ORIGINAL ARTICLE

Leptospirosis in Perak state for the year 2024: Hospitalisation rate and its associated factors

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ABSTRACT

Introduction: Leptospirosis remains a public health concern in Malaysia, particularly in high-burden states like Perak. Understanding the hospitalisation rate and its associated factors is important for informing early intervention strategies and optimising disease management; however, local data on these aspects remain scarce. This study seeks to address this gap by determining the hospitalisation rate and identifying the risk factors associated with hospitalisation among probable and confirmed leptospirosis cases in Perak.

Materials and Methods: This is a retrospective cohort study using secondary data from two data sources obtained from the e-Notifikasi system database and laboratory reports of all registered leptospirosis cases in Perak from January to December 2024. The outcome variable, which was hospitalisation status, was determined by the treating team based on clinical manifestation and disease severity. Multiple logistic regression was applied to identify factors associated with hospitalisation cases. Data was analysed using SPSS version 29.

Results: A total of 764 registered leptospirosis cases were included in the study, with 75.5% (n=577) required hospital admission (95% CI: 72%,79%). The average age of patients was 32 years (SD: 20.5), with two-thirds (67.8%) being male. Kinta district reported the highest proportion of cases (30.4%). Factors significantly associated with hospitalisation included: presence of complications (aOR: 8.06, 95% CI: 1.57,41.48), vomiting (aOR: 11.00, 95% CI: 6.63,18.25), headache (aOR: 4.44, 95% CI: 2.70,7.32), onset-to-diagnosis (aOR: 1.37, 95% CI: 1.23,1.52), histories of recreational activity exposure (aOR: 3.41, 95% CI: 2.07,5.62), soil exposure (aOR: 2.60, 95% CI: 1.11,6.07) and types of occupation; student (aOR: 2.79, 95% CI: 1.58,4.93), agriculture (aOR: 5.06, 95% CI: 2.20,11.63), military personnel (aOR: 4.87, 95% CI: 1.08,21.92) and pensioners (aOR: 5.96, 95% CI: 3.31,10.74).

Conclusion: This study adds to the existing knowledge on the hospitalisation rate and its associated factors among registered leptospirosis cases in Perak. These findings highlight the importance of targeted health education, enhanced clinical vigilance and risk-based interventions tailored to local exposure patterns. While the study's strengths include comprehensive case capture and validated data, limitations include the absence of meteorological, socioeconomic status and health literacy data. These limitations emphasise the need for future longitudinal and behavioural studies.

KEYWORDS:
Leptospirosis, Hospitalisation, Environmental Exposure

INTRODUCTION

Leptospirosis, caused by bacteria of the genus Leptospira, is the most prevalent zoonotic disease worldwide.[1] Globally, leptospirosis contributes to nearly one million cases and 59,000 deaths each year, often peaking during rainy seasons and in areas with poor sanitation or occupational exposure.[2] Human leptospiral infections primarily result from direct or indirect exposure to the urine of infected animals, which gain entry into the body through the skin via a cut or abrasion, or through the mucous membranes of the conjunctivae or oral cavity.[3]

Leptospirosis, an emerging infectious disease, has been a public health concern in Malaysia due to its association with flooding, agriculture, and urban environments. Its incidence rates fluctuated between 13 and 17 cases per 100,000 population from 2011 to 2022, which is higher than those of neighbouring countries such as Thailand and the Philippines.[4] The increase in cases is possibly associated with changes in population behaviours and surveillance activities during the COVID-19 pandemic.[5] In Malaysia, leptospirosis is most commonly diagnosed using serological tests, such as the Microscopic Agglutination Test (MAT), which identifies serovar-specific antibodies, and solid-phase assays that detect Immunoglobulin M (IgM) antibodies. A patient's serum is expected to test positive for the IgM serology test within five to 10 days after the onset of symptoms, while MAT is likely to yield positive results between 10 and 12 days from the onset of the illness.[6]

Perak, a state in the northwest of Peninsular Malaysia, has shown a persistently high incidence and mortality rate over the years. The incidence varied between 11.41 and 13.60 per 100,000 for the years 2016 and 2017,[7] with case fatality rates ranging from 3.14% to 14.3% from 2011 to 2016.[8] Research has shown that 57% of environmental samples from

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recreational forests in Perak were contaminated with pathogenic Leptospira,[9] thereby providing favourable environments for the bacteria, which contribute to the persistence of the disease. Moreover, Perak has a diverse economic structure with agriculture remaining one of the important sectors, thus exposing workers to soil and water potentially contaminated by Leptospira.[10] The state's unique geographical and economic profile makes it a noteworthy area for studying leptospirosis.

Leptospirosis presents with a wide range of clinical symptoms, varying from a mild, self-resolving febrile illness that can be managed as an outpatient to a severe, potentially fatal condition involving multiple organ failure and requiring inpatient treatment. Leptospirosis hospitalisation rates vary globally, reflecting differences in disease severity and health-seeking behaviour. In Netherlands, hospitalisation was required in 74.4% cases,[11] whereas in Sri Lanka, an annual hospitalisation incidence of 52.1 per 100,000 population,[12] and an average of 0.6 hospitalisations per 1,000,000 population was observed in the United States.[13]

Several studies has been conducted to identify factors associated with hospitalisation including sociodemographic variables (e.g. age, gender, economic status, types of residency, education level),[12,14-15] clinical characteristics (e.g. presence of complication, late onset diagnosis, types of serovar, MAT titre level),[14,16-17] and environmental exposure (e.g. occupation, history of recreational activity and exposure to animal).[14,18] However, most of these research were done globally, for example in New Zealand, Sri Lanka, and Columbia, which have different health system and surveillance structure and their findings may not fully be applicable in endemic region like Malaysia, where exposure and health-seeking attitude could vary.

Ideally, leptospirosis cases should be promptly identified through effective diagnosis and thorough understanding of risk factors in order to prevent severe disease progression which requires hospitalisation. However, despite leptospirosis being gazetted as a notifiable disease in Malaysia, the incidence remain inconsistent indicating that existing preventive strategies are not optimized.[4] The majority of existing studies in Malaysia focus on the severity of cases based on clinical and laboratory parameters,[19] with less emphasis on sociodemographic and environmental influences. This research gap delays the early identification of high-risk cases and the implementation of targeted intervention. Consequently, preventable complications, overburdened healthcare and reduced job productivity will occur. Understanding these gaps is important for improving disease management, guiding targeted public health interventions and optimizing resource allocation. This study seeks to address this gap by determining the hospitalisation rate and identifying risk factors associated with hospitalisation among probable and confirmed leptospirosis cases in Perak.

MATERIALS AND METHODS

A state-level retrospective cohort study using secondary data from January to December 2024 was conducted. It involved the registered leptospirosis case reported to the Perak State Health Department (*Jabatan Kesihatan Negeri Perak,* JKNP). Perak is a state located on the northwest of Peninsular Malaysia, comprising 12 administrative districts. As of 2024, there are approximately 2.57 million multi-racial communities residing in Perak, making it the fourth most densely populated state in Malaysia.[20]

Data Source

The present study obtained data from two sources using name and identification number as the common identifier. Data sources included: (i) the e-Notifikasi Database System, recorded and maintained by the Communicable Disease Control Unit to obtain patients' demographic information, clinical presentations, and epidemiological histories; and (ii) laboratory reports from the Ipoh Public Health Laboratory (Makmal Kesihatan Awam Ipoh, MKAI) to determine the Leptospira serogroup based on the MAT results.

Leptospirosis is a notifiable disease in Malaysia, mandated under the Prevention and Control of Infectious Diseases Act 1988 (Act 342). Medical practitioners notified all probable and confirmed leptospirosis cases at clinics or hospitals through the e-Notifikasi system. Upon notification, the case was reviewed and verified at the district level by a trained health inspector from the District Health Office (DHO), who completed the required case details in the system, including patient demographic data, clinical symptoms, and epidemiological exposure history. The health inspector investigated the notification via hospital visits for inpatients and phone calls or home visits to those treated as outpatient cases.

The district epidemiologist reviewed the data before submission to the JKNP, where they are centrally managed and monitored by the Communicable Disease Control Unit (CDC Unit) to ensure accuracy, completeness, and timely reporting. Laboratory data, which included Leptospira serogroup identification through MAT, were recorded by MKAI-trained laboratory personnel. All procedures were conducted based on the Standard Operating Procedures (SOP) outlined in the Guidelines for the Diagnosis, Management and Prevention of Leptospirosis by the Ministry of Health Malaysia (2011).

Study Population and Sampling

The study population comprised all registered leptospirosis cases in the state of Perak, including both confirmed and probable cases. In this study, a probable leptospirosis case is defined as a patient who presents with clinical features consistent with leptospirosis and a positive rapid test or ELISA (IgM serology) for *Leptospira*. A confirmed case is defined as an individual with a Microscopic Agglutination Test (MAT) titre ≥1:400 based on a single serum sample. Cases were included if the patients resided in Perak during the notification period. To ensure the accuracy and completeness of the data, subjects with incomplete laboratory diagnosis results for Leptospirosis (IgM serology and MAT), those with co-infections, and those transferred in from another state during the notification period were excluded from the study.
The sample size for this study was calculated using OpenEpi software version 3.01. The percentage of unexposed

Table I: Sociodemographic Characteristics of Leptospirosis Cases in Perak for Year 2024 (n=764)

Variables	Total (N=764) Mean (SD) / n (%)	Leptospirosis Cases		p-value
		Outpatient (n=187)	Inpatient (n=577)	
		n (%) Mean (SD)	n (%) Mean (SD)	
Sociodemographic				
Age (years)	32.0 (20.50)	31.0 (13.90)	32.0 (22.30)	0.638[a]
Gender				
Female	246 (32.2)	60 (32.1)	186 (32.2)	0.970[b]
Male	518 (67.8)	127 (67.9)	391 (67.8)	
Ethnicity				
Malay	545 (71.3)	132 (70.6)	413 (71.6)	0.298[b]
Chinese	35 (4.6)	5 (2.7)	30 (5.2)	
Indian	53 (6.9)	17 (9.1)	36 (6.2)	
Others	131 (17.1)	33 (17.6)	98 (17.0)	
Nationality				
Malaysian	726 (95.0)	174 (93.0)	552 (95.7)	0.152[b]
Non-Malaysian	38 (5.0)	13 (7.0)	25 (4.3)	
District				
Bagan Datuk	7 (0.9)	1 (0.5)	6 (1.0)	
Batang Padang	65 (8.5)	18 (9.6)	47 (8.1)	
Hilir Perak	14 (1.8)	1 (0.5)	13 (2.3)	
Hulu Perak	88 (11.5)	21 (11.2)	67 (11.6)	
Kampar	28 (3.7)	4 (2.1)	24 (4.2)	
Kerian	17 (2.2)	1 (0.5)	16 (2.8)	
Kinta	232 (30.4)	78 (41.7)	154 (26.7)	
Kuala Kangsar	146 (19.1)	27 (14.4)	119 (20.6)	
Larut, Matang, Selama	122 (16.0)	24 (12.8)	98 (17.0)	
Manjung	20 (2.6)	6 (3.2)	14 (2.4)	
Mualim	6 (0.8)	1 (0.5)	5 (0.9)	
Perak Tengah	19 (2.5)	5 (2.7)	14 (2.4)	

Notes: [a]Independent t-test/ [b]Pearson Chi-square/ [c]Others:Indigeneous group from Penisular and East Malaysia, and non-Malaysian; *level of significance set at 0.05

individuals with outcome was based on Sokolova, Marshall & Benschop (2021), who discovered that the prevalence of outpatient leptospirosis cases is 47%. The odds ratio for the risk factors associated with recreational activity was 2.36. By setting alpha at 0.05 and achieving a power of 80%, the minimum sample size required was 180. However, present analysis included all eligible cases to ensure good representativeness and high external validity.

Study Variables

A total of twenty-five variables were extracted from these two data sources (twenty-four variables from e-Notifikasi and one from the MKAI laboratory reports for analysis. The outcome variable was the hospitalisation status of leptospirosis cases, categorised as either outpatient or inpatient. The decision to admit relied on the clinical manifestations and their severity, as determined by the treating team.

The independent variables were selected based on relevance in previous studies and availability in the e-Notifikasi database system. The variables were classified into three domains, they were (i) socio-demographic (age, gender, ethnicity, nationality, and district of residency), (ii) clinical, and (iii) environmental factors. For clinical domain, eleven variables were included seven self-reported symptoms of leptospirosis such as fever, upper respiratory tract infection (cough, sore throat, flu), gastrointestinal symptoms (abdominal pain, vomiting, diarrhea), headache, myalgia; duration between symptom onset to diagnosis by medical doctor (days); MAT titre value (<1:400 or ≥1:400); number of serovar detected by each case (one or more than one type); and presence of leptospirosis complication e.g., sepsis/septic shock, meningitis, pulmonary haemorrhage, Weil's Syndrome and multi-organ failure.[6] For environmental domain, five variables related to patients' environmental exposure within 21 days before symptoms were included, they were: (i) job exposure (e.g., agriculture, student, military personnel, pensioner, others); (ii) animal exposure such as rodents, livestock, cats, dogs; (iii) history of flooding/exposure to flood water; (iv) history of recreational water activity; and (v) history of direct contact with soil such as gardening, landscaping, farming.

Data Management

Figure 1 illustrates the process of data extraction and management for this study. JKNP downloaded the data into Microsoft Excel Open XML Spreadsheet (.xlsx) format, and all personal identifiers were removed before release to the researcher to maintain participants' confidentiality. Data cleaning was performed using the final dataset (n=780). After applying the inclusion and exclusion criteria, 764 (98%) eligible cases were retained for final analysis. The final dataset (n=764) was then imported into Statistical Package for the Social Sciences (SPSS), version 29.0, to screen for missing data and perform statistical analysis. No missing data was found in this study. To maintain confidentiality and secure the data, all anonymous data was stored in a password-protected folder, accessible only to members of the research team.

Table II: Clinical and Environmental Characteristics of Leptospirosis Cases in Perak for Year 2024 (n=764)

Variables	Total (N=764) Mean (SD) / n (%)	Leptospirosis Cases Status		p-value
		Outpatient (n=187) n (%) / Mean (SD)	Inpatient (n=577) n (%) / Mean (SD)	
CLINICAL FACTORS				
Fever				
No	25 (3.3)	10 (5.3)	15 (2.6)	0.066[b]
Yes	739 (96.7)	177 (94.7)	562 (97.4)	
URTI				
No	623 (81.5)	134 (71.7)	489 (84.7)	< 0.001[b]
Yes	141 (18.5)	53 (28.3)	88 (15.3)	
Gastrointestinal Symptoms				
i) Abdominal Pain				
No	629 (82.3)	177 (94.7)	452 (78.3)	<0.001[b]
Yes	135 (17.7)	10 (5.3)	125 (17.7)	
ii) Vomiting				
No	371 (48.6)	153 (81.8)	218 (37.8)	<0.001[b]
Yes	393 (51.4)	34 (18.2)	359 (62.2)	
iii) Diarrhea				
No	480 (62.8)	159 (85.0)	321 (55.6)	<0.001[b]
Yes	284 (37.2)	28 (15.0)	256 (44.4)	
Headache				
No	477 (62.4)	139 (74.3)	338 (58.6)	<0.001[b]
Yes	287 (37.6)	48 (25.7)	239 (41.4)	
Myalgia				
No	463 (60.6)	121 (64.7)	342 (59.3)	0.186[b]
Yes	301 (39.4)	66 (35.3)	235 (40.7)	
Presence of complication				
No	707 (92.5)	185 (98.9)	522 (90.5)	<0.001[b]
Yes	57 (7.5)	2 (1.1)	55 (9.5)	
Onset-to-Diagnosis (Days)	4.0 (3.12)	3.0 (1.65)	5.0 (3.34)	<0.001[a]
MAT titre level				
<1:400	475 (62.2)	136 (72.7)	339 (58.8)	<0.001[b]
≥1:400	289 (37.8)	51 (27.3)	238 (41.2)	
Total Number of Serovar				
1	168 (22)	41 (21.9)	127 (22.0)	0.980[b]
>1	596 (78)	146 (78.1)	450 (78.0)	
ENVIRONMENTAL FACTORS				
Animal Exposure				
No	360 (47.1)	54 (28.9)	306 (53.0)	<0.001[b]
Yes	404 (52.9)	133 (71.1)	271 (47.0)	
Flood Exposure				
No	757 (99.1)	187 (100.0)	570 (98.8)	0.284[c]
Yes	7 (0.9)	0 (0.0)	7 (1.2)	
History of Recreational Activity				
No	443 (58.0)	146 (78.1)	297 (51.5)	<0.001[b]
Yes	321 (42.0)	41 (21.9)	280 (48.5)	
Soil Exposure				
No	687 (89.9)	176 (94.1)	511 (88.6)	0.028[b]
Yes	77 (10.1)	11 (5.9)	66 (11.4)	
Occupation				
Others[d]	199 (26.0)	83 (44.4)	116 (20.1)	<0.001[b]
Agriculture	85 (11.1)	12 (6.4)	73 (12.7)	
Military Personnel	14 (1.8)	4 (2.1)	10 (1.7)	
Student	230 (30.1)	43 (23.0)	187 (32.4)	
Sewage worker	12 (1.6)	6 (3.2)	6 (1.0)	
Pensioners	224 (29.3)	39 (20.9)	185 (32.1)	

Notes: URTI= Upper Respiratory Tract Infection; MAT= Microscopic Agglutination Test;
[a]Independent t-test/ [b]Pearson Chi-square/ [c]Continuity Correction (Yates correction)
[d]Others : occupation other than involving agriculture, military personnel, student, sewage worker, housewife and pensioner *level of significance set at 0.05

Table III: Factors associated with hospitalisation among Leptospirosis Cases in Perak using simple logistic regression (n=764)

Variables	B (SE)	Wald (df)	Crude OR (95% CI)	p-value
Age	0.002 (0.004)	0.141 (1)	1.002 (0.993, 1.010)	0.708
Gender				
Female	ref		1.000	
Male	-0.007 (0.180)	0.001 (1)	0.993 (0.698, 1.414)	0.970
Ethnicity				
Malay	ref		1.000	
Chinese	0.651 (0.493)	1.742 (1)	1.918 (0.729, 5.043)	0.187
Indian	-0.390 (0.311)	1.577 (1)	0.677 (0.368, 1.245)	0.209
Others	-0.520 (0.225)	0.054 (1)	0.949 (0.611, 1.474)	0.949
Nationality				
Malaysian	ref		1.000	
Non-Malaysian	-0.501 (0.353)	2.013 (1)	0.606 (0.304, 1.210)	0.156
Fever				
No	ref		1.000	
Yes	0.750 (0.417)	3.230 (1)	2.117 (0.934, 4.795)	0.720
URTI				
No	ref		1.000	
Yes	-0.787 (0.199)	15.605 (1)	0.455 (0.308, 0.672)	<0.001
Vomiting				
No	ref		1.000	
Yes	2.003 (0.208)	92.604 (1)	7.411 (4.928, 11.143)	<0.001
Headache				
No	ref		1.000	
Yes	0.717 (0.188)	14.605 (1)	2.048 (1.418, 2.957)	<0.001
Myalgia				
No	ref		1.000	
Yes	0.231 (0.173)	1.743 (1)	1.260 (0.894, 1.775)	0.187
Presence of Complication				
No	ref		1.000	
Yes	2.277 (0.725)	9.865 (1)	9.746 (2.354, 40.354)	0.002
Onset-to-Diagnosis (Days)	0.295 (0.044)	45.806 (1)	1.344 (1.233, 1.464)	<0.001
MAT titre level				
<1:400	ref		1.000	
≥1:400	0.627 (0.185)	11.528 (1)	1.872 (1.304, 2.689)	<0.001
Total Number of Serovar				
1	ref		1.000	
> 1	0.014 (0.204)	0.004 (1)	1.014 (0.680, 1.511)	0.947
Animal Exposure				
No	ref		1.000	
Yes	-1.023 (0.182)	31.707 (1)	0.360 (0.252, 0.513)	<0.001
History of Recreational Activity				
No	ref		1.000	
Yes	1.211 (0.195)	38.419 (1)	3.357 (2.289, 4.924)	<0.001
Soil Exposure				
No	ref		1.000	
Yes	0.726 (0.337)	4.634 (1)	2.067 (1.067, 4.002)	0.031
Occupation				
Others	ref		1.000	
Agriculture	1.471 (0.343)	18.379 (1)	4.353 (2.222, 8.527)	<0.001
Military Personnel	0.582 (0.609)	0.912 (1)	1.789 (0.542, 5.899)	0.339
Student	1.135 (0.222)	26.152 (1)	3.112 (2.014, 4.808)	<0.001
Sewage worker	-0.335 (0.595)	0.317 (1)	0.716 (0.223, 2.297)	0.574
Pensioners	1.222 (0.227)	28.877 (1)	3.394 (2.173, 5.300)	<0.001

Note: OR=Odds Ratio ; SE=standard error; df = degree of freedom; CI; Confidence interval; B=unstandardised regression weight *level of significance at 0.25

Table IV: Factors Associated with Hospitalisation among Leptospirosis Cases in Perak using multiple logistic regression (n=764)

Variables	B (SE)	Wald (df)	Adj OR(95% CI)	p-value
Clinical Factors				
Vomiting (Yes)	2.398 (0.258)	86.256 (1)	11.001 (6.632, 18.248)	<0.001
Headache (Yes)	1.491 (0.255)	34.241 (1)	4.443 (2.696, 7.322)	<0.001
Presence of Complication (Yes)	2.087 (0.836)	6.240 (1)	8.064 (1.568, 41.483)	0.012
Onset-to-Diagnosis (Days)	0.311 (0.054)	33.546 (1)	1.365 (1.229, 1.517)	<0.001
Environmental Factors (History of Exposure)				
Recreational Activity Exposure	1.227 (0.255)	23.108 (1)	3.410 (2.068, 5.624)	<0.001
Soil Exposure	0.954 (0.433)	4.854 (1)	2.596 (1.111, 6.067)	0.028
Types of Occupation				
Agriculture	1.620 (0.425)	14.534 (1)	5.055 (2.197, 11.627)	<0.001
Military Personnel	1.586 (0.768)	4.248 (1)	4.868 (1.081, 21.923)	0.039
Student	1.027 (0.290)	12.493 (1)	2.792 (1.580, 4.934)	<0.001
Pensioners	1.785 (0.301)	35.268 (1)	5.958 (3.306, 10.737)	<0.001

Note: AOR= Adjusted Odds Ratio; SE = standard error; B= unstandardised regression weight; d.f = degree of freedom; CI; Confidence interval; *level of significance at 0.05
Backward LR method was applied; No multicollinearity and no interaction; Hosmer Lemeshow test, p-value = 0.471; Area under Receiver Operating Characteristics (ROC) Curve = 0.88

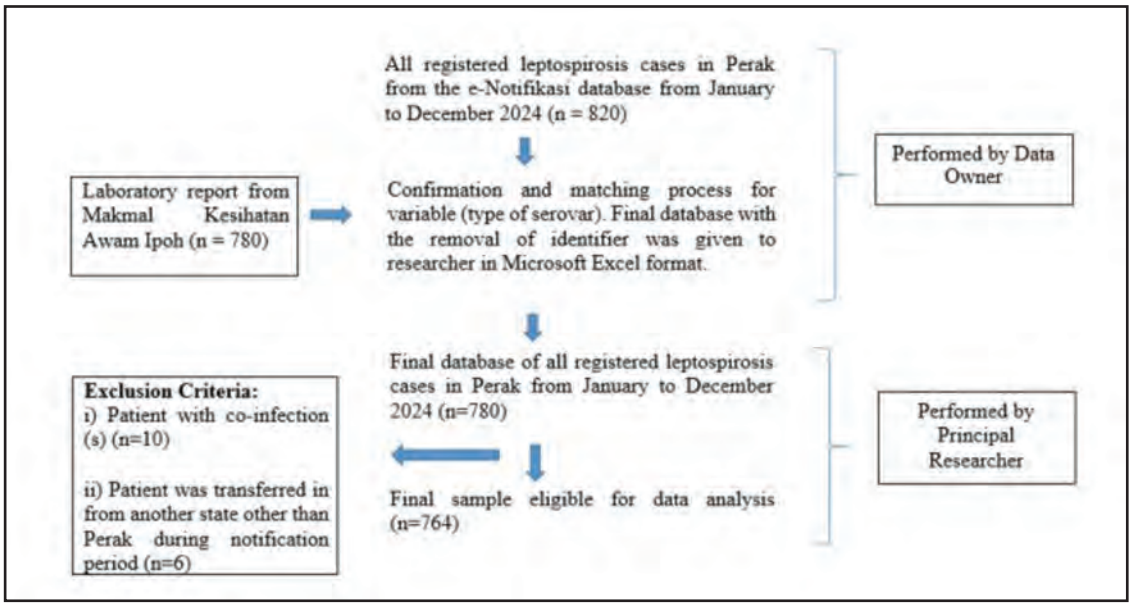

Fig. 1: Flowchart of data extraction

Statistical Analysis

All data were analysed using SPSS version 29.0. The leptospirosis hospitalisation rate was calculated by using the formula as followed:

$$\text{Hospitalisation Rate of Registred Leptospirosis Cases} = \frac{\text{Total number of registered leptospirosis cases require hospitalisation}}{\text{Total number of registered leptospirosis cases from January 2024 – December 2024}}$$

Estimation of the hospitalisation rate (95% confidence interval (CI) of the proportion interval was measured using the following formula: $95\%CI = p \pm z\ (\sqrt{(p(1-p)/n)}\ )$.

Descriptive analysis was performed to summarise the sociodemographic, clinical, and environmental characteristics of leptospirosis cases. Categorical variables were reported using frequencies and percentages, while continuous variables were summarised using mean and standard deviation (SD). A univariate analysis was conducted between in-patient and out-patient group characteristics, using the Pearson Chi-square test or continuity correction test for categorical variables and the independent t-test for continuous variables. To identify risk factors associated with hospitalisation, simple and multiple logistic regression analyses were conducted. Variables with clinical importance and a p-value less than 0.25 in simple logistic regression analysis were included in the preliminary multivariable model. The Backwards Likelihood Ratio method was used for variable selection. No interaction and

multicollinearity were observed in the final model. Model fitness was confirmed using the Hosmer–Lemeshow goodness-of-fit test, classification table and the Receiver Operating Characteristic (ROC) curve. Results were presented as crude and adjusted odds ratios (ORs) with 95% confidence intervals (CIs) and corresponding p-values.

RESULTS

A total of 764 registered leptospirosis cases were included in the study, comprising 37.8% confirmed cases and 62.2% probable cases. The majority of cases (n=577, 75.5%) required hospital admission (95% CI 72%,79%). Among confirmed cases, 82.3% (n=238) required hospitalisation, while 71.0% (n=339) of probable cases were also hospitalised.

The mean (SD) age of cases was 32 (20.5) years, and two-thirds of them were male (67.8%). The majority of cases were Malaysians (95.0%). The highest number of cases was reported from the Kinta district (30.4%), followed by the Larut, Matang and Selama districts (16.0%). Tables I and II demonstrated the sociodemographic, clinical and environmental characteristics of leptospirosis cases, respectively. The sociodemographic characteristics were comparable between outpatient and inpatient cases, with no statistically significant difference in their distributions.

To investigate the association between sociodemographic factors, clinical presentations and environmental exposures with hospitalisation status, simple logistic regression analysis was conducted, in which 13 out of 24 variables were statistically significant at $p<0.25$, including ethnicity, nationality, vomiting, headache, presence of complications, timing of diagnosis, MAT titre level, history of animal exposure, recreational activity, soil exposure and occupation (Table III). These variables were subsequently included in the multivariable binary logistic regression model. Seven significant risk factors associated with hospitalisation among leptospirosis cases were identified (Table IV). These included: presence of complications (aOR: 8.06, 95% CI: 1.57,41.48), vomiting (aOR: 11.00, 95% CI: 6.63,18.25), headache (aOR: 4.44, 95% CI: 2.70,7.32), onset-to-diagnosis (aOR: 1.37, 95% CI: 1.23,1.52), histories of recreational activity exposure (aOR: 3.41, 95% CI: 2.07,5.62), soil exposure (aOR: 2.60, 95% CI: 1.11,6.07) and types of occupation; student (aOR: 2.79, 95% CI: 1.58,4.93), agriculture (aOR: 5.06, 95% CI: 2.20,11.63), military personnel (aOR: 4.87, 95% CI: 1.08,21.92) and pensioners (aOR: 5.96, 95% CI: 3.31,10.74).

DISCUSSION

By analysing Leptospirosis cases notified to JKNP in 2024, this study aimed to investigate the hospitalisation rate among leptospirosis cases, the characteristics of leptospirosis cases overall and based on hospitalisation status, and to determine the risk factors associated with hospitalisation. Analysis revealed three main findings, they were (i) the hospitalisation rate was reported 75.5% (95% CI: 72%, 79%) among registered leptospirosis cases; (ii) leptospirosis cases involved young age group (in their thirties on average), mostly male and majority were from the Kinta district, and (iii) seven risk factors associated with hospitalisation included presence of vomiting, headache, leptospirosis complication, longer onset-to-diagnosis duration, presence of recreational activity and soil exposure, and occupation.

The hospitalisation rate revealed in the present study was similar to that in the Netherlands (74.4%) and New Zealand (53.0%), where the same inclusion criteria were used to recruit leptospirosis cases as in the present study.[11,14] Conversely, the United States reported a lower rate of 0.6 hospitalisations per 1,000,000 population annually.[13] This lower rate could be attributed to differences in case definition and surveillance system. In that study, hospitalised leptospirosis cases were included based on hospital discharge data where diagnosis was made by a physician using an ICD-Code without requiring laboratory confirmation as well as leptospirosis was not nationally notifiable until 2012. This led to underreporting and underestimation of hospitalised cases.[21]

It was demonstrated that the mean (SD) age of leptospirosis cases in Perak was 32 (20.5) years, with the majority of cases affecting the male population. This finding was in line with previous studies, where Malaysians aged 30-39 years and Thai young adults aged 15-34 years have been identified as the most affected group, attributed to greater exposure to environmental and occupational risk factors.[22-23] Apart from that, males had a higher risk of contracting leptospirosis due to behavioural factors, such as lower adherence to personal protective measures and increased outdoor activity, thereby increasing their susceptibility to infection.[24] Moreover, another study reported that post-pubertal males had a much greater incidence of leptospirosis, most likely due to a combination of increased environmental exposure and a weakened immune system impacted by testosterone.[25]

The Kinta district reported the highest proportion of leptospirosis cases, at 30.4%. This could be attributed to being the most populous district in Perak with an estimated population of 908,900 in 2023, accounting for approximately 35.8% of the state's total population of 2.54 million.[10] The high population density, especially in urban areas, increases the risk of exposure to contaminated environments, particularly in urban settings.26 Furthermore, the majority of the population in Kinta belongs to the working-age group (15-64), with 22% (140,000) ranging from 30 to 39 years old.[10] They are typically more engaged in occupational or outdoor activities that increase the risk of leptospirosis. These findings highlight the Kinta district as a hotspot area for Leptospirosis transmission in Perak, emphasising the need for local authorities to focus on strategic preventive public health measures and enhance disease surveillance in this district.

Furthermore, it was found that the sociodemographic characteristics were comparable between outpatient and inpatient leptospirosis cases. Clinical factors and environmental exposures were the important risk factors associated with leptospirosis cases in Perak. Leptospirosis cases that presented with vomiting, headache, and complications (such as meningitis, organ failure, and sepsis) had higher odds of getting hospitalised. Vomiting and headache may be warning signs of leptospirosis, requiring close observation to prevent further deterioration. These

symptoms were reported to be the most common clinical manifestations among hospitalised leptospirosis cases in previous studies.[27-31]

Vomiting may reflect hepatic involvement or electrolyte disturbances or early sepsis, and headache may reflect early neurological involvement or meningitis. To avoid serious complications such as seizure, altered mental status and intracranial hypertension, which have been reported in complicated cases, attending doctors should be vigilant in recognising this cardinal symptom.[32]

Leptospirosis cases presented with a longer onset-to-diagnosis duration had higher odds of hospitalisation, which was consistent with a study conducted in New Caledonia.[17] Pathogenetically, a late diagnosis would prolong the duration of bacterial replication and vascular damage, allowing the infection to shift from the leptospiremic to the immune phase, where complications are more likely to occur.[33] The patient and the healthcare provider can cause these delays. Leptospirosis cases might misinterpret the early symptoms of leptospirosis as mild or work-related fatigue, especially those working in high-risk jobs such as agriculture, which is linked to our finding that agriculture is a significant factor related to hospitalisation.[34] Apart from that, non-specific early symptoms of leptospirosis can mirror common viral infections, leading to under-recognition or misdiagnosis by primary healthcare providers.[35] Therefore, enhancing public awareness and provider training are important in reducing diagnosis delay to prevent hospitalisation that could jeopardise job productivity.

On top of that, environmental exposures, particularly those engaged in recreational activities or exposure to soil, were significantly linked to a higher risk of hospitalisation. The demographics of affected cases may explain this. Firstly, the majority reside in the Kinta district, which is known for its accessible rivers and recreational forests, and many of these sites are located near leptospira-contaminated water sources.[9] Secondly, young males, being the highly affected population, were more likely to engage in outdoor activities such as hiking, camping or swimming.[11,36] Additionally, farmers and students were at a higher risk of hospitalisation, possibly attributed to their relatively lower socio-economic status and/or lower health literacy, as highlighted in previous studies.[14,37] Farmers are often exposed to contaminated soil and infected animal urine during agricultural work or paddy field activities.[38] Similarly, students may engage in outdoor activities such as swimming or community clean-up events without adequate protective measures due to lack of awareness.[37] Consequently, prolonged exposure to contaminated water or soil, whether through recreational or job-related activities, may increase the risk of more severe disease manifestations, necessitating hospital admission.[39]

These findings offer several actionable insights and public health implications. While factors such as age and gender are non-modifiable, other factors, including the timing of diagnosis, occupational, recreational, and soil exposure, as well as clinical symptom recognition, can be addressed through targeted interventions. Delayed diagnosis and limited health literacy, particularly among students and farmers, underscore the need to strengthen health education campaigns on leptospirosis in the community, as well as among recreational centre owners/operators and local authorities, and to enhance clinical vigilance in healthcare settings.[40] Future behavioural studies are highly recommended to explore the public risk perception and preventive practices related to leptospirosis among the high-risk groups.

Overall, several strengths were demonstrated in the present study. Firstly, the inclusion of all serology-positive leptospirosis cases, regardless of MAT titre (including probable and confirmed cases), reflects the real-world clinical spectrum of leptospirosis, allowing for a broader representation of cases and reflect the overall burden of the disease. Secondly, data was primarily collected and verified in the national e-Notifikasi system by trained and experienced health inspectors working in the communicable disease unit. One-to-one interviews conducted through hospital visits or home interviews during the case investigation reduced the risk of information bias, particularly in documenting exposures and clinical presentations. Lastly, retrospective cohort study improves the ability to examine possible causal relationship between exposures and hospitalisation using available surveillance data.

Nevertheless, individual health literacy levels, comorbidities, socioeconomic status, healthcare access, and meteorological indicators such as rainfall or soil humidity were not captured in this study. These unmeasured factors may significantly influence both exposure and health-seeking behaviour, potentially leading to residual confounding. Despite efforts to minimise information bias through one-to-one interviews, some exposure data were self-reported and could introduce recall bias. Furthermore, hospital admission criteria were not standardised across facilities and may have resulted in variations in hospitalisation outcomes. Nonetheless, the findings still offer a better understanding of hospitalisation trends observed in routine clinical practice.

CONCLUSION

In conclusion, three in four leptospirosis cases were hospitalised. Leptospirosis primarily affected males, particularly those in their thirties, who resided in the Kinta district. Risk factors associated with hospitalisation included clinical factors (presence of vomiting, headache, and leptospirosis complication, as well as longer onset-to-diagnosis duration) and environmental factors (history of recreational activity or soil exposure within the past 21 days preceding the onset). Targeted leptospirosis awareness campaigns, particularly among recreational site operators and frequent visitors, should be prioritised to improve awareness and promote protective behaviours. As leptospirosis continues to pose a significant health threat in Malaysia, a multi-agency collaboration shall be strengthened to employ the One Health approach for prevention and control efforts.

ETHICAL APPROVAL

This study was conducted according to the guidelines of the Declaration of Helsinki and approved by two Institutional Review Boards. Ethical clearance was obtained from:
i) Research Ethics Committee (REC), UiTM (FERC-EX-25-04), and ii) Medical Research Ethics Committee (MREC), Ministry of Health Malaysia (NMRR ID-25-01199-484).

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