Original

The Occurrence of Leptospirosis in Prefectures in Japan Related to Typhoons as a Disaster-Related Infectious Disease

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Abstract

Background: Leptospirosis has been reported worldwide and is also considered a disaster-related infection. Leptospirosis is mainly transmitted to humans through contact via soil or water contaminated with rodent urine. The outbreaks occur after flooding and heavy rainfall. In Japan, flooding and heavy rainfalls are often caused by typhoons. Earthquakes, also, which occur in Japan, cause poor sanitary conditions. However, the association between leptospirosis and disasters, including typhoons and earthquakes, has not been evaluated. In this study, after confirming the seasonal and geographic distributions of leptospirosis, we examined the relation between leptospirosis and typhoons or earthquakes in Japan in the past 10 years.

Methods: The number of leptospirosis cases was counted based on the weekly reports from the National Institute of Infectious Diseases from March 2013 to February 2023. The numbers of typhoons and earthquakes from the same period were based on the data published by the Ministry of Land, Infrastructure, Transport, and Tourism. The seasonality and geographic distribution of leptospirosis were described. We analyzed the association between the monthly number of leptospirosis cases and that of typhoons and earthquakes in Japan by Spearman's correlation coefficient test.

Results: Leptospirosis cases totaling 381 were reported in Japan during the 10-year period of this study. The highest number of cases was observed in September then October. The prefecture with the most cases was Okinawa (n = 181) followed by Tokyo (n = 62), Kagoshima (n = 19), Kanagawa (n = 14), Miyazaki (n = 10), and Osaka (n = 8). There was a significant correlation between the number of leptospirosis and typhoons. However, there was no significant correlation between the number of leptospirosis and earthquakes.

Conclusion: Many cases of leptospirosis were reported in the southern part of Japan, including Okinawa, Kagoshima, and Miyazaki. A significant correlation with the number of cases of leptospirosis and typhoons suggest that leptospirosis is a disaster-related disease occurring most often in the southern part of Japan, where typhoons often reach landfall. Therefore, leptospirosis should be included in the differential for febrile patients especially after typhoons in the southern part of Japan.

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—Key words—
leptospirosis, typhoon, ecological study

Introduction

Leptospirosis is a common zoonotic infectious disease that is widely distributed throughout the world[1)]. Rodents are the main hosts of *Leptospira*, colonizing in their proximal tubules of kidney and excreted in urine over a long period[2)]. Leptospirosis is mainly transmitted to humans through contact via soil or water contaminated with rodent urine[3)4)].

One million people are infected with leptospirosis annually worldwide. Especially, in humid tropical re-

gions, the incidence is more than 10 cases per 100,000[5]. It is particularly prevalent among populations with poor sanitary conditions in tropical urban slums[6]. A warm and moist climate of 25℃ is reported to be a favorable environment for growth of *Leptospira*[7]. Therefore, leptospirosis occurs year-round in the tropics, however there is a seasonal variation in temperate regions, with peaks in summer and autumn. In Japan, as well, many cases of leptospirosis have been reported in summer and autumn[8)–10)]. There may be factors other than temperature related to the occurrence of leptospirosis.

Leptospirosis is generally referred to as a disaster-related infectious disease. The outbreaks of leptospirosis after flooding in tropical regions have been reported in several studies[11)–13)]. Flooding is caused by typhoons in Asia. Many cases of leptospirosis were reported after typhoons in the Philippines[14]. Saito et al.[15] demonstrated that when the soil was sampled 2 months after a typhoon in the Philippines, pathogenic *Leptospira* was detected in about half of the samples. In Japan, typhoons cause flooding in autumn as well. In previous studies of the geographic distribution of leptospirosis in Japan, the highest number of the cases observed was in Okinawa, the southernmost prefecture, in 2006[16] and 2016[9]. Many typhoons reach landfall in Okinawa. Therefore, it is of interest whether or not there is an association between leptospirosis and typhoons. Prior to this study, the associations between leptospirosis and typhoons have not been evaluated in Japan.

Another disaster which induces poor sanitary conditions is earthquakes. There are many earthquakes in Japan. The United Nations Development Programme report demonstrates that the annual average of the number of people exposed to earthquake hazards in Japan was the highest among all the countries worldwide from 1980 to 2000[17]. Earthquakes can cause insufficient garbage collection, which leads to poor sanitation and an increase in the number of rodents, resulting in the increased risk of exposure to contaminated rodent urine. A case of leptospirosis was reported in Japan after an earthquake, presumably caused by drinking water contaminated with *Leptospira* from a well that is not normally used[18]. After the 2011 Great East Japan Earthquake, the National Institute of Infectious Diseases called attention to the possibility of an increased risk of leptospirosis[19]. However, prior to this study, the association between leptospirosis and earthquakes, likewise, had not been evaluated in Japan.

The objective of this study, therefore, was to clarify the relation between leptospirosis and typhoons and earthquakes. Ecological studies have been used to analyze the relations between disasters and diseases[20)21)]. Therefore, after confirming the seasonal and geographic distributions in Japan in the past 10 years, the correlations between leptospirosis and typhoons and earthquakes were analyzed using ecological study methods.

Methods

We conducted an ecological study using data from March 2013 to February 2023. In Japan, physicians who diagnose any cases of leptospirosis must immediately report them under the Infectious Diseases Control Law. The information is compiled by the National Institute of Infectious Diseases and the number of cases is reported weekly. We counted the number of cases of leptospirosis from those and reported the monthly number of cases in the present study. The geographic distribution of leptospirosis was shown by the number of cases in each prefecture in Japan. The number of typhoons and earthquakes are based on data published by the Ministry of Land, Infrastructure, Transport and Tourism from the same period.

We analyzed the correlation between the monthly number of cases of leptospirosis and that of typhoons and earthquakes in Japan by Spearman's correlation coefficient test. In addition, the correlation between cases of leptospirosis and earthquakes with seismic intensity 4 or greater was also analyzed. All statistical analyzes were performed using R v4.2. 1 software (R Foundation for Statistical Computing, Vienna, Austria).

Results

A total of 381 cases of leptospirosis were reported from March 2013 to February 2023 in Japan. Fig. 1 shows the number of leptospirosis by month during that period. The highest number of the cases was observed in September then October. The median number of leptospirosis per month was 13.0 (Interquartile range [IQR], 6.8 – 39.5).

Fig. 2 shows the number of leptospirosis by prefectures during the same period. Cases of leptospirosis

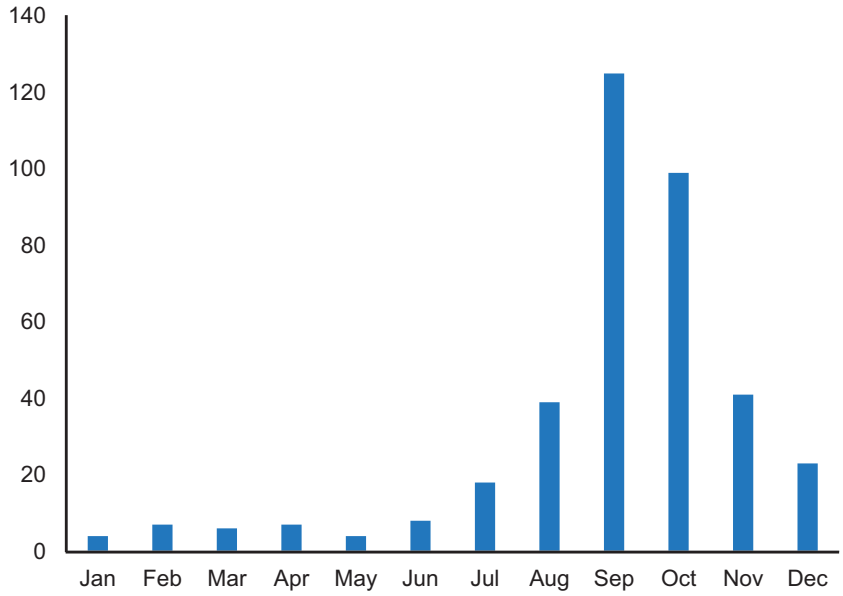

Fig. 1 Number of leptospirosis cases by month in Japan, March 2013 – February 2023

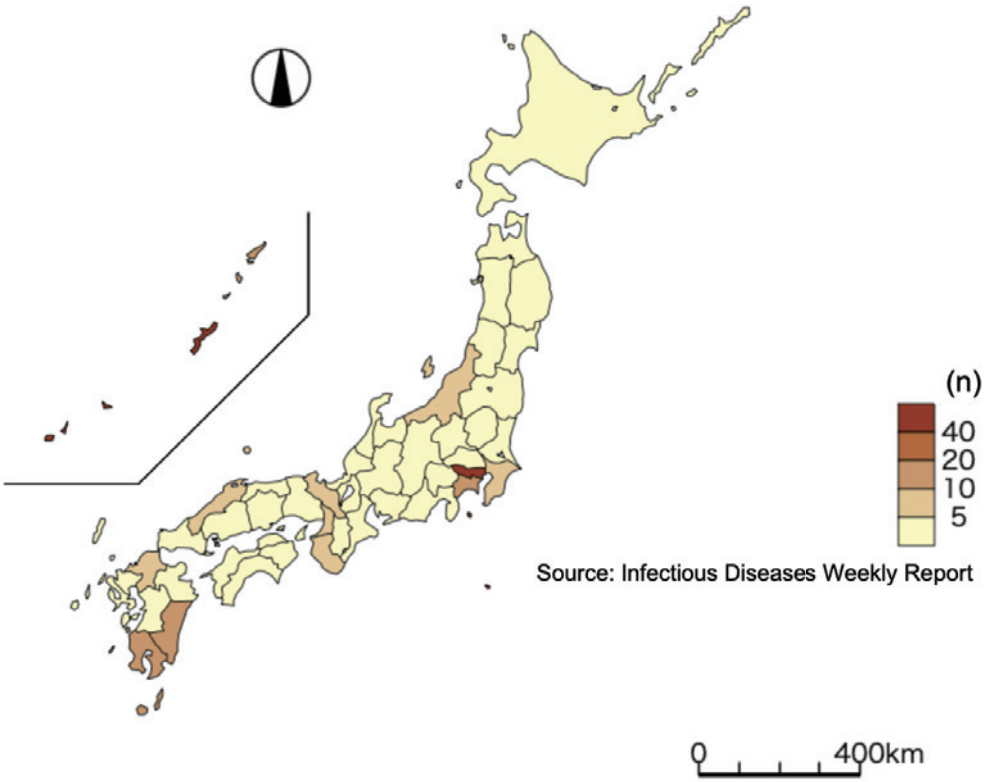

Fig. 2 Distribution of leptospirosis cases in Japan, March 2013 – February 2023

were reported in 33 prefectures. The highest number of cases was in Okinawa (n = 181) followed by Tokyo (n = 62), Kagoshima (n = 19), Kanagawa (n = 14), Miyazaki (n = 10), and Osaka (n = 8).

Table 1 shows the monthly number of typhoons, earthquakes, and earthquakes of intensity 4 or greater during that period. The median number of typhoons per month was 14.5 (IQR, 5.0 − 37.5). The median number of earthquakes was 1,846 (IQR, 1,641 − 1,918). The median number of earthquakes of intensity 4 or over per month was 43 (IQR, 38 − 53).

Fig. 3 shows the significant correlation between the natural log transformed monthly number of leptospirosis and typhoons (Coefficient = 0.88, $p < 0.001$). There were no significant correlations between the monthly

Table 1 The number of typhoons and earthquakes per month, Japan, March 2013 – February 2023

Month	Typhoons	Earthquakes	Earthquakes (intensity ≥ 4)
January	5	1,458	33
February	5	1,400	32
March	3	1,628	38
April	7	4,993	171
May	4	2,184	53
June	19	1,882	59
July	37	1,746	42
August	55	1,645	37
September	52	1,846	54
October	39	1,859	48
November	24	1,846	42
December	10	2,027	44
Total	260	24,514	653

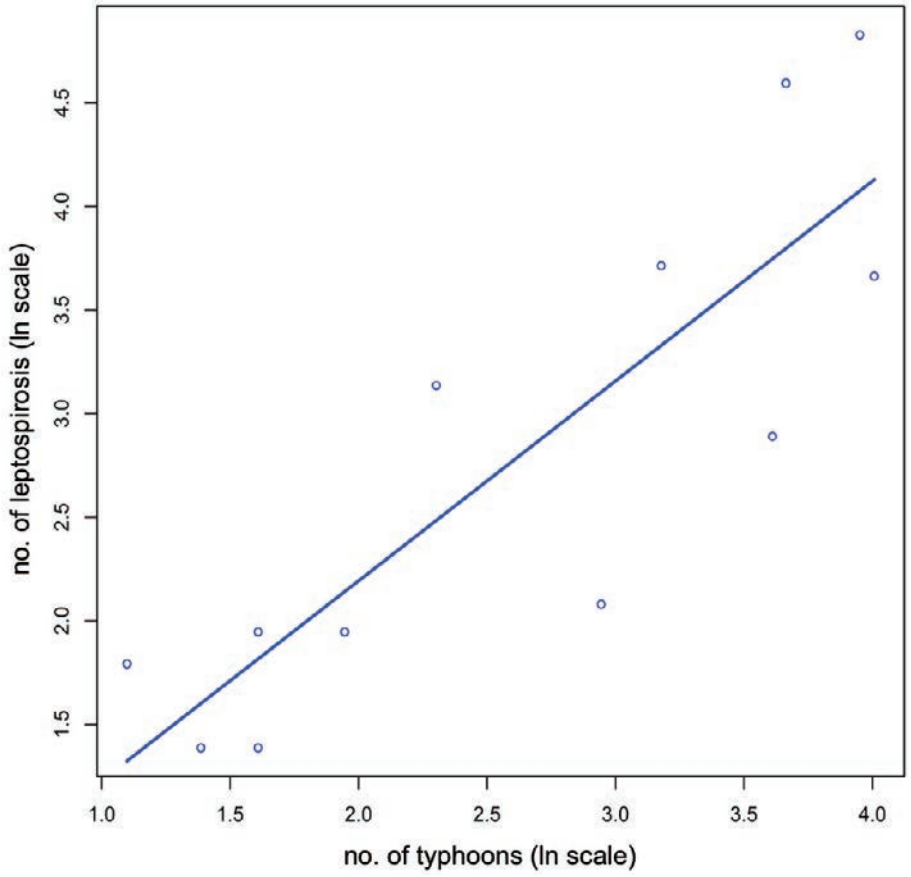

Fig. 3 Correlation between the number of leptospirosis cases and typhoons in Japan, March 2013 – February 2023
The X-axis and Y-axis were a natural log scale.
A significant correlation was observed (Spearman's correlation coefficient = 0.88, $p < 0.001$).

number of leptospirosis and earthquakes or those with a seismic intensity of 4 or greater (Coefficient = 0.11, p = 0.728 and Coefficient = 0.21, p = 0.503, respectively).

Discussion

The highest number of leptospirosis per month in Japan was recorded in September followed by October from March 2013 to February 2023. That of typhoons per month was in August followed by September then

October during that period. The seasonality of leptospirosis with a peak from summer to autumn was similar to the occurrence of typhoons as shown in this study. As an ecological study analysis, a significant correlation between the number of leptospirosis and typhoons was observed. The peaks of leptospirosis cases in September and October were most likely due to typhoons reaching landfall, which increased the likelihood of people being exposed to contaminated water.

The geographic distribution of leptospirosis in Japan shown in this study was in accordance with those of previous studies[9)10)16)]. It was demonstrated that the cases of leptospirosis were reported from two major parts of Japan. One is the southern part of Japan including Okinawa, Kagoshima, and Miyazaki Prefectures, which has a moist and warm climate and many strong typhoons. The highest estimated source of infection was reported to be recreation in rivers in Okinawa[22)–24)], whereas that in Miyazaki and Kagoshima was from farm work[8)]. Farm work often involves exposure to contaminated water. Contaminated water is considered to be a major source of infection in southern Japan, and typhoons increase the risk of exposure to contaminated water thereafter. Therefore, leptospirosis should be included in the differential diagnoses of febrile patients after typhoons reach landfall.

The other part is the heavily populated urban area of Tokyo and Kanagawa Prefectures. It has been estimated that the contact with contamination from rodents is the main source of infection in Tokyo[25)], which has the second highest number of leptospirosis cases in Japan. Thus rodents are the main source of infection in the urban areas of Tokyo and Kanagawa. It is suggested that the major sources of infection are different between east and west Japan.

There was no significant correlation between the monthly number of leptospirosis cases and earthquakes in Japan. One reason is that when we analyzed this correlation, the analysis did not include whether or not earthquakes deteriorated sanitary conditions. Large earthquakes often cause poor sanitary conditions, however, we could not analyze the correlation between the number of leptospirosis cases and earthquakes with a seismic intensity of 5 or greater because the number of those earthquakes was small. In future studies, to elucidate the relation between leptospirosis and earthquakes, it would be useful to describe individual cases of leptospirosis in areas affected by large earthquakes that deteriorated sanitary conditions.

One limitation of this study is that causality cannot be confirmed because it is an ecological study. Another limitation is that the regions where typhoons actually reached landfall were not determined because we merely analyzed the correlation between the number of leptospirosis cases and typhoons.

We identified the seasonal and geographic distribution of leptospirosis on a national scale for 10 years, including the most recent information. The seasonal peak of leptospirosis cases was in autumn. Many leptospirosis cases were reported from the southern part of Japan including Okinawa, Kagoshima, and Miyazaki. The significant correlation between the number of cases and typhoons was observed, suggesting that leptospirosis is a disaster-related disease in the southern part of Japan. Leptospirosis should be included in the differential for febrile patients after typhoons, especially in the southern part of Japan.

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災害関連感染症として台風と関連のあるレプトスピラ症の都道府県毎発生状況について

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—キーワード—
レプトスピラ症，台風，生態学的研究

背景：レプトスピラ症は世界中で報告されているが，災害関連感染症とも言われている．レプトスピラは主にネズミの尿で汚染された土壌や水との接触によりヒトに感染し，洪水や大雨の後にアウトブレイクを引き起こす．日本では洪水や大雨は台風によって引き起こされることが多い．また，日本では衛生状態悪化の原因となりうる地震も多い．しかし，レプトスピラ症と台風や地震などの自然災害との関連はこれまで検証されてこなかった．本研究ではレプトスピラ症の季節的・地理的分布を確認した上で，過去 10 年間の日本におけるレプトスピラ症と台風や地震との関連を明らかにすることを目的に生態学的研究を行った．

方法：2013 年 3 月から 2023 年 2 月までの国立感染症研究所の週報をもとにレプトスピラ症患者数を集計した．同時期の台風や地震の発生数は，国土交通省の発表資料に基づいて集計した．レプトスピラ症の季節性・地理的分布について記述した後に，日本におけるレプトスピラ症の月別患者数と台風・地震の月別発生数との関連をスピアマンの相関検定により解析した．

結果：2013 年 3 月から 2023 年 2 月の 10 年間に日本で報告されたレプトスピラ症は 381 例であった．患者数は 9 月から 10 月で最も多かった．都道府県では沖縄県（n = 181），東京都（n = 62），鹿児島県（n = 19），神奈川県（n = 14），宮崎県（n = 10），大阪府（n = 8）の順に多かった．月別のレプトスピラ症患者数と台風発生数に有意な関連を認めた．しかし，月別のレプトスピラ症患者数と地震発生数との間には有意な関連を認めなかった．

結論：レプトスピラ症は，人口の多い地域とは別に沖縄，鹿児島，宮崎など日本の南部で多く報告された．月別のレプトスピラ症の患者数と台風発生数との間に有意な関連があることから，台風が上陸することが多い日本の南部においては，レプトスピラ症は災害関連疾患であると考える．したがって，特に日本の南部においては台風通過後の発熱患者の鑑別でレプトスピラ症を含める必要がある．

［COI 開示］本論文に関して開示すべき COI 状態はない

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