AMERICAN ACADEMIC PUBLISHER

INTERNATIONAL JOURNAL OF MEDICAL SCIENCES

ISSN NUMBER: 2692 - 5206 Volume 6. No 05. MAY ,2026

LEPTOSPIRA SPP.: MORPHOLOGY, DISTRIBUTION, PATHOGENESIS, AND LABORATORY DIAGNOSIS

Mirvaliyeva Nafisa
Assistant, Department of Microbiology, Virology and Immunology,
Tashkent State Medical University
Odilov Umidjon Husanovich
Student, Faculty of General Medicine No. 2, Group 213-B,
Tashkent State Medical University
Mirodilov Muhammadqodir Islomali ugli
Student, Faculty of General Medicine No. 2,
Tashkent State Medical University

Abstract: Objective: This review summarizes the morphology, structural features, epidemiology, pathogenesis, clinical manifestations, and laboratory diagnosis of Leptospira spp.

Methods: A narrative literature review was conducted using international scientific databases, including PubMed, Scopus, Web of Science, and ScienceDirect, as well as guidelines and reports from the World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC). Relevant review articles, clinical studies, and diagnostic guidelines were selected based on scientific relevance and methodological quality. [1-4]

Results: Leptospira spp. are thin, motile spirochetes that survive well in moist environments. Their spiral morphology and periplasmic flagella contribute to tissue invasion and environmental persistence. Leptospirosis is a globally distributed zoonotic infection maintained in nature by animal reservoirs, especially rodents and livestock, and transmitted to humans mainly through contact with contaminated water, soil, or animal fluids. The clinical spectrum ranges from mild self-limited febrile illness to severe multisystem disease involving the liver, kidneys, lungs, and central nervous system. Laboratory diagnosis is highly stage-dependent. Polymerase chain reaction (PCR) is most useful during the early septicemic phase, whereas serological methods, especially the microscopic agglutination test (MAT) and IgM-based assays, are more informative in the later phase. Culture and direct microscopy have limited routine diagnostic value because of slow growth and low sensitivity. [5-11]

Conclusion: Accurate diagnosis of leptospirosis requires an integrated approach combining clinical suspicion, epidemiological history, and stage-appropriate laboratory testing. Early recognition and timely treatment are essential to reduce complications and improve clinical outcomes. [1,5,9-11]

Keywords: Leptospira; leptospirosis; spirochetes; zoonotic infection; pathogenesis; epidemiology; laboratory diagnosis; PCR; serology

Introduction

Leptospirosis is a widespread zoonotic infection of major epidemiological importance. Its causative agents, Leptospira spp., belong to the spirochete group and are characterized by a thin spiral morphology, active motility, and the ability to survive in moist environments. These biological features play a crucial role in environmental persistence, waterborne transmission, and infection in both humans and animals. [5,6,7]

AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES
ISSN NUMBER: 2692 - 5206 Volume 6. No 05. MAY ,2026

The main reservoirs of infection are infected or carrier animals, particularly rodents, cattle, and other mammals, which excrete leptospires in their urine. Humans are usually infected through contact with contaminated water, wet soil, or objects polluted with animal urine. Entry into the body occurs through small breaks in the skin or mucous membranes, including the eyes, nose, and mouth. According to CDC data, leptospires may persist for weeks or even months in contaminated water or soil under favorable environmental conditions. [1,2,3,5]

The clinical relevance of leptospirosis lies in its broad spectrum, ranging from mild or subclinical disease to severe forms with liver, kidney, lung, and central nervous system involvement. The pathogenesis involves hematogenous spread, adhesion to host tissues, endothelial injury, and strong inflammatory responses. Because the early clinical manifestations are nonspecific and resemble many other infections, laboratory diagnosis is essential for timely recognition and treatment. [3,4,6,10]

The aim of this article is to provide a systematic literature-based review of the biological characteristics of Leptospira spp., the diseases they cause, and modern approaches to laboratory diagnosis.

Materials and Methods

This article was prepared as a narrative review with comparative analysis. Scientific literature on the morphology, structure, distribution, pathogenesis, clinical manifestations, and laboratory diagnosis of Leptospira spp. was selected from international databases and authoritative sources. [1-4]

The literature search was performed in PubMed, Scopus, Web of Science, ScienceDirect, and other reliable databases. The following keywords were used: “Leptospira,” “leptospirosis,” “spirochetes,” “pathogenesis,” “epidemiology,” “laboratory diagnosis,” “PCR,” “serology,” and “culture.”

Priority was given to publications from the last 5–10 years, while classical and foundational references on leptospirosis were also included when necessary. Articles were selected based on their direct relevance to the topic, scientific reliability, methodological quality, and practical value for laboratory diagnosis and clinical interpretation. [5-11]

The collected information was organized into thematic categories covering morphological and structural features, transmission and reservoir hosts, pathogenic mechanisms, clinical manifestations, and laboratory methods. The data were then synthesized through logical and comparative analysis. Accordingly, this paper should be interpreted as an evidence-based literature review rather than an original experimental study.

Results

1. Morphology and Structure of Leptospira spp.

Leptospira spp. are thin, spiral-shaped, aerobic spirochetes measuring approximately 0.1 µm in diameter and 5–25 µm in length. Pathogenic species such as L. interrogans are of major clinical importance. Their motility is provided by periplasmic flagella, which facilitate movement in aqueous environments and host tissues. [5,6,7,8]

Pathogenic leptospires are classified into more than 25 serogroups and over 300 serovars, reflecting their epidemiological and laboratory diversity. Structurally, Leptospira spp. have a double-membrane envelope similar to Gram-negative bacteria; however, their cell wall architecture and surface proteins have distinct characteristics. The spiral shape and endoflagella

ISSN NUMBER: 2692 - 5206 Volume 6. No 05. MAY ,2026

are important virulence-related features that support tissue penetration and dissemination within the host. [5,6,8]

2. Distribution, Reservoirs, and Routes of Transmission

Leptospirosis is a worldwide zoonotic disease, with a higher incidence in tropical and humid regions. Pathogenic leptospires can persist asymptomatically in the renal tubules of animals and are excreted into the environment through urine. Rodents, cattle, small mammals, and other vertebrates are considered important reservoirs. Contaminated water and moist soil serve as major sources of infection. [5-8]

Transmission to humans usually occurs through contact with contaminated water, soil, or animal secretions. Leptospires enter the body through minor cuts, abrasions, or mucosal surfaces such as the mouth, nose, and eyes. Person-to-person transmission is extremely rare. Occupational risk is higher among agricultural workers, veterinarians, sewage workers, and individuals frequently exposed to water or wet environments. [1,3,5,6]

The ability of leptospires to survive for weeks, and sometimes longer, in moist environments gives them an ecological advantage. Therefore, the spread of leptospirosis strongly depends on climate, sanitation, water conditions, and the degree of human contact with animals. [1,5,6,7]

3. Pathogenesis and Clinical Significance

The pathogenesis of leptospirosis is typically described as having two clinical phases: a septicemic phase and an immune phase. In the first phase, leptospires spread hematogenously and circulate in the blood. Later, the host immune response produces antibodies, and the organisms begin to be excreted in urine. Severe disease is associated with inflammatory mediator release, increased capillary permeability, and endothelial damage. [5,6,7,10]

Clinically, leptospirosis commonly presents with fever, headache, myalgia, especially calf muscle pain, conjunctival suffusion, nausea, vomiting, diarrhea, and abdominal pain. According to CDC data, approximately 90% of infections may be mild or self-limited, while severe disease develops in about 5–10% of patients. [3,10]

In severe cases, leptospirosis may manifest as Weil's syndrome, with jaundice, hepatic dysfunction, renal injury, bleeding, aseptic meningitis, respiratory failure, and hemodynamic instability. This confirms that leptospirosis is not merely a febrile illness but a potentially life-threatening multisystem infection. [3,4,10]

At the pathogenic level, surface proteins, tissue adhesion, immune evasion, cytokine dysregulation, and microvascular injury are central to disease development. [6,7]

4. Diseases Caused by Leptospira

In humans, Leptospira spp. primarily cause leptospirosis. The incubation period is usually 2–30 days, most commonly 5–14 days. In many patients the infection is mild or subclinical, but a minority develop severe disease with multiorgan involvement. [3,4,10]

Clinically, leptospirosis may be grouped into three broad forms: mild febrile disease, moderate icteric disease, and severe disease with organ failure. Severe forms may include pulmonary hemorrhage, acute kidney injury, and hemorrhagic complications. For this reason, leptospirosis should be regarded as an infection that may require intensive care and close laboratory monitoring. [3,4,10]

5. Laboratory Diagnosis

ISSN NUMBER: 2692 - 5206 Volume 6. No 05. MAY ,2026

The choice of laboratory test in leptospirosis depends strongly on the stage of disease. According to CDC and WHO recommendations, blood, serum, and urine samples should be collected when possible, and paired acute and convalescent sera are preferred for serological confirmation. [1,2,3,9,11]

During the early phase, PCR is especially useful. It can detect leptospiral DNA in whole blood during the first week of illness and later in urine. In suspected meningitis, PCR may also be helpful in cerebrospinal fluid. Among serological methods, the microscopic agglutination test (MAT) is considered the reference standard and is often used as a confirmatory test. [9,11]

IgM-based serological tests are commonly used for screening, but positive results should ideally be confirmed by MAT. Serological sensitivity increases during the second week of illness, so relying only on serology in the early phase may be insufficient. Culture remains important in principle, but it is slow, technically demanding, and has low sensitivity. [9,11]

Dark-field microscopy and phase-contrast microscopy may demonstrate leptospires, but these methods have limited routine clinical value and are mainly used for presumptive assessment. [1,9]

Table 1. Stage-Dependent Laboratory Diagnosis of Leptospirosis [1,9,11]

Disease stage	Preferred specimen	Most useful method	Comment
First week, septicemic phase	Whole blood, sometimes CSF	PCR	Useful for rapid early diagnosis
After the second week	Serum, urine	MAT, IgM serology, PCR	Antibody level increases; urinary shedding becomes more prominent
Convalescent phase	Paired serum samples	MAT	A fourfold or greater rise in titer is confirmatory [1,9,11]

Note: This table summarizes stage-dependent diagnostic approaches based on WHO, CDC, and diagnostic review data [1,3,9,11].

Note: The diagnostic algorithm reflects a stage-based approach supported by WHO, CDC, and review literature [1,3,9,11].

Figure 1. Practical Diagnostic Algorithm for Leptospirosis [1,9,11]

Discussion

Diseases caused by Leptospira spp., especially leptospirosis, occupy an important place in clinical microbiology and infectious disease practice. Their significance is explained by the broad clinical spectrum, strong dependence on environmental factors, and the risk of severe complications if diagnosis is delayed. [3,5,10]

The biological features of Leptospira directly influence epidemiology and diagnosis. Their spiral shape and endoflagella enhance motility and facilitate invasion of host tissues. Their ability to survive in warm, moist environments creates natural reservoirs of infection. Therefore, the spread of leptospirosis is closely associated with climate, sanitation, water exposure, and contact with animals. [5-8]

From a pathogenic perspective, after entering the body, leptospires rapidly disseminate through the bloodstream and may damage multiple organs. Adhesins, interactions with the extracellular matrix, complement evasion, and proteolytic disruption of cell junctions are important mechanisms in host invasion. [6,7]

In terms of laboratory diagnosis, a stage-based strategy is the most appropriate. In the first phase, PCR is especially valuable, while in later stages serological methods, particularly IgM-based assays and MAT, become more informative. This clearly shows that laboratory findings depend on the timing of specimen collection relative to the course of disease. [1,9,11]

Culture and microscopy may assist diagnosis, but their practical value is limited. Culture is slow and technically difficult, which can delay clinical decision-making. Microscopy is rapid but insufficiently sensitive. Therefore, in modern practice, PCR and serological tests remain the cornerstone of laboratory diagnosis. [1,9]

Another important issue is differential diagnosis. Leptospirosis may resemble viral infections, malaria, dengue, viral hepatitis, sepsis, and other febrile syndromes. This is especially challenging in settings with limited laboratory capacity. Therefore, in patients with relevant risk factors, early testing for leptospirosis is strongly recommended. [3,4,10]

The practical value of this article lies in its integrated view of Leptospira spp. from morphological, epidemiological, pathogenic, and laboratory perspectives. Such a comprehensive approach is useful for microbiologists, infectious disease specialists, laboratory professionals, and clinicians. Effective management of leptospirosis requires not only diagnosis, but also early suspicion, correct specimen collection, selection of the appropriate laboratory method, and timely clinical decisions.

Conclusion

Leptospira spp. are clinically and epidemiologically important spirochetes characterized by thin spiral morphology, active motility, the ability to survive in moist environments, and a strong association with animal reservoirs. These properties support the wide dissemination of leptospirosis. [5,6,7,8]

The pathogenesis of the disease involves hematogenous spread, adhesion to endothelium and tissues, inflammatory responses, and multiorgan injury. Clinically, leptospirosis may range from mild febrile illness to severe disease involving the liver, kidneys, lungs, and central nervous system. This makes early recognition and accurate assessment essential. [6,7,10]

For laboratory diagnosis, stage-appropriate testing is crucial. PCR is most useful in the early phase, whereas serological methods, especially MAT and IgM-based assays, are more informative later. Culture and microscopy may support diagnosis, but their limitations must be recognized. Therefore, leptospirosis should be diagnosed by combining clinical findings, epidemiological history, and laboratory results. [1,9,11]

Overall, a deep understanding of Leptospira spp. is essential for early diagnosis, differential interpretation, and timely treatment of leptospirosis. This topic remains highly relevant in microbiology, virology, and immunology. [1,5,9,10]

References

1. World Health Organization. Human leptospirosis: guidance for diagnosis, surveillance and control. Geneva: WHO; 2003.

2. World Health Organization. Leptospirosis outbreak toolbox. Geneva: WHO; 2022.

3. Centers for Disease Control and Prevention. Clinical Overview of Leptospirosis. CDC; 2026.

4. Centers for Disease Control and Prevention. Leptospirosis. CDC Yellow Book 2025. 2025.

5. Haake DA, Levett PN. Leptospirosis in humans. Curr Top Microbiol Immunol. 2015;387:65-97. doi:10.1007/978-3-662-45059-8_5.

6. Samrot AV, Sean TC, Bhavya KS, Sahithya CS, Chandrasekaran S, Palanisamy R, Robinson ER, Subbiah SK, Mok PL. Leptospiral Infection, Pathogenesis and Its Diagnosis—A Review. Pathogens. 2021;10(2):145. doi:10.3390/pathogens10020145.

7. Daroz BB, Fernandes LGV, Cavenague MF, Kochi LT, Passalia FJ, Takahashi MB, Nascimento Filho EG, Teixeira AF, Nascimento ALTO. A Review on Host–Leptospira Interactions: What We Know and Future Expectations. Front Cell Infect Microbiol. 2021;11:777709. doi:10.3389/fcimb.2021.777709.

8. Bilung LM, Tahar AS, Pui CF, Bakeri MKS, Su'ut L, Ngui R, Kira R, Apun K. Leptospira and Leptospirosis: A Review of Species Classifications, Genomes, Morphological Structures, Antimicrobial Resistances, Transmissions, and Clinical Manifestations. Curr Microbiol. 2026;83(2):122. doi:10.1007/s00284-026-04722-7.

9. Waggoner JJ, Pinsky BA. Molecular diagnostics for human leptospirosis. Curr Opin Infect Dis. 2016;29(5):440-445. doi:10.1097/QCO.0000000000000295.

10. Rajapakse S. Leptospirosis: clinical aspects. Clin Med (Lond). 2022;22(1):14-17. doi:10.7861/clinmed.2021-0784.

11. Rodríguez-Rodriguez VC, Castro AM, Soto-Florez R, Urango-Gallego L, Calderón-Rangel A, Agudelo-Flórez P, Monroy FP. Evaluation of Serological Tests for Different Disease Stages of Leptospirosis Infection in Humans. Trop Med Infect Dis. 2024;9(11):283. doi:10.3390/tropicalmed9110283.