Human Leptospirosis in Malaysia: Reviewing the Challenges After 8 Decades (1925-2012)

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Abstract
The history and epidemiology of human leptospirosis in Malaysia from 1925 to 2012 are described. Previous studies have demonstrated that leptospirosis is an endemic disease in Malaysia occurring in both urban and rural locations. The number of cases has risen dramatically since the Ministry of Health Malaysia highlighted leptospirosis as a notifiable disease in 2010, with reported cases increasing from 248 cases in 2004 to 3604 in 2012. The incidence of infection among the population suggests that occupation, sex, age, ethnic background, water recreational activities, and sporting events are risk factors. A robust surveillance system is now in place to monitor temporal and spatial changes in the incidence and prevalence of infection and to identify risk areas and disease behavior. Despite extensive studies over the past decade, there is a still a need to describe local serovars in host carriers and the human population, with the view to develop an effective vaccine against leptospirosis.

Keywords
Leptospira, leptospirosis, outbreaks, rodents, risk factors, prevention

Introduction
Leptospirosis is an emerging zoonotic disease with more than 1 million cases per year globally.1 It has been recognized as a reemerging infectious disease, particularly in tropical and subtropical countries.2 A striking rise in the number of reported cases and frequency of outbreaks have been reported in Southeast Asia (Thailand, India, Malaysia, and Indonesia) and also Central and South America.3,4 The number of human cases worldwide is not well documented, and as a

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consequence of underreporting in many areas of the world, the prevalence of leptospirosis in the tropics varies from 0.1 to 10 per 100,000 population, with an average case fatality rate (CFR) of 10%. It is possible that 100 or more of 100,000 may become infected during outbreaks or in high-risk areas. However, these figures are likely to be an underestimate because of misdiagnosis and inadequate surveillance systems in many countries.

Leptospirosis is caused by spirochetes belonging to the genus *Leptospira*, with at least 22 species classified according to DNA-DNA hybridization analysis and more than 300 serovars based on agglutinating LPS antigens. Rodents, dogs, cattle, and swine are regarded as the principal reservoirs for this spirochete, which has been reported in at least 150 mammalian species. Human and animal infections are acquired via direct contact with urine, blood, or infected animal tissue or indirect contact with water or soil contaminated with the urine of reservoir animals. Although particular serovars have been related to specific animal reservoirs, all animals are susceptible to infection by any serovar. In the past, leptospirosis was recognized as an occupational disease, infecting mainly farmers, veterinarians, miners, fishermen, and abattoir and sewer workers. However, travel to endemic areas and recreational activities such as water sports have increasingly been reported as major risk factors for this infection.

In Malaysia, leptospirosis is a reemerging disease, and the high humidity and warm temperatures allow *Leptospira* to survive for long periods in the environment. Heavy rainfall and frequent flooding, especially during the monsoon season, also increase the incidence of leptospirosis. Several outbreaks of leptospirosis associated with rainfall have been documented. Historically, the annual incidence of leptospirosis in Malaysia ranged between 1 and 10 per 100,000 population. Despite the dramatic increase in cases reported over the past 9 years (Figure 1), the human incidence is still likely to be underestimated because of misdiagnosis and underreporting, and the epidemiology of this infection remains unclear.

The present review describes the historical and epidemiological features of leptospirosis in Malaysia, and preventive measures are discussed with the view to reduce the possible risk of disease transmission.

**Methods**

MEDLINE, PubMed, and Scopus databases were used to search for peer-reviewed articles on the current status of leptospirosis as well as risk factors, control, and prevention. Studies on the history and current status of the disease in Malaysia were obtained by searching local university libraries and websites of the local government health office. Data on the status of leptospirosis in Asia-Pacific countries were also presented.

**Historical Aspects of Human Leptospirosis in Malaysia**

Inada et al isolated *Leptospira* for the first time from human patient blood in Japan, in 1915, whereas in 1928, Fletcher was not only the first to isolate this pathogen from the blood, liver, and kidneys of 21 patients in Malaysia, but also identified 3 different serovars—namely, *Leptospira interrogans* serovar Icterohaemorrhagiae, *L. interrogans* serovar Hebdomadis, and *L. interrogans* serovar Pyrogenes. Fletcher also introduced a new medium for the isolation of leptospires, and this is still used in many laboratories in Malaysia and worldwide.

Earlier work in Malaysia primarily focused on those individuals serving in the military. In 1957, McCrumb et al reported that of 614 military personnel and 238 civilian patients suffering from fever who were admitted to the military hospital, 34.7% and 13%, respectively, were confirmed to be infected with *Leptospira*, based on serology tests. Tan and Lopes carried out a survey on 2 categories of Malaysian soldiers. The first category included those in service between 6 months to 20 years, whereas the second category included the new recruits (2 to 3 weeks) in...
training. Based on serological results, the prevalence values among newly recruited soldiers (22.0%) was almost double compared with those who had been in service longer (12.1%). In another survey, Supramaniam\textsuperscript{18} reviewed the status of leptospirosis among army personnel and confirmed through serological testing that 2 fatal cases in 1969 and 1978 were a result of leptospirosis. In this survey, only 4.6% of soldiers presented with fever symptoms, although a higher incidence of 30% was recorded for British soldiers.

Several studies were also extended to include civilians in order to link occupation, intrinsic factors (sex and age), and ethnicity. Tan\textsuperscript{19-21}, Ungku Omer\textsuperscript{22} and Shafei et al\textsuperscript{23} noted that rubber plantations laborers and those dealing with sewage, drainage, forestry, and town cleaning as well as antimalaria workers were at high risk of infection, whereas laborers, military personnel, tin miners, farmers, and paddy planters were at moderate risk. Shop owners, policemen, and veterinary staff also fell in the moderate-risk group, whereas school teachers, housewives, and office workers had the least risk.

Relative to host age, the highest incidence occurred among patients between the ages of 20 and 40 years, with a higher rate of infection among male patients.\textsuperscript{24,25} Based on ethnicity, infection among the Malays was the highest, followed by the Indians and Chinese. The general clinical features recorded included fever, chills, jaundice, abdominal pain, cough, and hepatomegaly.\textsuperscript{24,25}

**Chronology of Leptospirosis Outbreaks in Malaysia**

Since the first reported case in the early 1920s, subsequent outbreaks have been reported, with an increasing number of cases over the years. The chronology (Table 1) and location (Figure 2) of leptospirosis outbreaks in Malaysia since 1984 are given below.
<table>
<thead>
<tr>
<th>Outbreaks</th>
<th>Year</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mulu caves, Sarawak</td>
<td>1984</td>
<td>After exploration of the Mulu caves in Gunung Mulu National Park, Sarawak, 16 British cave explorers return to Britain ill; 5 patients had fever of unknown origin and hepatomegaly with no renal failure. Leptospirosis was suspected and later confirmed by serology</td>
<td>Waitkins (1986)(^{26}); Self et al (1987)(^{27})</td>
</tr>
<tr>
<td>Sarawak</td>
<td>1985</td>
<td>A group of British tourists visited the Sarawak chamber and 2 contracted leptospirosis</td>
<td>Sheena and Buchan (1987)(^{28})</td>
</tr>
<tr>
<td>Beaufort, Sabah</td>
<td>1999</td>
<td>After swimming in a creek near an oil palm plantation in Kampung Kebatu, Beaufort, Sabah, 46 locals fell ill. One fatality was reported when a 15-year-old boy died from hemorrhagic shock secondary to pulmonary hemorrhage. Investigations revealed creek water contaminated with urine tainted with leptospirosis of animal origin (cattle, pigs, dogs, rodents, and wild animals), with prior flooding facilitating the spread of the organism</td>
<td>Koay et al (2004)(^{11})</td>
</tr>
<tr>
<td>The Eco-Challenge, Segama River, Sabah</td>
<td>2000</td>
<td>Athletes kayaking and swimming in the Segama River were diagnosed with leptospirosis. This outbreak was recognized as the first international outbreak associated with outdoor adventure. Experts pinpointed the river water as the source of outbreak. Athletes who took doxycycline prior to the challenge were spared from infection</td>
<td>Sejvar et al (2003)(^{29})</td>
</tr>
<tr>
<td>Johor</td>
<td>2006-2007</td>
<td>Following floods that affected all 8 districts in Johor between December 2006 and January 2007, 20 cases of leptospirosis, with 2 deaths, were reported</td>
<td>Badrul Hisham et al, 2009(^{12})</td>
</tr>
<tr>
<td>Juru, Penang</td>
<td>2009</td>
<td>There were 26 leptospirosis cases, with 2 deaths, reported at the illegal migrant detention center in Juru, Penang. The 2 who died were Burmese migrants, and drinking water contaminated with animal urine, potentially rats, was suspected to be the cause</td>
<td>International Detention Coalition (2009)(^{30})</td>
</tr>
<tr>
<td>Maran, Pahang</td>
<td>2010</td>
<td>A total of 8 deaths were reported among the 83 people involved in the rescue operation of a drowned victim. The investigations disclosed that the river water was contaminated with urine of rats or other animal carriers. The infections occurred while rescuers used river water for their daily chores. On outbreak confirmation, the recreational park was temporarily closed to the public</td>
<td>Sapian et al (2012)(^{31})</td>
</tr>
<tr>
<td>The Bukit Jugra Royal Malaysian Air Force base</td>
<td>2011</td>
<td>A total of 24 air force trainee commandos were infected; it was confirmed serologically as caused by <em>Leptospira</em>. Investigation showed that the infection occurred while training in water contaminated with urine of rats or other animals</td>
<td>Malay Mail Online (2011)(^{32})</td>
</tr>
<tr>
<td>Kangar, Perlis</td>
<td>2012</td>
<td>A family of 8 of 28 men who went fishing at a swamp developed symptoms and were hospitalized in Hospital Tuanku Fauziah, Kangar, Perlis. Serological tests for leptospiral IgM confirmed that 6 of the 8 men tested positive. Water samples from the swamp were screened and confirmed by PCR as being tainted with <em>Leptospira</em></td>
<td>Baharudin et al (2012)(^{33})</td>
</tr>
</tbody>
</table>
Despite extensive studies over the past 8 decades, there are still gaps in our knowledge related to the epidemiology of human infections. Misdiagnosis and underreporting are the main obstacles in estimating the incidence not only in Malaysia but also in many Asian countries because of the similarity in clinical symptoms with other tropical diseases such as dengue fever, malaria, or hemorrhagic fever.

The present method of diagnosis includes the microscopic agglutination test (MAT), which is undertaken by a small number of public health laboratories, which focus on the detection of positive cases without first determining the circulation of serovars locally. However, with MAT false-negative results do occur, and an extensive range of antisera is required. Tests in Malaysia are run within such a limited range of 25 antisera that new serovars have not been identified domestically.\(^3^4\) Positive samples need to be processed further at overseas reference laboratories, but this is not always followed through. Without this crucial information, there is no evidence to link the modes of transmission between humans and potential host reservoirs to provide a further understanding of the epidemiology of this disease. More important, the development and commercialization of a vaccine is not possible.

Prior to 2010, the number of reported cases and outbreaks increased significantly, resulting in a high number of deaths. This added pressure on local health authorities made them recommend that leptospirosis be classed as a mandatory notifiable disease from December 2010. Following the directive, between 2011 and 2012, 5869 cases were reported with more than 100 fatalities (Figure 1). The annual incidence rates ranged from 7.83 to 12.49 cases per 100 000 population, and the CFR decreased from 2.42% in 2011 to 1.30% in 2012. The highest incidences occurred in the west-coast states of Peninsular Malaysia—namely, Selangor, Perak, Kelantan, and Pahang (Figure 3), with most cases being reported during heavy rainfall and flooding during the monsoon season. This demonstrated that extrinsic factors such as climatic conditions played a major role in disease transmission.\(^3^5\) Intrinsic factors such as host sex were also shown to influence
infection, with men at a higher risk of contracting leptospirosis than women (by 4:1) because of the nature of their occupations and more extensive outdoor activities.

The epidemiology of leptospirosis is dynamic. New risk groups may be formed as a result of changes in agricultural or social practices or new reservoir hosts may emerge. Continuous surveillance, improved management systems, and the establishment of a monitoring system are key components in regulating the impact of this disease. Because of its sporadic nature, leptospirosis is not given the same priority as dengue fever and malaria to the extent that high-impact research activity, disease monitoring, and long-term control measures, especially of rodent populations, have been overlooked by government bodies and organizations.

**Leptospirosis in the Asia-Pacific Region**

Similar to the scenario seen in Malaysia, other countries in this region underestimate the disease burden of leptospirosis because of underreporting and the unavailability of laboratory diagnostics. The South East Asia region, in particular, is noted to have the highest incidence, often influenced by sociocultural, occupational, behavioral, and environmental factors. Rural areas are at higher risk because the population is mainly involved in agriculture or animal husbandry, and animals are present in large numbers.36 The annual incidence in this region varied from low (<1 per 100 000), to moderate (1-10 per 100 000), to high (>10 per 100 000),3 with mortality between 5% and 40%.37

Thailand recorded the highest number of cases, which occurred primarily during the rainy season. Disease notification reports indicated a drastic increase in the number of cases, with an incidence of 0.3 per 100 000 in 1995, which peaked in 2000 to an incidence of 23.7 per 100 000 population.36 The outbreaks corresponded with the wet season in August and declined by November.
In the past decade, the number of reported cases stabilized to between 2800 and 5500 cases annually. As of December 1, 2008, reported cases totaled 3350, with 59 deaths in 71 of 76 provinces in 48 weeks. The overall incidence was 5.3 per 100,000 population, with a male to female ratio of 1:0.25. The predominant serovar circulating in the population was \textit{L} \textit{interrogans} serovar \textit{Autumnalis}.39

In the Philippines, both urban and rural areas recorded outbreaks usually during the typhoon season (July-October). The most prevalent \textit{Leptospira} serovars isolated were Pyrogenes, Bataviae, Pomona, Grippotyphosa, Manilae, and Javanica mainly among workers involved with animals, such as abattoir and dog pound employees as well as fish inspectors. During a typhoon that occurred between September and mid-November 2009, Metro Manila reported 2299 patients, including 178 who died (CFR of 8%), in 15 hospitals with suspected signs and symptoms of this illness, as determined by the Department of Health.41

In Indonesia, leptospirosis is often linked to the disease being clinically unapparent, too mild for definitive diagnosis, or misdiagnosed as dengue fever or other endemic diseases; laboratory facilities to perform confirmatory tests are also lacking.42 The annual number of reported cases from 2007 to 2011 were 664, 426, 335, 409, and 857, respectively; however, not all provinces routinely report leptospirosis cases to the authorities. The annual case fatalities recorded for 2007 to 2011 were 8.28%, 5.16%, 6.87%, 10.51%, and 9.57%, respectively. However, the actual number was possibly higher. The predominant serovar circulating in the population was identified as \textit{L} \textit{interrogans} serovar Bataviae.44

Leptospirosis has been endemic in India since the early 20th century and related both to monsoon and poor sanitary conditions, with multiple epidemics reported in recent years.45,46 The Andaman and Nicobar Islands reported the highest incidence, where serovars Ratnapura, Valbuzzi, and Grippotyphosa were reported as causes of severe epidemics. Based on data published in 2013, the prevalence was 38.1% in Calicut, 52.7% in the Andaman and Nicobar islands, and 32.9% in Chennai.47

Leptospirosis has been gazetted a notifiable disease in all territories of Australia since 1988. Queensland and Victoria recorded the highest incidences, with the average annual incidence in humans being 1.0 per 100,000 population and prevalent among agriculture sector workers, especially banana farmers and dairy workers. In 2009, 149 cases were reported nationally, with more than 75% of the cases in Queensland. A total of 24 serovars were isolated from domestic, native, and feral animals and included the following species: \textit{L} \textit{interrogans}, \textit{L} \textit{borgpetersenii}, \textit{L} \textit{santarosai}, \textit{L} \textit{weilii}, and \textit{L} \textit{meyeri}.50

\textbf{Mode of Transmission and Maintenance Hosts}

Leptospirosis is caused by pathogenic organisms belonging to the genus \textit{Leptospira}, and human infections are the result of direct or indirect exposure to urine of infected animals. Other modes of transmission include handling infected animal tissues and ingestion of contaminated food and water. Presence of moisture is an important factor to the survival of this pathogen in the environment.

In other regions, different serovars are prevalent and associated with one or more maintenance hosts, which are most often wildlife species and, sometimes, domestic animals and livestock. Although the rodent was recognized as the primary carrier, especially in South East Asia, farm animals and dogs have also been incriminated as common reservoirs that can shed leptospires throughout their life span without clinical manifestations.

In Malaysia, \textit{Leptospira} was first isolated from the kidneys and urine of the black rat (\textit{Rattus rattus}). Other studies incriminating the rodent followed suit in the South East Asia region, isolating primarily the Icterohaemorrhagiae serovar, however other serovars have also been isolated.
Historically, leptospirosis was recognized as a disease of dogs prior to any other animals, including humans.\textsuperscript{57} Dogs are primarily carriers of Canicola serovars; however, other serovars have also been reported: Icterohaemorrhagiae, Pomona, Bratislava, and Grippotyphosa.\textsuperscript{58} Similar studies in highlighting dogs as carriers were also conducted in India and Thailand.\textsuperscript{55,59} Farm animals such as cattle, sheep, and pigs are noted to be maintenance hosts for several \textit{Leptospira} serovars, and therefore, pose a high risk of infection, especially to farmers, abattoir workers, and livestock handlers. In the Asia-Pacific region, several serovars were reported from cattle, sheep, and pig.\textsuperscript{60,61} Generally, cattle are the natural host of serovars Hardjo, Pomona, and Grippotyphosa, whereas pigs harbor Pomona, Tarassovi, and Bratislava and sheep harbor Hardjo and Pomona.\textsuperscript{62} Among wild animals, \textit{Leptospira} sp have been isolated from monkeys, bats, squirrels, and mongooses.\textsuperscript{63}

\section*{Risk Factors}

Several factors contribute to the spread of leptospirosis, especially in tropical and subtropical regions, where the warm weather and heavy rainfall make it favorable for the survival of leptospires in the environment. Natural disasters, such as cyclones and subsequent flooding, have been noted as high-risk factors because of the leaching of leptospires from the environment. Other factors include types of agricultural and social practices, inadequate housing, and poor sanitation\textsuperscript{64} in addition to occupational and recreational activities.\textsuperscript{3} Information regarding these vital factors is grossly missing, and therefore, it is imperative that future studies are able to relate the risk factors to disease incidence in order to predict disease outbreaks.

\section*{Recreational Activities}

In recent years, recreational activities have emerged as the primary risk factor for leptospirosis in Malaysia,\textsuperscript{31,33} particularly after 2000,\textsuperscript{29,31} particularly outdoor and leisure activities, including gardening and water sports (canoeing, swimming, and fishing). Those at risk include international visitors, particularly those travelling to endemic areas and engaging in jungle activities, camping, hiking, kayaking and water skiing,\textsuperscript{6} and cave exploration.\textsuperscript{65} In a recent study among febrile patients (with no other associated symptoms for inclusion criteria) in the northeastern states of Malaysia, serological (ELISA, MAT) results revealed that 16.2\% (33/204) of patients became positive after a recent recreational activity.\textsuperscript{66}

\section*{Occupational Exposure}

Leptospirosis has been recognized as an occupational disease for many decades, occurring mainly among sewer workers, miners, and fish farmers. These workers are at a higher risk of contracting the disease because of their constant contact with water polluted with leptospires via contaminated urine of reservoir hosts. Nevertheless, workers in other occupations, such as garbage collectors, abattoir workers, farmers, livestock handlers, rodent control workers, pet shop workers, rice field workers, rubber and palm oil collectors, and military personnel have recently also been identified as at risk of contracting the infection.\textsuperscript{3,23,37,66}

\section*{Natural Disasters}

Several leptospirosis outbreaks have been linked to flooding, typhoons, and cyclones.\textsuperscript{3,12,67} Floods damage water and sanitation networks, displace populations, destroy homes, and increase environmental exposure to pathogens. Floods also flush drains, leading to the contamination of water bodies with the urine of infected dead animals, which become a source of contagion.\textsuperscript{67} In
2007, serological investigations carried out after a major flood hit in Johor confirmed 20 leptospirosis cases, with 2 deaths, among 2000 cases of waterborne diseases reported.12

**Other Factors**

Rapid urbanization and the high population density in the cities of developing countries have attracted the primary host reservoir of this disease—rodents. A recent study identified 2 pathogenic serovars infecting the population—predominantly *L borgpetersenii* serovar Javanica (85%) and *L interrogans* serovar Bataviae (15%).34 The great abundance of rodents has been linked to increased human exposure to the pathogen; however, it is also dependent on human susceptibility, which varies according to time and place. Overcrowding of cities, with inadequate living facilities, poor sanitary systems, improper garbage management, and the boundless presence of stray animals in the environment increase the risk of leptospirosis in humans.68

**Control and Prevention**

The control and prevention of leptospiral infection is a complex process because it requires an understanding of the epidemiology of the disease before proper intervention can be put in place to reduce the risk of infection. The primary method of prevention can be achieved by controlling the infection source (reservoir), the transmission route between infection source and human host, and the infection in the human host.

**Reservoirs.** Rodents are known to be natural reservoirs and potential lifelong carriers of leptospires,69 not only for humans but also for domestic animals. Several strains are directly linked to rodents such as *L interrogans* serovar Copenhageni, *L interrogans* serovar Icterohaemorrhagiae, *L kirschneri* serovar Bim, and *L borgpetersenii* serovar Ballum.2,70 Mohamed-Hassan et al71 also noted leptospiral antibodies to serogroups Canicola, Pyrogenes, and Hebdomadis from *L interrogans* species in rats. Despite some positive reports on the use of antileptospiral vaccines in humans, long-term studies have not been carried out.2 Rodent control is essentially the most effective method of preventing human infection, particularly in urban areas. Currently, the conventional use of rodenticides and continuous trapping in urban cities have reduced the rodent population, thus reducing the risk of infection. Good sanitation and proper garbage disposal are important factors to reduce the rodent population in urban areas. Immunization of livestock and pets can reduce the risk of human transmission; however, the existence of wildlife reservoirs has complicated prevention. Therefore, it is advisable for owners to minimize contact between their animals and rodents and other wild animals.

**Water and Soil in the Environment.** Pathogenic leptospires colonize the renal tubules of mammals and are shed in their urine, contaminating surface water and soil, where leptospires can survive for long periods. Early research on the isolation of *Leptospira* from water and soil began in the 1970s in Malaysia after Alexander et al72 successfully isolated 29 serovars from natural waters and wet soils. Several pathogenic *Leptospira* species were successfully isolated—namely, *L interrogans*,72 *L Borgpetersenii*,73 and *L kmetyi*.74 More recently, Benacer et al75 recovered 1 pathogenic species (*L alstonii*) and 1 intermediate species (*L wolffii*) from water and soils in urban sites. The removal of leptospires from the surrounding water and soil is certainly impractical. However, drainage of wet areas and minimizing indirect contact with urine-contaminated soil and water remain the most effective preventive measures. It is advisable to cover blisters, cuts, or broken skin with waterproof plasters, especially while swimming in fresh water. Wearing protective clothes during recreational and occupational activities may additionally decrease the risk of infection.
Based on the cases reported, more than 60% were the result of occupational or recreational activities. Therefore, creating awareness among high-risk groups about disease transmission and taking preventive measures is the key to prevention. Public health authorities can take the initiative to provide information packs to be distributed to high-risk groups, which includes those serving with the military and adventure travelers. Information should include advice on drinking only purified and boiled water, proper water and food storage, avoiding prolonged immersion in and consumption of river water, and finally, wearing waterproof clothing such as rubber boots and gloves.76 Tour companies and adventure sport organizers could also assist in distributing the information packs to travelers.

Finally, preexposure chemoprophylaxis could become increasingly important as more people engage in adventure travel and ecotourism. The use of doxycycline as a prophylactic measure has been reported.29,77 Sejvar et al29 noted that taking doxycycline prior to engaging in water activities was effective as a prophylaxis for leptospirosis in individuals with identifiable, short-term exposure to high-risk activities and environments. However, such a prophylactic method is only suitable when exposure can be accurately predicted and only for a short period of time. Therefore, the use of doxycycline is unlikely to be applicable as a general public health measure unless convenience-based clinical trials are undertaken in the longer term.

**Conclusion**

Eight decades after it was first discovered in Malaysia, leptospirosis is still a widely prevalent disease in the country, with an increasing number of cases over the years, especially after leptospirosis was gazetted as a notifiable disease in 2010. Therefore, there is an urgent need to formulate and institute better disease control and prevention strategies. Presently, local authorities play a major role by providing better garbage management and establishing good rodent control programs around human habitation and recreational areas. However, the involvement of more health workers is necessary to educate the public about the dangers of the disease, its mode of transmission among the population, and who is most at risk, so that the disease can be recognized and treated immediately. The limitation of the present study not only relates to the underreporting and misdiagnosis of the disease, but also to the lack of information about the type of serovars that infect the human population in Malaysia. Hence, the method of transmission of leptospires between potential reservoir hosts to humans requires further investigation in order to contribute to our understanding of the epidemiology of the disease. Only when such data are available can an effective veterinary and human vaccine be developed and commercialized to reduce mortality.

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**References**


