis in world events is higher in men. However, the real essence of gender is on whether they have the job at a place with the risk of beng contaminated with leptospirosis bacteria. In the finding, it is explained that if there is a chance where men and women work in the same risk place, leptospirosis among both genders can equally happen (Haake, 2015).

Leptospirosis case based on the education level shows that primary school educated population is the highest patients with 17 people (48.6%). Residents with low education have a risk of suffering from leptospirosis amounting to 3.74 times greater (95% CI: 1.72 to 8.12) than those who have high education (Okatini, 2007). The result of the same study in Brazil finds that leptospirosis is associated with low levels of education especially in the rural areas (Dias, 2007). It can be understood because a person's level of education will determine the level of knowledge, attitudes and behavior in fighting the disease. Knowledge about the incidence, risk factors and preventive measures are often not owned by residents with low education, including the leptospirosis disease (Mohan, 2011).

The level of education also indirectly affects a person's work where this type of work

is one factor risk exposure to leptospirosis, especially the kind of work that is often in direct contact with water, particularly water contaminated by the urine of infected animals with bacteria leptospira, such as farmers, gutter workers, and miners (Kaur, 2003). These results indicate that the population suffering from leptospirosis mostly work as farmers (62.9%). Leptospirosis is an occupational disease, so the risk of leptospirosis infection is greater in those who work or carry out activities in the rea/ environment at risk (Riyaningsih, 2012). Jobs are at risk for infection leptospirosis is a job that has the possibility of contact with water infected by leptospirosis bacteria.

The SaTScan analysis result shows that there is one cluster formed which is suspected as source of infection. The formations of clusters are in the area of Bantul City, Bambanglipuro District and Pandak District which have 11 cases (31.4%). This indicates that the three areas are areas with greater risk of infection of leptospirosis as compared with the other nearby areas. Radius cluster formed on clustering analysis is as far as 4.6 km, showing the risk radius of transmission of leptospirosis in the region. Bantul Kota, Bambanglipuro District and Bantul Pandak District are central parts which have a sloping and flat topography including a fertile agricultural region. The sloping and flat topography allows the formation of permanent puddles which is strongly associated with the formation of the flood and becomes a potential source of transmission of leptospirosis (Yuliadi, 2013; Febrian, 2013). This is thought to be the trigger of leptospirosis cases in urban areas of Bantul. The rapid urbanization in the city triggers the growth of irregular settlements; this encourages the growth of slums which tends not to have good environmental sanitation and becomes a trigger of leptospirosis cases. However, it does not mean that the incidence of leptospirosis in Bantul always occurred in a slum area. However, it should be suspected in similar characteristics, such as the drains which are stopped and cannot flow smoothly or their landfill is not in place.

Lowland conditions in Bantul Regency are made up of a stretch of fluvial land (river sedimentation process result). The location of Bantul Regency which is close to the southern coastal areas is potentially subjected to danger of flooding. Flooding is one of the disasters that can cause the spread of leptospirosis rapidly. Floods will inundate much of the land and increase the growing and survival of leptospira bacteria to the flooded land (Wasiński, 2013). Agricultural areas such as rice fields, riverbanks and bushes in coastal environments have the potential to become a habitat for rats that become one cause of leptospirosis transmission. Paddy fields are place for the development of leptospira bacteria which causes of leptospirosis because the highest rat density is in paddy fields (Yuliadi, 2013; Ikawati, 2010). This is also supported by research in Southeast Asia that some species of rodent densities tend to be in rain-fed area (Cosson, 2014). In addition, leptospirosis bacteria can live at temperatures of 28-30^{0}C which is a high enough temperature and pH 7 (Hariastuti, 2011). With such conditions, high temperatures lead to evaporation of the water sources (paddy etc.) and at the same time, there is human activity. When leptospirosis bacteria is in the area, it will be an infection for the human.

Referring to Figure 2, it shows that the highest incidence of leptospirosis in Bantul Regency is in early May followed in August and continued to decline until December. Although it is not necessarily regarded as a pattern given the research is only conducted in the same year, but it should be assumed that the events are associated with the season and it is associated with the amount of rainfall. The study in India which studies patterns of leptospirosis outbreaks mentions that the peak of the outbreak of leptospirosis usually occurs at 10 days post peak rainfall occurs (Pappachan, 2004). This proves that there is a relationship between rainfall and the incidence of leptospirosis. However, conditions in Bantul may be different to India, in May 2014, Bantul was experiencing a transition from the peak of the rainy season to moderate rain, it is shown in the statistical data of Bantul in 2015 (Badan Pusat Statistik Kabupaten Bantul, 2015). The conditions trigger the traps water on the surface of the ground which makes stagnant water. The puddle is potential as a source of leptospirosis transmission.

The observations show that 9 cases out

of 11 cases which enter the buffer zone come from area with puddles such as permanent sewer and also the fields around the house with a distance of less than 2 meters. Permanent ditches and paddy fields are transmission media of leptospirosis. Linkage cases of leptospirosis with the fields in this study is likely because the majority of patients with leptospirosis work as farmers and the rice field becomes the habitat for rats as well as the source of alternative feed for rats (Rejeki, 2013). In addition to rice paddies, a puddle is also a risk factor for the occurrence of leptospirosis because it is the environment of leptospirosis bacteria in nature. These bacteria can survive for several months in a puddle. Appropriate temperature and pH puddles will prolong the life of leptospirosis bacteria. When high rainfall permanent water overflow gutters, the flood will occur. Flood becomes one of the risk factors associated with the occurrence of leptospirosis for their puddles into the growth media leptospirosis bacteria derived from urine or body fluid reservoir (Widiastuti, 2008; Rejeki, 2013; Lau, 2012).

Conclusion

The proportion of leptospirosis cases in Bantul district in May-December 2014 is more dominant to be found on the population with primary school education (48.6%) than high school graduates (2.9%) and more dominant among the population that have a job as a farmer (62.9%) than traders (2.9%). The pattern of distribution of cases of leptospirosis in Bantul Regency is relatively clustered in areas that have flat sloping topography. The areas have many puddles and rice farming areas which become the breeding habitat for leptospirosis bacteria. Spatial analysis is useful for identifying the patterns of distribution and clustering of cases of infectious diseases such as malaria, rabies, dengue hemorrhagic fever (DHF), Tuberculosis (TB) and filariasis. Therefore, the appropriate mapping can help the preparation of the planning and implementation of the program of elimination of a disease.

This research can serve as a ground for further research. This study finds a strong connection between rain temporal seasons with cases of leptospirosis. The data shows that the pattern of season affects the spread of leptospirosis cases, so it is advisable in future studies conducted research in a longer study period (5 or 10 years) so the time pattern will be visible clearly in Bantul Regency. This can be useful for Bantul area and the result can be used for preparation of the Early Warning System (EWS) for leptospirosis disease.

References

BPK. 2015. Profil Kabupaten Bantul. Kabupaten Bantul.

Badan Pusat Statistik Kabupaten Bantul. 2015. *Bantul Dalam Angka 2015*. BPS Kabupaten Bantul.

Chanda, E. et al., 2012. Using a geographical-Information-System-Based Decision Support to Enhance Malaria Vector Control in Zambia. *Journal of Tropical Medicine*. 1–10

Chua, M. L., Alejandria, M. M., Bergantin, R. G., Destura, R. P., Panaligan, M. M., Montalban, C. S.,et al. 2010. *Leptospirosis*. CPG : 7-14

Cosson, J.F. et al. 2014. Epidemiology of Leptospira Transmitted by Rodents in Southeast Asia. *PLoS Neglected Tropical Diseases*, 8(6).

Dias, J.P. et al. 2007. Factors associated with Leptospira sp Infection in a Large Urban Center in Northeastern Brazil. *Revista da Sociedade Brasileira de Medicina Tropical*, 40(5): 499–504.

Dinas Kesehatan Daerah Istimewa Yogyakarta. 2013. *Profil Kesehatan Daerah Istimewa Yogyakarta Tahun 2013.*

Dinas Kesehatan Kabupaten Bantul. 2014. *Situasi Leptospirosis Di Kabupaten Bantul Tahun 2014*. Yogyakarta

Febrian, F. & Solikhah. 2013. Analisis Spasial Kejadian Penyakit Leptospirosis Di Kabupaten Sleman Propinsi Daerah Istimewa Yogyakarta Tahun 2011. *Journal -Kesehatan Masyarakat* 7 (1) :7-13

Gracie, R. et al., 2014. Geographical Scale Effects on the Analysis of Leptospirosis Determinants. *International Journal of Environmental Research and Public Health*, 11(10): 10366–10383.

Haake, D.A. & Levett, P.N., 2015. Leptosporis in Human. *Current Top Microbiology Immunilogy*, 387:.65–97.

Hariastuti, & Ika, N. 2011. Diagnosis Leptospirosis Dan Karakterisasi Leptospira Secara Molekuler. *Journal BALABA*, 7 (2) : 59-61.

Ikawati, B., & Nurjazuli. 2010. Analisis Karakteristik Lingkungan Pada Kejadian Leptospirosis di Kabupaten Demak Jawa Tengah Tahun 2009. *Jounal Media Kesehatan Masyarakat*

Indonesia 9 (1) : 33-40.

Jontari, H., Supargiyono, H. K., & Hamim, S. 2014. Faktor-Faktor Risiko Kejadian Penyakit Lymphatic Filariasis di Kabupaten Agam, Propinsi Sumatera Barat Tahun 2010. *Outbreak, Surveillence and Investigation Reports (OSIR)* 7 (1) : 9-15.

Kaur, IR., et al. 2003. Preliminary Survey of Leptospirosis Amongst Febrile Patients from Urban Slums of East Delhi. *Journal JAPI,* 51 : 249-251.

Lau, C. L., et al. 2012. Leptospirosis in American Samoa – Estimating and Mapping Risk Using Environmental Data. *Journal PLOS Negleted Tropical Diseases* 6 (5) : 1-11.

Mau, F., Desato, Y., & Yuliadi, B. 2011. Pemetaan Daerah Penyebaran Kasus Rabies Dengan Metode Gis (Geographical Informasion System) Di Kabupaten Sikka Provinsi Nusa Tenggara Timur, *Journal Vektora* 3 (1) : 12-21.

Mohan, A.R.M. & Chadee, D.D., 2011. Knowledge, Attitudes and Practices of Trinidadian Households Regarding Leptospirosis and Related Matters. *International Health*, 3(2): 131–137.

Mulasari, S.A. & Sulistyawati, 2014. Jurnal Kesehatan Masyarakat. *Jurnal Kesehatan Masyarakat*, 9(2): 122–130.

Murhandarwati, E.E.H. et al., 2014. Early Malaria Resurgence in Pre-Elimination Areas in Kokap Subdistrict , Kulon Progo , Indonesia. *Malaria Journal*, 13(130): 1–15.

Okatini, M., Purwana, R., & Djaja, I. M. 2007. Hubungan Faktor Lingkungan Dan Karakteristik Individu Terhadap Kejadian Penyakit Leptospirosis Di Jakarta, 2003-2005. *Journal MAKARA* 11 (1) : 17-24.

Pappachan, M.J., Sheela, M. & Aravindan, K.P., 2004. Relation of Rainfall Pattern and Epidemic Leptospirosis in the Indian State of Kerala. *Journal of epidemiology and community health*, 58(12): 1054.

Ramadhani, T. & Yunianto, B., 2010. Kondisi Lingkungan Pemukiman yang Tidak Sehat Berisiko terhadap Kejadian Leptospirosis (Studi Kasus di Kota Semarang). *Suplemen Media Penelitian dan Pengembangan Kesehatan*, XX: 46–54

Rejeki, D. S. S., Nurlaela, S., & Octaviana, D. 2013. Pemetaan dan Analisis Faktor Risiko Leptospirosis. *Journal Kesehatan Masyarakat Nasional* 8 (4) : 179-186.

Riyaningsih, Hadisaputro, S., & Suhartono. 2012. Faktor Risiko Lingkungan Kejadian Leptospirosis di Jawa Tengah (Studi Kasus di Kota Semarang, Kabupaten Demak dan Pati). *Journal Kesehatan Lingkungan Indonesia* 11 (1) : 87-94.

Soares, et al. 2010. Spatial And Seasonal Analysis On Leptospirosis In The Municipality Of São Paulo, Southeastern Brazil 1998 To 2006. *Journal Rev Saúde Pública* 44 (2) : 1-9.

Sulistyawati, 2012. Kejadian Malaria Di Kabupaten Purworejo Dengan Gis. *Kes Mas*, 6(2): 162–232.

Sumanta, H., Wibawa, T., Hadisusanto, S., Nuryati A., & Kusnanto, H. 2015. Spatial Analysis of Leptospira in Rats, Water and Soil in Bantul District Yogyakarta. Indonesia. *Journal Open Journal Of Epidemiology* 5 : 22-31.

Widiastuti, D., & Djati, Rr. A. P. 2008. Gambaran Umun Kasus Leptospirosis Di Kota Semarang Tahun 2004-2006. *Journal Vektor Penyakit* 2 (1) : 39-45.

Wasiński, B. & Dutkiewicz, J., 2013. Leptospirosis - Current Risk Factors Connected with Human Activity and the Environment. *Annals of Agricultural and Environmental Medicine*, 20(2): 239–244.

World Health Organisation. 2010. *Report of the First Meeting of the Leptospirosis Burden Epidemiology Reference Group, Geneva.*, Geneva..

Yuliadi B., Wahyuni, & Ristiyanto. 2013. Distribusi Spasial Leptospirosis Di Wilayah Provinsi Jawa Tengah Tahun 2002-2012. *Journal Vektora* 5 (2) : 66-72.