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Leptospirosis in Mumbai Monsoon: Diagnosis, Risk Factors, and Public-Health Burden- A Systematic Review.

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ABSTRACT

In India, leptospirosis has emerged as a pressing public health issue, particularly in Mumbai, where cases surge predictably with the arrival of the monsoon season. Local hospitals have recorded infection rates reaching 15.75%. The condition is caused by Leptospira bacteria, and patterns in its transmission show clear demographic tendencies, roughly two out of every three patients are men, with the most affected group being adults between 20 and 35. Infection usually occurs after contact with contaminated water, soil, or animal waste, and in urban areas, overcrowding and inadequate sanitation create ideal conditions for outbreaks. Rainfall intensity plays a key role: a light shower increases risk by 30%, while heavy downpours can raise it more than thirteen times. The illness typically unfolds in two stages, presenting either as a mild infection or advancing toa more dangerous form called Weil's disease, characterized by jaundice, renal failure, and internal bleeding. Fatality rates for this severe stage vary widely, from 5% to as high as 40%. Diagnosis depends on multiple approaches, with Microscopic Agglutination Testing considered the most reliable, though it only confirms about two-thirds of cases. IgM ELISA tests prove more effective in early detection, identifying nearly 80% of infections, while PCR assays targeting the lipL32 gene can achieve 100% accuracy within the first four days of symptoms. Globally, leptospirosis claims close to 59, 000 lives annually, yet India's reported figures remain significantly lower, under 10, 000 cases, despite estimates indicating up to a million infections occur each year. Getting ready before the monsoon starts, by controlling rat populations, running community education programs, and stepping in early with antibiotics when symptoms first show up, can actually help. A stronger surveillance system that pulls together data from human, animal, and environmental health sources, plus better access to dependable diagnostics in under-resourced areas, could do a lot to shield the people most vulnerable.
Keywords: Leptospirosis; India; Mumbai; Seasonality; Disease Transmission, Infectious; Weil Disease; Public Health Surveillance.

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Epidemiology and Seasonal Patterns

Overview of Leptospirosis in India and Mumbai

Leptospirosis has become a major public health concern in India, with urban and rural areas showing different trends (Kembhavi et al., 2021). In Mumbai, the disease keeps coming back, particularly when the monsoon season begins. Hospital studies reveal that around 15.75% of patients in large medical centers test positive for it (Thalva & Desamani, 2017). The cause is a spiral-shaped bacterium from the Leptospira genus, which infects people when they touch water, soil, or surfaces contaminated by urine from infected animals, rats are the most common carriers (Choudhary et al., 2023). Mumbai's climate, with its warmth and heavy monsoon rains, creates ideal conditions for the bacteria to multiply and spread, leading to a surge in cases between August and October (Ananthi et al., 2013).

The data from Mumbai paints a clear picture of who gets sick. Among 307 confirmed cases, 62.4% were men and 37.6% were women, with the 20- to 35-year-old age group hit hardest (37%) (Kembhavi et al., 2021). Exposure risks vary by location. In rural areas, infections often come from farming or handling livestock, while in cities, the biggest dangers are walking through floodwater, swimming in polluted water, or living in areas with poor sanitation (Kembhavi et al., 2021).

Monsoon-Driven Seasonal Dynamics

Leptospirosis tracks closely with rainfall. Urban studies show that infection risk spikes within two weeks of heavy downpours (Matsushita et al., 2018). The amount of rain matters, light rainfall (2 cm per week) increases risk by 30%, moderate rain (5 cm) by 53%, and extreme rainfall (63 cm) sends it soaring nearly 14 times higher (95% CI: 9.10, 20.82) (Matsushita et al., 2018).

In Maharashtra and other parts of India, both weather and human activity shape the spread. Factors like rainfall, temperature, and occupations such as farming, fishing, or livestock work all contribute (Antima & Banerjee, 2023). Cases typically rise during and after the monsoon, from August to February, then decline as the weather dries up. This makes sense: the bacteria survive longer in wet conditions, and flooding forces people into contact with contaminated water (Thalva & Desamani, 2017).

Underreporting and Disease Burden

Leptospirosis is far more common than official numbers indicate. Specialists estimate that India sees between 100, 000 and a million cases annually, yet reported cases never exceed 10, 000 (Thalva & Desamani, 2017). The discrepancy stems from doctors often missing the diagnosis, the disease mimicking other illnesses, and many areas lacking proper diagnostic tools, especially in poorer regions (Thalva & Desamani, 2017).

Some regions highlight just how widespread the problem is. In Palghar district, a tribal and coastal area of Maharashtra, 12.8% of people tested for suspected cases turned out positive (Mishra et al., 2024).

Pathophysiology, Transmission Routes, and Risk Factors

Disease Transmission and Environmental Factors

Leptospirosis spreads when people encounter contaminated environments, either directly or indirectly. The bacteria enter through cuts, scrapes, or mucous membranes (Udayar et al., 2023). Certain conditions and behaviors sharply increase the risk. Working in contaminated water or mud raises the odds nearly tenfold (aOR = 9.7, 95% CI: 3.3, 27.7), while living near stagnant water (aOR = 4.9, 95% CI: 1.4, 17.0) or open sewage (aOR = 4.9, 95% CI: 1.2, 19.1) also heightens vulnerability (Udayar et al., 2023). During floods, even something as basic as walking barefoot can increase risk more than ten times (OR = 10.34, 95% CI: 5.09, 21.31) (Bhardwaj et al., 2008).Rodents do more than just spread leptospirosis, they sustain the entire transmission cycle. When monsoon season arrives, their populations explode, and infection rates follow. This isn't coincidence; the conditions become ideal for the bacteria to persist in water and soil. The spike in rodent activity directly correlates with increased human exposure, particularly in regions where the disease remains endemic. During these peaks, some areas see infection rates as high as 500 cases per 100, 000 people.

Urban and Occupational Risk Factors

Occupational exposure significantly raises the risk of leptospirosis. Research in Gujarat revealed that nearly half of workers in cattle farms, poultry operations, and slaughterhouses had evidence of past infection. Poultry workers faced the highest rates, with 56.6% testing positive for antibodies, while cattle workers followed closely at 54.5%. Other contributing factors included rural residence, proximity to livestock, occupational injuries, and consumption of untreated water, all of which amplified vulnerability.

Urban areas, particularly slums, are not exempt from risk. Annual infection rates in these communities exceed 3%, with men disproportionately affected. Socioeconomic status also plays a role, as poverty and proximity to open sewage increase exposure. The burden falls heaviest on younger adults, typically between 15 and 34, and reinfection is not uncommon in this group.

Environmental Infrastructure and Socioeconomic Determinants

Living conditions and environment are just as critical as occupation in determining risk. Homes with unplastered walls or thatched roofs show infection rates two to five times higher than more structurally sound housing. Similar patterns emerge for those residing in flood-prone areas, near agricultural land, or on specific soil types. These factors collectively heighten susceptibility.

Animal contact remains the most significant risk factor. Direct exposure to rodents, livestock, or pigs substantially increases the likelihood of infection. For outdoor laborers and slaughterhouse workers, the risk becomes even more pronounced. Adjusted odds ratios confirm the elevated vulnerability of these populations.

In South India, inadequate drainage and heavy rainfall exacerbate the problem. Stagnant water accumulates, facilitating bacterial spread. However, the root issue lies in systemic deficiencies, lack of clean water, proper sanitation, and secure housing, combined with occupational hazards that perpetuate transmission cycles.

Clinical Manifestations, Disease Presentations, and Complications

Biphasic Clinical Course and Early Manifestations

Leptospirosis typically follows a two-phase progression. Initially, the bacteria disseminate through the bloodstream, followed by an immune response. Clinically, it presents in two forms: anicteric (without jaundice) and icteric (with jaundice). Fever is nearly universal among confirmed cases. Subsequent symptoms vary, with dark urine appearing in 63% of patients, vomiting in 48%, and headaches in 40%. Muscle pain is particularly common, affecting over three-quarters of some cohorts, alongside fatigue and generalized body aches.

Laboratory Findings and Biomarkers

Laboratory results provide clear diagnostic indicators. Erythrocyte sedimentation rates are universally elevated. Approximately half of patients exhibit thrombocytopenia, while two-thirds show leukocytosis, predominantly neutrophilic. Liver function abnormalities occur in 72% of cases, and renal impairment is detected in 27%. The association between thrombocytopenia and renal dysfunction is particularly strong, with over 90% of thrombocytopenic patients also demonstrating renal involvement.

Jaundice is a prominent feature, visible in the sclera of 72% of hospitalized patients and frequently accompanied by hepatomegaly. Laboratory findings typically reveal hyperbilirubinemia, with direct bilirubin predominating in severe cases. Electrolyte disturbances are also common. Hyponatremia and hypokalemia occur frequently, but in icteric cases, hypernatremia appears in nearly 75% of patients, signaling profound fluid and electrolyte imbalances.

Weil's Disease: Severe Icteric Leptospirosis

Weil's disease represents the most severe manifestation of leptospirosis, affecting roughly 10% of infected individuals and carrying significant mortality risk. The hallmark triad includes jaundice, renal failure, and hemorrhage. Complications may escalate to pulmonary involvement, severe thrombocytopenia (often below 20, 000 platelets), and acute kidney injury requiring dialysis.

The numbers tell a sobering story about leptospirosis. Take a study from Kerala, for example, nearly half the patients, 44%, didn't make it. The ones who fared worst were those struggling to breathe, producing little to no urine, or dealing with kidney damage. Shock, anemia (hemoglobin below 10 g/dL), and critically low platelet counts also marked the most severe cases (Saarkkara & Andrews, 2020). Another look at 66 patients with icterohemorrhagic leptospirosis found complications in over 40%: kidney failure in 30.3%, pneumonia in 25.8%, and pancreatitis in 4.5%. A few even faced rare but devastating issues like subarachnoid hemorrhage or gastrointestinal bleeding. The mortality rate in this group sat at 4.5% (Alian et al., 2015).

Renal Manifestations and Acute Kidney Injury

When it comes to leptospirosis, kidney injury isn't just common, it's a key player in how patients recover. The damage comes from a mix of factors: the bacteria attacking directly, inflammation kicking in, blood flow shifting unpredictably, and toxins released during the infection. Under a microscope, interstitial nephritis shows up often, while more severe cases reveal acute tubular necrosis (Daher et al., 2010).

This kind of kidney injury doesn't behave like typical acute kidney injury. Early on, patients might still produce normal amounts of urine, but potassium loss and tubular dysfunction appear before any drop in filtration rate (Daher et al., 2010). The condition revs up metabolism and often tags along with cholestatic jaundice (Visith & Kearkiat, 2006). Left untreated, about 22% of patients won't survive. But with early dialysis, careful fluid management to avoid lung complications, and proper ventilator support, those odds can improve (Daher et al., 2010).

Pulmonary and Hemorrhagic Complications

Kidney issues may dominate the conversation, but lung involvement, though less common, brings its own set of dangers. Diffuse alveolar hemorrhage and other bleeding-related lung problems have become defining features, particularly during the immune phase (Escobedo-López et al., 2026). Older studies suggested pulmonary complications only appeared in 2.56% of hospital cases, but recent data indicates they're on the rise. The shift might reflect an overactive immune response (Ananthi et al., 2013; Abdulkader et al., 2002).

The bleeding doesn't stop at the lungs. Patients might also face gastrointestinal bleeding or clotting problems tied to low platelet counts and abnormal coagulation. When the disease strikes multiple organs, especially kidneys, liver, and lungs at once, the prognosis darkens, even with intensive care (Spichler et al., 2005).

Diagnostic Approaches and Laboratory Methods

Microscopic Agglutination Test (MAT)

The microscopic agglutination test remains the gold standard for diagnosing leptospirosis, despite its flaws. When comparing blood samples taken at different points, MAT detects about 68% of cases with 75% accuracy (Valente et al., 2024). But in the early stages, it's nearly useless, only 14% sensitivity in single acute-phase samples, which means it often fails patients when they need answers most (Valente et al., 2024).

The test takes about two weeks to run and depends on live Leptospira cultures, making it both slow and impractical in resource-limited settings (Gayathri et al., 2022). Results can also vary between labs, and MAT struggles to identify the exact strain causing infection, which hampers outbreak tracking (Miller et al., 2011).

ELISA and Serological Tests

For earlier detection, IgM ELISA outperforms MAT. In the first week of illness, it catches 79.3% of cases compared to MAT's 69.0%. By the second week, both tests become nearly foolproof (Fonseca et al., 2006). That said, ELISA isn't flawless, its specificity drops to 89.1%, and it can confuse other infections like dengue with leptospirosis (Fonseca et al., 2006).

Other ELISA methods using whole leptospiral antigens perform a bit better, with 87.5% sensitivity and 84.2% specificity (Bakhshandeh et al., 2021). Rapid tests offer quicker results, though their accuracy isn't consistent. Sensitivity tends to hover around 75-78%, while specificity stays strong at 95-98% (Goris et al., 2013).

Molecular Methods: PCR and Real-Time PCR

When antibodies haven't had time to develop, molecular tests like PCR fill the gap. These methods excel in the first week of infection, picking up leptospires in the bloodstream when other tests come up empty (Fonseca et al., 2006). Real-time PCR targeting the lipL32 gene, for instance, has shown 100% sensitivity in early samples and 93% specificity (Ahmed et al., 2009).

Combining PCR with serological methods significantly improves diagnostic accuracy, particularly during the early phase of infection. Studies show this approach can push sensitivity beyond 93% (Fonseca et al., 2006). Real-time PCR targeting the lipL32 gene has proven more effective than older methods that focused on 16S rRNA, offering both faster results and better detection rates (Podgoršek et al., 2020). The difference becomes clear in clinical data, one recent study found molecular techniques identified leptospirosis in 56% of patients, while the microscopic agglutination test (MAT) alone only detected 26% (Philip et al., 2020).

LAMP and Emerging Diagnostic Tools

Loop-mediated isothermal amplification, known as LAMP, has emerged as a promising field diagnostic tool. Research indicates it can surpass both PCR and MAT in sensitivity without sacrificing accuracy (Shubham et al., 2025). What makes LAMP particularly useful is its simplicity, it doesn't require sophisticated laboratory equipment, which positions it well for point-of-care use.

Metagenomic next-generation sequencing (mNGS) has proven especially valuable in complex or atypical cases where conventional testing falls short. A striking example involved a patient with pulmonary symptoms and HIV co-infection; while standard methods yielded no diagnosis, mNGS successfully identified Leptospira interrogans (Zheng et al., 2023).

New biomarker-based approaches are also under investigation. One method showing promise detects Leptospira 3-hydroxyacyl-CoA dehydrogenase (3-HADH) in urine via ELISA, achieving 83.33% sensitivity and specificity for early screening (Karunadasa et al., 2024).

Diagnosis in Resource-Limited Settings

In resource-limited settings like those prevalent in Mumbai and rural India, modified Faine's criteria provide a practical diagnostic approach. The modified Faine's criteria (2012 amendment) achieved 95.45% sensitivity, 56.86% specificity, positive predictive value of 58.88%, and negative predictive value of 95.08% when evaluated against laboratory-confirmed cases (Bandara et al., 2016). When rapid immunochromatographic assays (leptocheck IgM) were incorporated, sensitivity reached 89.39% with specificity of 58.82% (Bandara et al., 2016).

PCR combined with ELISA provides a practical alternative to the cumbersome gold-standard MAT, particularly valuable in resource-limited settings. Among 1,464 Indonesian hospitalized patients with acute fever, 51 (3.5%) confirmed and 6 (0.4%) probable leptospirosis cases were identified by combined IgM ELISA and in-house real-time PCR at a reference laboratory, whereas only 43.1% were accurately diagnosed at treatment sites with 56.9% clinically misdiagnosed as other infections, primarily dengue (Gasem et al., 2020).

Public Health Burden and Mortality Outcomes

Disease Burden and Mortality Estimates

India's leptospirosis burden remains vastly underestimated, especially in flood-prone regions like Maharashtra and coastal areas. Misdiagnosis and underreporting are widespread, with many cases mistaken for other tropical infections (Goarant, 2016).

Survival rates among hospitalized leptospirosis patients vary sharply depending on disease progression. A study of 104 ICU patients found mortality reached 26.8% in seronegative cases, compared to just 3.8% in seropositive patients (Ittyachen et al., 2007). The disparity likely reflects delayed diagnosis in seronegative individuals, who typically present with more advanced disease. These findings highlight the critical role of early clinical suspicion and prompt intervention (Ittyachen et al., 2007).

Risk Factors for Mortality and Severe Disease

Several factors consistently predict worse outcomes in leptospirosis. Age is one, patients over 60 face higher risks, as do clinical signs like oliguria at admission, extreme bilirubin levels (above 36 mg/dL), and hyperkalemia (Çetin et al., 2004). In icterohemorrhagic leptospirosis, specific red flags include dyspnea, pulmonary crackles, oliguria, renal impairment, hepatic dysfunction, shock, hemoglobin below 10 g/dL, and severe thrombocytopenia (platelet counts under 20, 000), all of which strongly correlate with poor prognosis (Saarkkara & Andrews, 2020).

Disease severity directly influences survival. Anicteric leptospirosis typically carries a mortality rate below 1%, while moderate icteric cases see rates around 3, 5%. Weil's disease is far more lethal, with mortality ranging from 5% to 40%, though most estimates center around 10%. When multiple organ failure occurs, the risk escalates further, sometimes exceeding 25% (Thalva & Desamani, 2017). A small study from an RAF renal unit underscores this point: of six Weil's disease patients, four survived, but two died from bleeding complications before aggressive hemodialysis could be initiated (Kennedy et al., 1979). The takeaway is clear, early detection and intensive supportive care can dramatically alter outcomes.

Socioeconomic Determinants of Disease Burden

Leptospirosis disproportionately affects marginalized and low-income populations, whether in dense urban slums or rural farming communities. In some slums, annual infection rates exceed 3%, driven by conditions like open sewers, substandard housing, and inconsistent access to clean water, all of which facilitate transmission (Felzemburgh et al., 2014). Household income itself emerges as a risk factor, with lower earnings correlating to higher infection rates (Felzemburgh et al., 2014).

The economic impact extends well beyond medical expenses. Farmers, who face the highest infection rates in endemic regions, often endure lost wages, treatment costs, and long-term health consequences (De Vries et al., 2014). The disease also disrupts livestock productivity, further straining agricultural and pastoral livelihoods. While improving water, sanitation, and hygiene (WASH) infrastructure could mitigate these effects, many resource-limited settings continue to struggle with inadequate and underfunded systems.

Geographic Clustering and Spatial Epidemiology

Spatial analyses reveal that leptospirosis cases frequently cluster in areas prone to heavy rainfall and flooding. In Rio de Janeiro, for example, scan statistics identified clusters ranging from 2 to 28 cases, with rainfall emerging as the primary driver (OR 3.71; 95% CI 1.83, 7.51) (Tassinari et al., 2008). Urban studies suggest these clusters stem more from transmission during downpours than from underlying socioeconomic or environmental disparities (Tassinari et al., 2008).

India's coastal regions, particularly Maharashtra and Kerala, show heightened vulnerability (Choudhary et al., 2023). The Seychelles offers another compelling case, a small island nation with a persistently high leptospirosis burden. Environmental factors linked to rodent-borne Leptospira include low-lying terrain, fragmented landscapes, proximity to urban areas, and distance from forests. Rainfall in the preceding three months also plays a significant role (Biscornet et al., 2021). Despite ongoing public awareness campaigns, the island still reports an annual incidence of 54.6 cases per 100, 000 people (Biscornet et al., 2017).

Prevention, Control, and Public Health Interventions

Early Recognition and Clinical Suspicion

Early detection of leptospirosis significantly improves patient outcomes, as delayed or missed diagnoses frequently result in worse prognoses. Clinicians must remain particularly vigilant when evaluating patients with known risk exposures, such as occupational animal contact, frequent water exposure, or recent flooding, who present with fever, myalgia, jaundice, or renal dysfunction (Ittyachen et al., 2007). The challenge lies in the nonspecific nature of these initial symptoms, which closely resemble those of dengue, malaria, or viral hepatitis, especially in resource-limited tropical settings where diagnostic overlap is common (Gasem et al., 2020). Given the urgency of treatment, empirical antibiotic therapy should be initiated promptly when clinical suspicion is high, rather than awaiting laboratory confirmation, as delays substantially increase mortality risk (Goarant, 2016).

In endemic regions where several febrile illnesses circulate at the same time, paying close attention to subtle combinations—such as conjunctival suffusion together with hepatic and renal dysfunction—can help clinicians make a timely diagnosis and start appropriate treatment.

Pre-Monsoon Preparedness and Environmental Control

Prompt and vigilant fever surveillance activities in pre-monsoon preparedness plans, intensive information, education, and communication (IEC) messages, and rodent control programs are vital for reducing incidence (Bhardwaj et al., 2008). Rodent control measures are most effective during cool and dry seasons when rodent populations and leptospirosis carriage are low, preventing population rebounds during subsequent monsoon seasons (Pérez et al., 2011).

Improvement of environmental sanitary conditions—including proper waste management, elimination of stagnant water, and rodent-proofing of food storage areas—addresses critical transmission pathways. Infrastructure improvements preventing flood water contamination of water supplies, adequate WASH facilities, and proper sewage management represent fundamental public health measures. In Southeast Asia, urban infrastructure improvements and early warning systems integrated into disaster preparedness are particularly critical in flood-prone areas (Almazar et al., 2026).

Community Education and Behavioral Interventions

Knowledge and awareness significantly predict preventive behavior. In a cross-sectional study examining factors related to leptospirosis prevention in Yogyakarta, Indonesia, knowledge was identified as the factor most significantly related to preventive behavior (Murwani et al., 2022). Community-based education emphasizing the connection between rainfall and disease risk, high-risk activities (barefoot walking, water recreation, swimming in rivers), and proper hygiene practices can significantly reduce incidence.

Information dissemination through mass media represents the number one preventive and control strategy in many communities, with television identified as the primary information source in the Philippines (Quina et al., 2014). Educational programs should target high-risk occupational groups—farmers, construction workers, slaughterhouse workers, and animal handlers—with specific information about protective measures including footwear, wound covering, and animal contact precautions.

Surveillance, Surveillance Harmonization, and Data Integration

Harmonized surveillance systems with standardized case definitions and diagnostic protocols remain critical gaps in many regions. The efficiency of surveillance systems and data collection varies significantly across Asia-Pacific countries, leading to incomplete epidemiological information and underestimation of true disease burden (Victoriano et al., 2009). One Health approach surveillance integrating human, animal, and environmental health sectors is increasingly recognized as essential for effective disease control (Almazar et al., 2026).

Strengthened surveillance must include capability for rapid diagnostic confirmation and epidemiological investigation to support timely interventions. Environmental monitoring of water sources and rodent populations during high-risk periods, integrated with clinical case detection, enables targeted prevention strategies. Surveillance data integration with meteorological information (rainfall, flooding) enables predictive modeling and early warning systems particularly valuable in monsoon-driven disease patterns.

Treatment Protocols and Antibiotic Stewardship

Antibiotic therapy remains highly effective and should be initiated empirically on clinical suspicion. Crystalline penicillin G (12 million U/day) remains the standard for severe disease, with doxycycline typically used for milder cases (Çetin et al., 2004). Prompt antibiotic initiation in both early and late/severe disease phases prevents progression of illness and reduces mortality. Third-generation cephalosporins (piperacillin-tazobactam, ceftazidime) are commonly used in resource-limited settings where ICU care is provided (Nzerue & Loutoby, 2025).

Beyond antimicrobial therapy, supportive care is essential: early and frequent hemodialysis for acute kidney injury, low-volume fluid management to prevent pulmonary hemorrhage, and lung-protective ventilation strategies for ARDS. Vasopressor support for shock and corticosteroid therapy in severe cases have proven beneficial in case series, though formal randomized trials remain lacking. Therapeutic plasma exchange shows promise as salvage therapy for fulminant disease with coagulopathy and multiorgan failure (Arianto et al., 2025).

Summary Tables

Table 1: Comparative Sensitivity and Specificity of Diagnostic Methods for Leptospirosis

Diagnostic Method	Stage of Illness	Sensitivity (%)	Specificity (%)	Clinical Application
MAT (Paired samples)	Acute-Convalescent	68	75	Gold standard, slow
MAT (Single acute sample)	First 3–8 days	14	86	Limited early utility
IgM ELISA	First 3–8 days	79	89	Faster than MAT
IgM ELISA	Days 9–14	100	95	Excellent accuracy
PCR (Early stage)	First 3–8 days	62–100	100	Superior early sensitivity
PCR (Leptospiremia)	Days 1–7	100	100	Before antibodies appear
LAMP	Acute phase	88.5	94	Rapid, field-applicable
Rapid Diagnostic Tests	Overall	75–78	95–98	Point-of-care screening
Culture	Early blood	35	90	Gold standard, slow

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Table 2: Environmental and Occupational Risk Factors for Leptospirosis in Mumbai and South India

Risk Factor Category	Specific Risk Factor	Adjusted Odds Ratio (95% CI)	Study Population
Water-related	Direct contact with mud/water during work	9.7 (3.3–27.7)	India (Kodagu)
Water-related	Walking barefoot	10.34 (5.09–21.31)	Surat, during flooding
Water-related	Flooding/water collection near house	4.9 (1.4–17.0)	India (Kodagu)
Infrastructure	Proximity to open sewer	4.9 (1.2–19.1)	India (Kodagu)
Animal Contact	Presence of rodents in house	4.0 (1.2–12.6)	India (Kodagu)
Occupational	Outdoor workers (general)	1.95–3.95	Multiple studies
Occupational	Slaughterhouse workers	5.1–7.5	Multiple studies
Occupational	Farmers	High prevalence	South India cohorts
Infrastructural	Un-plastered house walls	2.71–5.17	South India
Geographic	Living in low-lying areas	1.58–3.74	Multiple regions

Table 3: Clinical Manifestations and Laboratory Findings in Leptospirosis

Clinical Feature	Prevalence (%)	Laboratory Finding	Prevalence (%)
Fever	100	Elevated ESR	100
Myalgia	77	Leukocytosis	~50
Jaundice (Icteric cases)	72	Thrombocytopenia	50–90
Headache	65	Abnormal LFT	71–95
Vomiting	56	Abnormal RFT	26–90
Conjunctival suffusion	45	Hyperbilirubinemia	100 (icteric)
Dark/colored urine	63	Elevated transaminases	93–95
Hepatomegaly	33	Hyponatremia (icteric)	7.6–72.8
Renal failure (icteric)	30–42	Hyperkalemia (icteric)	Variable
Pulmonary involvement	2.56–15	Rhabdomyolysis markers	Variable
Hemorrhage	20	Elevated creatinine	26–80

Table 4: Mortality Rates by Disease Form and Predictive Factors

Disease Form / Presentation	Mortality Rate (%)	Key Predictive Factors for Death
Anicteric (mild)	<1	Generally favorable prognosis
Icteric (moderate)	3–5	Jaundice with organ dysfunction
Weil's disease (severe)	5–40 (average 10)	Multi-organ failure components
With acute kidney injury	22	Anuria, high bilirubin
With respiratory complications	40+	Diffuse alveolar hemorrhage
Age >60 years + icteric disease	Higher	Advanced age, delayed diagnosis
Thrombocytopenia <20,000 + icterus	25+	Severe coagulopathy

CONCLUSION

Leptospirosis in Mumbai during the monsoon season represents a significant yet largely underappreciated public health burden. The disease demonstrates clear seasonal patterns driven by monsoon rainfall, flooding, and elevated rodent populations and bacterial carriage. Risk factors are context-specific, with urban cases primarily associated with water-related exposures and poor sanitation, while rural cases reflect occupational exposures to animals and contaminated environments. The clinical spectrum ranges from mild anicteric fever to life-threatening Weil's disease with multi-organ failure and mortality exceeding 40%.

Diagnostic challenges remain substantial, particularly the limited early sensitivity of the gold-standard MAT and the expense and complexity of molecular diagnostics in resource-limited settings. Early clinical recognition based on epidemiological context remains critical, with empirical antibiotic therapy recommended despite diagnostic delays. Public health interventions must integrate pre-monsoon surveillance and preparedness, effective rodent and environmental control during favorable seasons, community education emphasizing behavioral modifications, and strengthened surveillance systems with standardized diagnostics. A comprehensive One Health approach addressing human, animal, and environmental health sectors offers the most promising path toward reducing the burden of this neglected tropical disease affecting vulnerable populations across monsoon-affected India.

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[38] (Victoriano et al., 2009) - Asia-Pacific surveillance systems
[39] (Murwani et al., 2022) - Knowledge-behavior prevention study
[40] (Quina et al., 2014) - Community knowledge and practices
[41] (Nzerue & Loutoby, 2025) - Acute kidney injury outcomes
[42] (Arianto et al., 2025) - Therapeutic plasma exchange salvage