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The Trend of Leptospirosis in the Philippines: A Basis for an Effective Workflow of Early Warning System

RJ Krista Raye Y. Leocadio*

Department of Environmental Science and Technology, College of Science and Mathematics, University of Science and Technology of Southern Philippines, Cagayan de Oro, Philippines

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Abstract

The Philippines has a tropical climate prone to typhoons and heavy flooding. Since 1932, Leptospirosis has remained endemic in the country, with an increasing number of cases and deaths every year. Usually, reports of leptospirosis cases occur after the occurrence of heavy flooding and typhoons. With this overwhelming situation of Leptospirosis in the Philippines, this paper reviewed the trends and patterns of the occurrence of Leptospirosis with the hydrometeorological data. Based on findings, the occurrence of Leptospirosis is closely connected with heavy rainfall or a typhoon in NCR/Region I/Region VI, and Typhoons occur mostly from June to December, and the first heavy rainfall after the dry season. A proposed workflow for an early warning system was established in this paper for local government units and healthcare facilities to be guided in their decision-making for the target population to receive advance notice about the likelihood of a leptospirosis outbreak happening at a specific time and location. An established early warning system for Leptospirosis is valuable for the prevention and control of disease outbreaks.

* **Corresponding Author:** RJ Krista Raye Y. Leocadio ✉ rjkristaraye.leocadio@ustp.edu.ph

Introduction

Leptospirosis is one of the most widespread zoonosis caused by domestic animal species. About 100 years ago, *Leptospira* was identified and isolated almost at the same time in Japan and Europe. It is known to be the causative agent of the severe form of Leptospirosis called Weil's disease (Adler, 2015). The *Leptospira* genome sequences and mutagenesis systems have provided insights into its pathogenesis. Based on the report of the World Health Organization (WHO), there is an annual estimate of 873,000 cases with over 40,000 deaths in the world for Leptospirosis (Wang *et al.*, 2021).

In the Philippines, *Leptospira* was first isolated from one patient suffering from Weil's disease in 1932 (Basaca-Sevilla *et al.*, 1986). A total of 65 cases were sporadically tested in 1970. With an increasing trend from 1971 to 1973, about 82 out of 390 cases (21.02%) were found positive during the serological examination. From 1976 to 1983, 31% of the tested patients in a penal farm located in Sabalayan, Mindoro, reacted positively to the antigen test for Leptospirosis during the outbreak. Based on current medical reports, leptospirosis cases in the country persist. According to the Department of Health (DOH), there are 589 leptospirosis cases in a span of six (6) months, from January to June 2021. The number of cases is higher than what was reported in the same months of 2020, which is 520. The case fatality rate of the disease is higher in 2021 (11.4%) than in 2020 (9.8%).

Leptospirosis often develops when exposed to the urine of infected animals through direct or indirect contact with contaminated soil or water (Fig. 1). The *Leptospira* bacteria can survive in freshwater for up to sixteen (16) days and in soil for around twenty-four (24) days. It can invade skin with open wounds and mucous membranes. There are also reports that the bacteria can cross the placenta in an infected pregnant mother, resulting in miscarriage, stillbirth, and intrauterine death. Once the bacteria enter the bloodstream, the infection can easily spread and target the liver and kidneys. The symptoms of the disease take about one (1) to two (2) weeks to show up, while for others can take up to a month. Usually, it remains unreported because its symptoms are quite similar to other diseases such as dengue, brucellosis, malaria, measles, meningitis, and hepatitis A.

Leptospirosis disease is typical in temperate countries during the late summer or early fall in the Western and during the rainy season in the Tropics (Wang *et al.*, 2021). Notably, the tropics have ten (10) times more cases than the temperate countries. Having a tropical climate, the Philippines is also frequently visited by typhoons for at least twenty (20) a year. Moreover, the Philippines has been reported as one of the most flood-prone countries in the world, with at least sixty (60) major floods in the past ten (10) years based on a report of the National Disaster Risk Reduction and Management Council (NDRRMC). Several leptospirosis outbreaks have been attributed to climate change. Extreme weather events caused by global warming, such as typhoons, floods, and increased rainfall, are highly associated with the upsurge of leptospirosis incidence (Lau *et al.*, 2010). In addition, leptospirosis outbreaks happen and usually follow after periods of excess rainfall during the rainy season (Mason *et al.*, 2016).

Aside from the climatic factors, the lack of knowledge about the risks of Leptospirosis and how it is being transmitted to humans remains unresolved. It has been observed in our country that people deliberately expose themselves directly to the floodwaters without any hesitation (Fig. 2). Effective strategies for effective control and preventive measures must be well known by the general public to avoid getting the disease. According to Prof. Yoshida Shin-ichi of Kyushu University, Japan, Leptospirosis, an endemic infectious disease in the Philippines, has been neglected while he was working on a project to prevent and control the disease in the country by developing prototype diagnostic kits. Professor Shin-ichi has observed that there are only a few research publications and surveys about the severity and pathogenesis of Leptospirosis. It is also an underreported disease. A growing number of cases and deaths have been repoigrted annually, and there is no proper program for the surveillance, monitoring, and tracking of Leptospirosis in the country. The country has not established an instrument on how to communicate information about the risks of Leptospirosis to the vulnerable population, especially before a leptospirosis infection can occur. It would be more likely that leptospirosis outbreaks will keep on occurring, leading to medical burdens and drains for health practitioners and the general public as well. Early warning systems will reduce potential harm or prevent a leptospirosis outbreak from happening. Public health officials and the general public must receive advance notice about the likelihood of a leptospirosis outbreak happening at a specific time and location.

Thus, this review aimed to evaluate the patterns of leptospirosis cases in the Philippines in the past five (5) years (2016-2020) to effectively formulate an early warning system against leptospirosis outbreaks. Specifically, this paper identified which regions in the country have the highest number of leptospirosis cases and deaths, described a connection between the occurrence of Leptospirosis and the hydrometeorological factors, and proposed a workflow for an early warning system to prevent leptospirosis outbreaks in the country. The timing and mode of the public communication system for early warning systems are highly focused on the development of workflow based on the findings and patterns of different research related to this review for timely dissemination of hazards and risks related to leptospirosis outbreaks.

To sustain an effective control measure for Leptospirosis, there is a need to properly plan and implement strategies for the protection of the whole population. However, these activities may have been restricted by insufficient epidemiologic and health impact data, vague guidelines and tools to identify and predict high-risk areas for leptospirosis infection and outbreaks, and incompetent strategies for public health interventions. Ideally, an integrated environmental health impact assessment is needed to deliver information to high-risk individuals and areas about the risk of leptospirosis infection and outbreaks. In determining an overall impact on health, there are multiple aspects to consider, such as the environmental hazards linked to the infection's exposure pathway, parameters used in the population, and other socio-economic influences (Fig. 3) (Lau *et al.*, 2012). This approach stirs up collaborative activities between the government and private sectors that manage environmental health interventions for the prevention and control of Leptospirosis. To understand the trend of leptospirosis outbreaks in the country, ecological observations and climate forecasts are essential to predict the occurrence of Leptospirosis and potentially minimize its transmission. Furthermore, these facilitate decision-making of the local and national health institutions for the vulnerable population to take actions to reduce their exposure to an impending hazard related to Leptospirosis.

Materials and methods

This is a review of trends and patterns related to the occurrence of Leptospirosis with the hydrometeorological factors in the Philippines. The Philippines is located in Southeast Asia in the Western portion of the Pacific Ocean, consisting of three (3) main islands – Luzon, Visayas, and Mindanao. It is subdivided into seventeen (17) regions – eight (8) in Luzon, three (3) in the Visayas, and six (6) in Mindanao (Fig. 4). Based on the 2020 census, the regions with the highest population are CALABARZON (16,195,042), the National Capital Region (13,484,462), and Central Luzon (12,422,172).

Almost 40 percent of the national population is found in these three (3) regions alone. For less than 10 percent of the national count, the least populated regions are Cordillera Administrative Region (1,797,660), Caraga (2,804,788), and MIMAROPA Region (3,228,558), whose combined populations account. The Philippines is also located in the Pacific Ring of Fire, which makes the country vulnerable to typhoons, earthquakes, cyclones, and volcanic hazards.

The number of Leptospirosis cases and deaths was collected from 2016 to 2020 in annual reports published by DOH. In the same period, the number of typhoons per month was obtained from the published reports of the Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA). The time of the year when typhoons usually occur was needed to design the early warning system for Leptospirosis in the country.

The map was generated using the Quantum Geographic Information System (QGIS) version 3.16 Hannover to create, edit, visualize, analyze, and publish the geospatial data and information about the cases and deaths of Leptospirosis in the Philippines. This software is available in an open-source online for GIS applications and operations developed by the Open-Source Geospatial Foundation.

In designing an early warning system for Leptospirosis in the Philippines, the formulation of the workflow was based on the hydrometeorological and environmental findings of this review, as well as the observations taken from other related studies. For effective public communication strategies in an early warning system against leptospirosis outbreaks, different trends were observed based on the mode and timely dissemination of information with regard to hazards, risk scenarios, and preparedness strategies.

Results

As shown in Table 1, the reported cases of Leptospirosis in the Philippines from 2016 to 2020 are shown by region based on the retrieved databases in the Department of Health (DOH). Based on the incidence rate, the top three (3) highest cases and deaths of Leptospirosis are in the National Capital Region (NCR), Ilocos Region (Region I), and Western Visayas (Region VI). With an incidence rate of 6.49%, the National Capital Region (NCR) (n=875) has the highest average number of cases across all regions. Ilocos Region (Region 1) has an average of 331 cases with an incidence rate of 6.24%, while Western Visayas (Region VI) has an average of 381 cases with an incidence rate of 4.78%.

Table 1. Leptospirosis Cases and Deaths in the Philippines, By Region (2016-2020).

Region		2016		2017		2018		2019		2020		Average (2016-2020)		Incidence Rate (%)
		Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	
Philippines		**1,771**	**177**	**3,067**	**317**	**5,556**	**533**	**3,541**	**366**	**182**	**81**	**2,823**	**295**	
NCR	National Capital Region	440	48	568	82	2,163	200	1,203	117	3	0	875	89	6.49
CAR	Cordillera Administrative Region	39	0	76	2	76	6	107	11	19	10	63	6	3.53
I	Ilocos Region	315	47	432	57	587	75	320	45	1	1	331	45	6.24
II	Cagayan Valley	64	8	197	20	196	23	322	21	25	14	161	17	4.36
III	Central Luzon	308	19	235	26	493	36	455	49	0	0	298	26	2.40
IVA	CALABARZON	136	16	137	11	457	47	313	38	0	0	209	22	1.29
IVB	MIMAROPA	33	0	25	6	58	1	28	4	32	7	35	4	1.09
V	Bicol Region	58	1	102	11	131	7	163	15	18	12	94	9	1.55
VI	Western Visayas	194	18	651	51	697	74	327	32	34	24	381	40	4.78
VII	Central Visayas	28	8	170	23	103	15	60	10	0	0	72	11	0.89
VIII	Eastern Visayas	13	0	112	10	86	9	34	2	2	2	49	5	1.09
IX	Zamboanga Peninsula	19	1	45	5	109	15	39	6	4	1	43	6	1.11
X	Northern Mindanao	57	2	84	3	59	8	47	3	31	0	56	3	1.11
XI	Davao Region	39	7	167	6	128	10	86	9	7	5	85	7	1.63
XII	SOCCSKSARGEN	7	2	8	0	9	1	9	0	0	0	7	1	0.13
Caraga	Caraga	19	0	52	4	198	6	20	2	6	5	59	3	2.10
BARMM	Bangsamoro Autonomous Region in Muslim Mindanao	2	0	6	0	6	0	8	2	0	0	4	0	0.10

Source: Philippine Integrated Disease Surveillance and Response, Epidemiology Bureau, Department of Health

Note: Number of cases and deaths are per 100,000 population and are reported without any adjustment

The least number of leptospirosis cases is in Soccsksargen (Region XII) (n=7) and Bangsamoro Autonomous Region in Muslim Mindanao (BARMM) (n=4). The distribution of these human leptospirosis cases and deaths in the Philippines from 2016 to 2020 is also presented in Fig. 5.

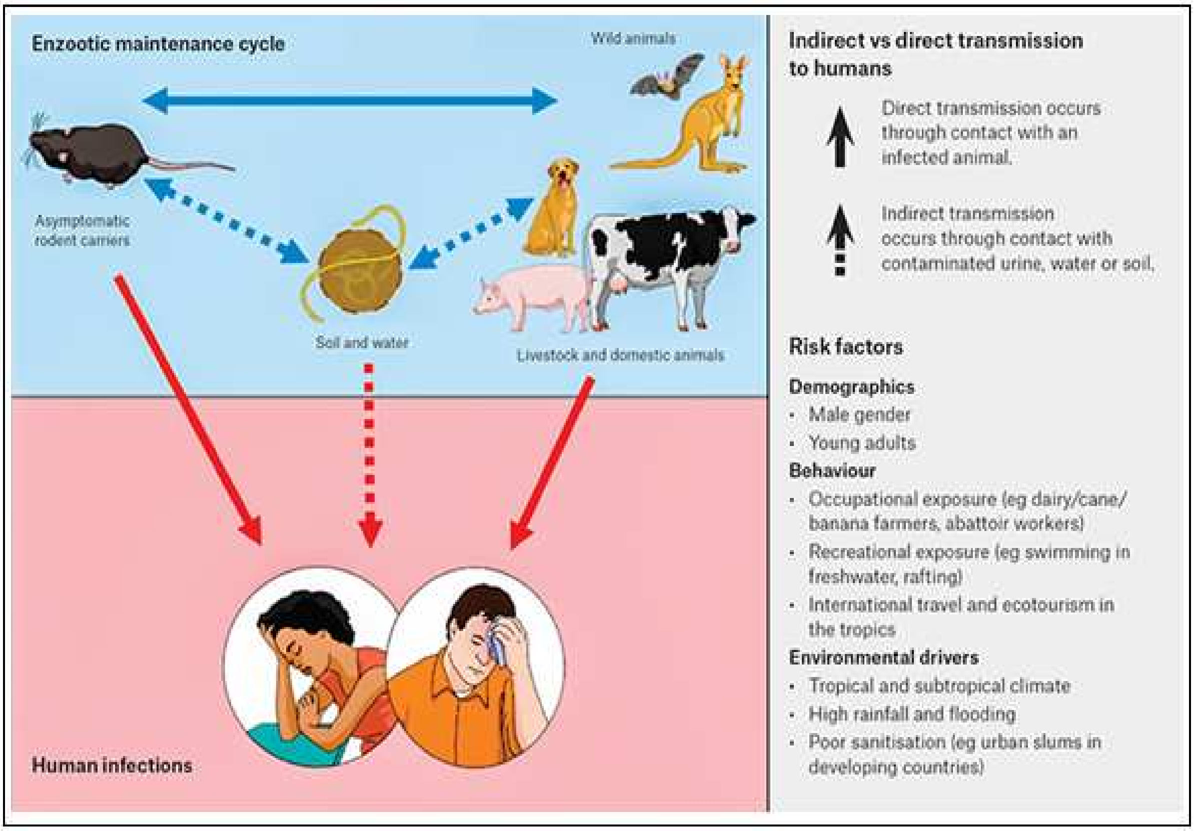

Fig. 1. Transmission pathways and risk factors of Leptospirosis.

As seen in Fig. 6, there are more than six (6) visits of typhoons commonly occurring from June to December. In five (5) consecutive years, the month of September has the highest number of typhoon visits, while the least number is in March and April. Based on the recorded data, the month of May has no record of typhoons. According to PAGASA, the rainy season is from June to November, while the dry season is from December to May.

Fig. 2. Filipinos directly expose themselves to floodwaters.

Based on the findings of the hydrometeorological and environmental patterns, the occurrence of Leptospirosis is closely connected with heavy rainfall or a typhoon in NCR/Region I/Region VI. Typhoons occur mostly from June to December, and the first heavy rainfall after the dry season (Fig. 7). When PAGASA announces an expected typhoon or heavy rainfall, the Local Government Units (LGUs) of the affected areas must request a frequent local broadcast about the risk and prevention of Leptospirosis.

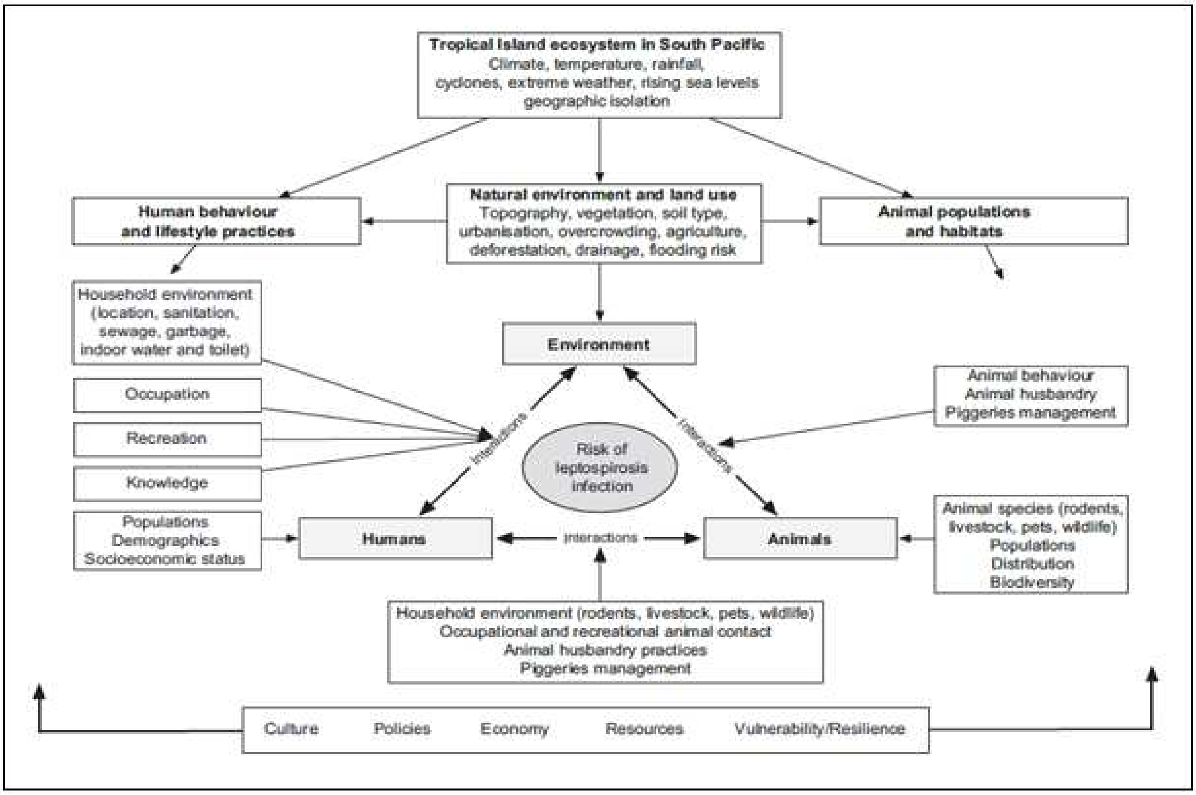

Fig. 3. The conceptual framework for assessing and predicting the environmental health impact of Leptospirosis.

After the onset of heavy rainfall or typhoon, LGUs must keenly observe for any upsurge of leptospirosis cases within two (2) weeks. At the same time, local healthcare facilities must prepare for an upsurge of Leptospirosis at any time. LGUs and local healthcare facilities must prepare the capacity and availability of their doctors and practitioners, beds, medicines, etc. If a sudden increase in Leptospirosis occurs, the capacity of treatment among the local healthcare facilities must be increased to cater to the needs of leptospirosis patients. Monitoring and surveillance activities by the LGUs must continue for forty (40) weeks. Monitoring and surveillance activities may end if there is a consistent decrease in the number of local leptospirosis cases. If there is no upsurge of leptospirosis cases after the onset of heavy rainfall and typhoons, monitoring and surveillance activities must continue for one (1) month. After one month of no sudden increase in local leptospirosis cases, monitoring and surveillance activities may end.

Discussion

Researchers have linked the occurrence of leptospirosis outbreaks with different climatic, abiotic, and biotic factors. The endemicity of Leptospirosis in tropical areas is strongly driven by typhoons and seasonal changes (Rood *et al.*, 2017; Matsushita *et al.*, 2018). It has long been known that NCR, specifically Metro Manila, is one of the most disaster-prone cities in the world. The NCR is along a coastline having perennial floods during rainy seasons where some grounds are below water level or sinking due to over-extraction of water. In the past decades, the NCR has been experiencing destructive typhoons, causing severe floods in the area. Not too long ago, Ilocos Region and Western Visayas were classified as high-risk and vulnerable to climate-related natural disasters (German *et al.*, 2019). When Porio (2011) interviewed residents in flood-prone areas in Metro Manila like the Pasig-Marikina River basin, West Mangahan, and the KAMANAVA area (Kalookan, Malabon, Navotas, Valenzuela), respondents reported that landfilling activities in real estate developments have increased flooding since waterways were converted to buildings and other infrastructures. Another factor that these people are prone to leptospirosis outbreaks is that they mostly live in congested informal houses situated in dike walls, creeks, tributaries, rivers, and swampy areas.

Unsanitary dwellings can be a potential reservoir of various pathogenic or non-pathogenic *Leptospira* species, especially in contaminated soil and water sources (Mendoza *et al.*, 2019).

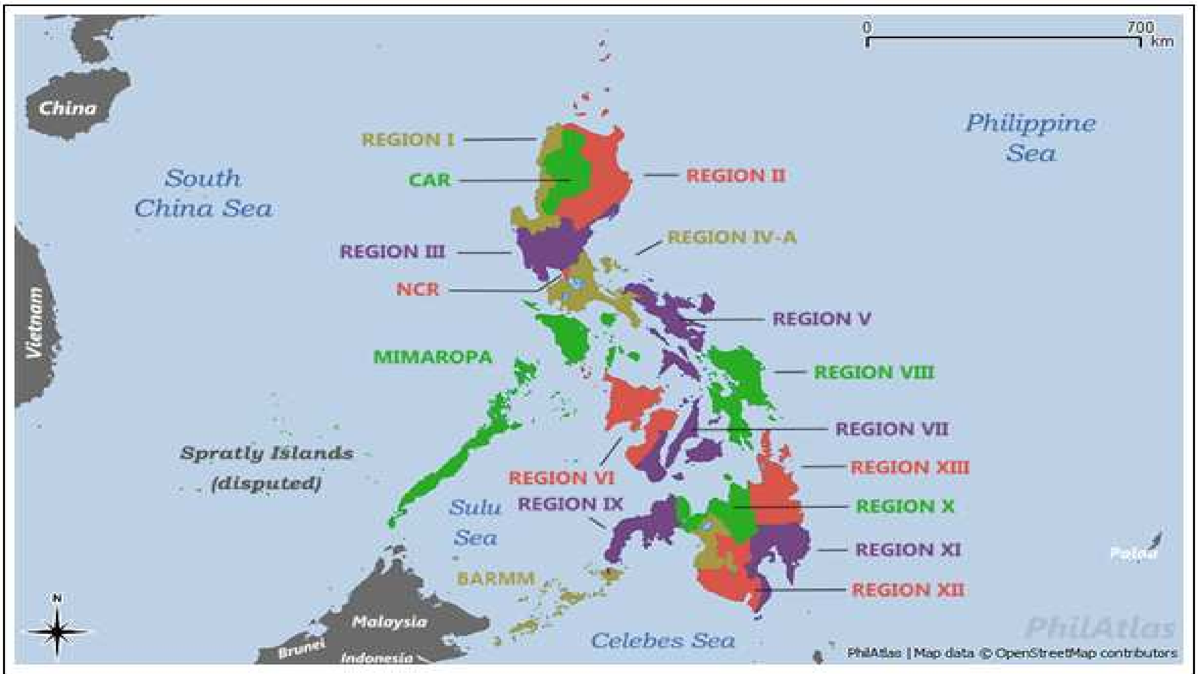

Fig. 4. Political map of the Philippines.

In these regions where Leptospirosis is endemic, their social and physical location can make them more prone to the disease. Moreover, there are few surveillance activities for Leptospirosis in the country. In Regions I, III, and X after the Typhoons Nesat, Nalgae, and Washi, respectively, surveillance of Leptospirosis was conducted among the residents (Gloriani *et al.*, 2016). Among the persons investigated, 94% were found positive in the microscopic agglutination test (MAT), where 54% were symptomatic. Most of the affected are farmers in the productive age group aged 21-40 years old. In another hospital-based investigation done at San Lazaro Hospital, surveillance was conducted on 486 cases of Leptospirosis after a typhoon in September 2009, which reported an outbreak of the disease in Metro Manila (Amilasan *et al.*, 2012). In a report given by Porio (2011), residents in NCR experience storm surges and floods from typhoons and heavy monsoon events from June to November. Additionally, the areas in KAMANAVA experience the effects of sea-level rise and tidal surges throughout the year. With this, the rainy months coincided with the upsurge of leptospirosis cases in our country based on the results of other studies (Sumalapao *et al.*, 2019; Wang *et al.*, 2021). As a tropical country, Wang *et al.* (2021) confirm that leptospirosis cases are ten (10) times more prevalent during the rainy seasons compared to temperate countries. Based on the results of Sumalapao *et al.* (2019), rainfall was strongly associated with many hospital admissions for Leptospirosis at a lag of two (2) weeks and was explained by the occurrence of flooding in the affected areas.

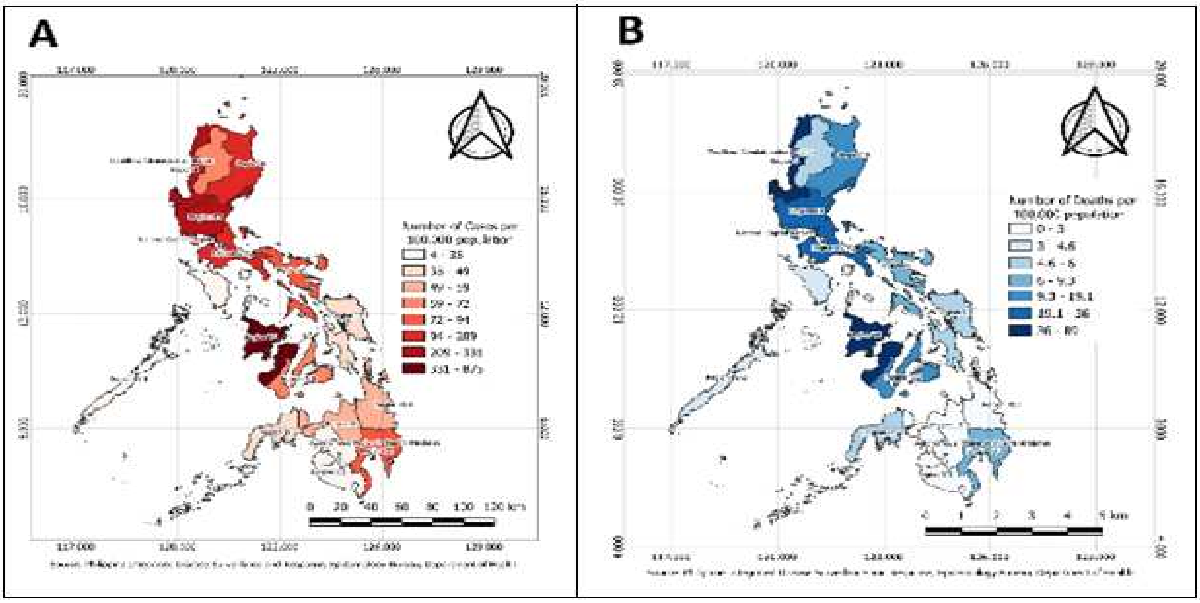

Fig. 5. Hotspot analysis of human leptospirosis cases (A) and deaths (B) in the Philippines, 2016-2020.

This can be explained by the incubation period of 5-14 days required by the *Leptospira sp.* to become infective after exposure.

For timely dissemination of risk, impacts, and prevention of Leptospirosis, LGUs must be active in campaigning the risk, impact, and prevention of Leptospirosis through broadcast media such as television and radio programs immediately after the weather forecast from the Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA). As Quina *et al.* (2014) have reported, television was found to be the most effective medium to disseminate information about the risk and prevention of Leptospirosis based on the conducted survey.

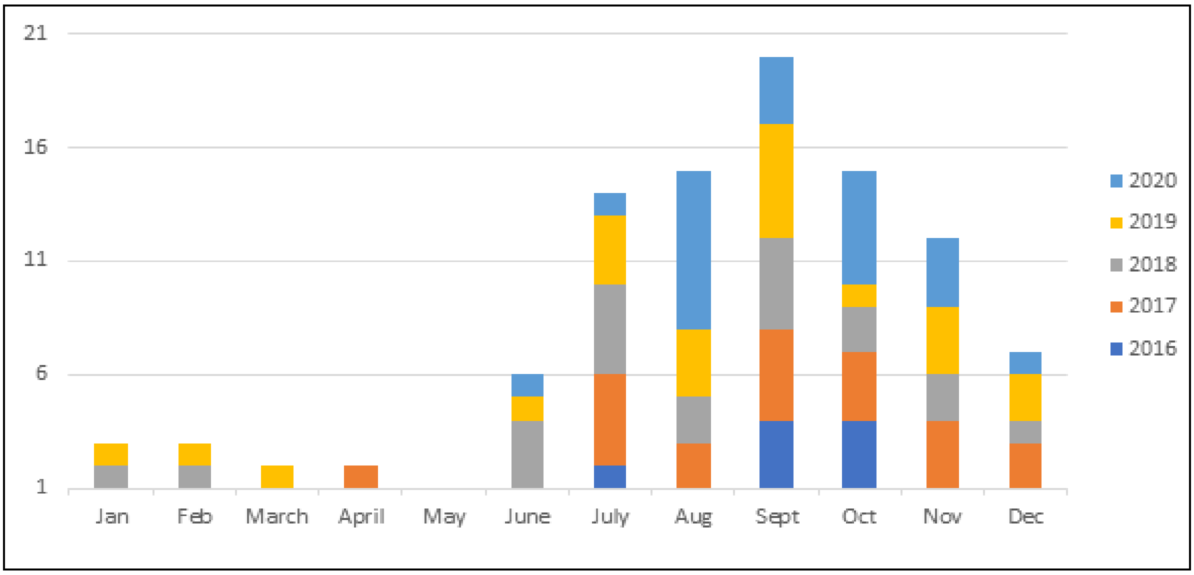

Fig. 6. The annual number of tropical cyclones in the Philippines, 2016-2020. Source: Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA).

The given two-week waiting time for LGUs and local healthcare facilities to expect an impending risk of Leptospirosis was based on the incubation period for *Leptospira sp.* to become infective. According to Lau *et al.* (2018), the *Leptospira sp.* can become infective after 5 to 14 days from the initial exposure.

Based on a study conducted by Ledien *et al.* (2017), the first flooding after the dry season has significantly caused a leptospirosis outbreak. It was only until forty (40) weeks that the cases started to decrease. Whenever there is a leptospirosis outbreak, monitoring and surveillance activities must continue until forty (40) weeks after the onset of heavy flooding and typhoons.

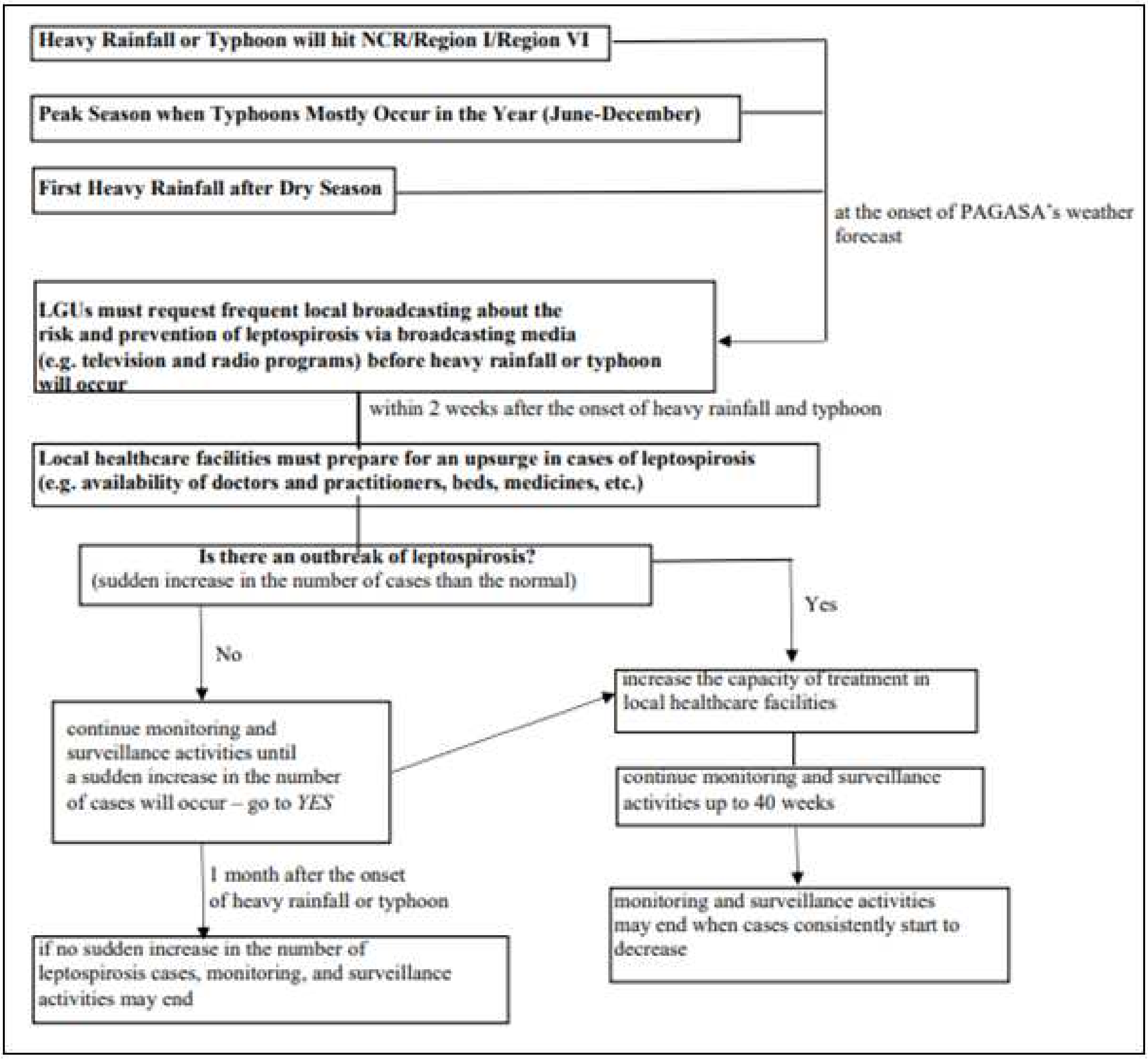

Fig. 7. A proposed workflow for an early warning system in the prevention and control of leptospirosis outbreaks in the Philippines based on hydrometeorological and environmental trends.

In addition, the Global Leptospirosis Environmental Action Network (GLEAN) is assigned to improve local and abroad strategies on how to predict, prevent, detect, and intervene in leptospirosis outbreaks (Durski *et al.*, 2014). Good communication, effective health education, and active social mobilization are critical roles in making vulnerable populations aware of the risks of Leptospirosis. Before an outbreak of Leptospirosis can happen, it is necessary to raise awareness of the disease among the population at risk. Furthermore, it is important to help them understand the use of weather alerts and forecasts to reduce the impacts of leptospirosis outbreaks.

Conclusion

Based on reviews, the occurrence and increase of leptospirosis cases were strongly connected with heavy rainfall and flooding. In this review, the trends and patterns of leptospirosis cases in the Philippines in the past five (5) years (2017-2021) are solely based on the available hydrometeorological and environmental data. NCR, Region I, and Region VI were found with the highest number of leptospirosis cases and deaths. During typhoons, heavy rainfall and flooding usually happen and reports of leptospirosis cases were relatively high. Based on hydrometeorological and environmental data, the months of June to December frequently have more typhoons compared to other months in a year. These trends and patterns have shaped the formulation of an early warning system that can be adapted to prevent and control leptospirosis cases in the country. With these observations, the proposed early warning system must be grounded in the most vulnerable circumstances and areas where leptospirosis outbreaks can happen. These include the areas in NCR/Region I/Region VI, months with frequent typhoons (June to December), and the first flooding after the dry season. Timing and mode of disseminating the information are primarily important to prevent and control leptospirosis cases and deaths in the country. It is also recommended that the contents of this information strikingly catch the attention of the vulnerable groups to effectively impart the risks, impacts, and prevention of Leptospirosis. In disseminating the early warning information, the target audience must be the working-age group and the riskiest areas frequently affected by heavy flooding and typhoons. To precisely predict the amount of rainfall and flooding occurring in real time, the country should be equipped with satellites and radar system technologies. Moreover, monitoring and surveillance activities must be conducted with proper guidance and training. Calling and reporting any symptoms of Leptospirosis to the local healthcare institutions fis vital in the control of leptospirosis outbreaks.

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