Review

Leveraging one health to combat leptospirosis: a global strategy for enhancing transmission knowledge, diagnostics, and surveillance

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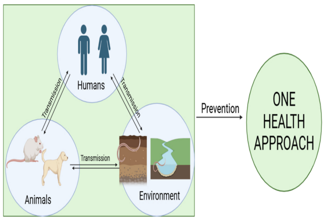

Abstract: Leptospirosis, a zoonotic bacterial infection caused by *Leptospira* species, significantly impacts both human and animal populations, particularly in tropical and subtropical regions. Transmission typically occurs through contact with contaminated water or soil, with rodents, livestock, and other animals serving as key reservoirs. Despite its prevalence, leptospirosis remains underreported due to diagnostic challenges, complex transmission dynamics, and insufficient surveillance systems. This paper proposes the establishment of a Global One Health Coordination Committee to address these issues, focusing on improving the understanding of transmission pathways, developing accessible and accurate diagnostic tools, and strengthening surveillance efforts. By integrating insights from human, animal, and environmental health sectors, this committee would facilitate global data sharing, prioritize research funding, and support public health initiatives. Such a collaborative framework is essential for mitigating leptospirosis' global health burden and fostering sustainable preventative measures across diverse ecological and socio-economic contexts.

Keywords: Leptospirosis; transmission knowledge; zoonotic; bacterial infection; one health approach

1. Introduction

Globally, it is estimated that zoonoses cause approximately one billion cases of illness and millions of deaths each year [1,2]. Around 60% of human infections are zoonotic, with 75% of these zoonotic infections being either emerging or re-emerging [1]. One such disease is Leptospirosis, an environmentally transmitted bacterial zoonotic disease that is either emerging or re-emerging in tropical and temperate areas. It is also known by various synonyms, including Weil's disease, Weil-Vasiliev disease, Swineherd's disease, rice-field fever, waterborne fever, nanukayami fever, cane-cutter fever, swamp fever, mud fever, Stuttgart disease, and Canicola [3] . It is sensitive to climate conditions [4]. It is primarily transmitted through contact with water, soil, or food contaminated by the urine of infected animals [5]. It affects both humans and a wide range of animals, including rodents, livestock, and pets [6]. All mammals, particularly rodents, can serve as reservoirs for pathogenic Leptospira, spreading the bacteria through their urine into soil and water. In contrast, humans are considered incidental and vulnerable hosts for the infection. The increasing human population in peri-urban informal settlements or slums provides optimal conditions for rodent proliferation, leading to a higher risk of transmission of rodent-borne pathogens, including pathogenic *leptospires*[7]. The disease is caused by pathogenic spirochetes belonging to the genus Leptospira, which has recently been reclassified to include 66 different species and over 300 serovars [6].

Leptospira organisms are slender, tightly coiled spirochetes that are obligate aerobes, distinguished by their unique flexible motility. The genus is classified into two main species: the pathogenic *Leptospira interrogans* and the free-living *Leptospira biflexa*. Serotypes of *L. interrogans* are responsible for causing leptospirosis, a zoonotic disease [8]. These bacteria thrive in moist environments, particularly in warm, tropical climates [9]. The life cycle of *Leptospira* begins with reservoir hosts, mainly rodents, where the bacteria colonize the kidneys and are excreted through urine into the environment. These bacteria can survive in moist conditions such as water, soil, and vegetation for weeks or months, especially in warm climates[10]. Humans and other animals become infected when they come into contact with contaminated water or soil, allowing the bacteria to enter through broken skin or mucous membranes. Once inside the host, *Leptospira* spreads through the bloodstream, potentially causing organ damage, particularly to the kidneys and liver. Humans, who are considered incidental hosts, typically do not spread the bacteria further. The life cycle completes when the bacteria are shed back into the environment through the urine of infected reservoir animals, allowing the process to continue[11]. Severe cases may result in kidney failure, liver damage, and reproductive issues, including abortions in pregnant animals. Some animals can become chronic carriers, shedding the bacteria without showing symptoms, which perpetuates the cycle of infection in the environment. This can lead to economic losses in livestock due to decreased productivity and increased veterinary costs[12,13]. In humans, the disease presents with symptoms ranging from mild flu-like signs—such as fever, headache, and muscle aches—to severe manifestations like jaundice, kidney damage, and multi-organ failure, particularly in cases known as Weil's disease[14]. Humans are considered incidental hosts, contracting the disease through exposure to contaminated water or soil, especially in flood-prone areas. Additionally, some individuals may experience long-term health issues, such as chronic kidney disease, even after recovering from the acute phase of infection[15].

The fatality rate of leptospirosis varies significantly between animals and humans. In humans, the overall fatality rate is estimated to range from 5% to 15%, particularly in severe cases associated with Weil's disease, where mortality can exceed 30% if left untreated[16]. The fatality rate in animals varies by species. For instance, in dogs, the mortality rate can be around 10% to 20% in severe cases[17] while other domestic animals, such as cattle and pigs, may experience variable fatality rates depending upon factors like age, health status, and the specific serovar involved[18]. The case-fatality rate for severe leptospirosis can surpass 50%[19]. Few vaccines are available in case of animals but as of now, commercial vaccines for human leptospirosis are available only in a few countries, including Japan, China, Cuba, and France. These vaccines, made from inactivated Leptospira (bacterins), elicit a short-term immune response that is specific to certain serovars and may have significant adverse side effects[20].

The treatment and prevention of leptospirosis require a comprehensive approach that incorporates the One Health framework, which recognizes the interconnectedness of human, animal, and environmental health[21]. Treatment typically involves the early administration of antibiotics, such as doxycycline or penicillin, alongside supportive care to manage symptoms and complications, particularly in severe cases[22]. Preventive measures are crucial and include reducing rodent populations through sanitation and waste management, wearing protective clothing when in potentially contaminated environments, and vaccinating pets and livestock to minimize transmission[23]. Public health campaigns play an essential role in educating communities about the risks associated with leptospirosis and promoting good hygiene practices. Additionally, implementing disease surveillance systems helps monitor cases in both humans and animals, facilitating timely interventions. Public health campaigns play an essential role in educating communities about the risks associated with leptospirosis and promoting good hygiene practices. Additionally, implementing disease surveillance systems helps monitor cases in both humans and animals, facilitating timely interventions[24]. This review offers insights into the importance of integrating these strategies within the One Health approach. By doing so, we can effectively manage and mitigate the incidence and severity of leptospirosis, ultimately protecting the health of humans, animals, and the environment. This comprehensive strategy fosters collaboration among health sectors, enhances disease surveillance, and promotes preventive measures that address the interconnectedness of human and animal health, leading to more sustainable outcomes in combating leptospirosis.

2. Basic approach and methodology

A global review was conducted to assess circulating serogroups of leptospirosis pathogens and identify gaps in existing research. A systematic approach involved screening and reviewing 412 articles published between 2015 and 2024, using the keyword "Leptospirosis" on PubMed. Articles included were selected based on the reporting of serovars through serological and molecular techniques across various geographic regions, human, animal, and environmental samples. Data extraction recorded information on the authors, publication year, study location, identification methods, and sample sources. The findings were organized to reflect the distribution of serogroups worldwide, pinpointing regions with the most significant knowledge gaps. Additionally, insights were provided for developing interventions to control leptospirosis infections, aligning with the One Health (OH) approach, which emphasizes interdisciplinary collaboration to address zoonotic diseases.

The literature review indicated that Leptospirosis was first identified as a disease in Japan in 1886 by a physician named Adolf Weil, who documented the symptoms of the severe form now known as Weil's disease[25]. This form of leptospirosis includes symptoms like jaundice, fever, haemorrhaging, and kidney involvement[26]. The causative bacterium, Leptospira interrogans, was identified later in the early 20th century by Japanese scientists Ryukichi Inada and Yutaka Ito, who were able to culture the organism for the first time around 1914-1916[27]. Yet, despite decades of research, critical aspects like disease patterns, transmission mechanisms, and pathogenesis remain only partially understood[2]. Globally, leptospirosis is notably prevalent in regions with humid, tropical climates, which enhance its spread and persistence. Many serogroups of Leptospira interrogans found in animals are also infectious to humans, though the reverse human-to-animal transmission is rare[28].

Studies indicated that other pathogenic Leptospira species are primarily associated with rodent populations, highlighting the role of these animals as reservoirs[29]. Although zoonotic transmission from animals to humans has been documented, the intricate dynamics between animals, humans, and the environment remain complex and insufficiently explored[30]. Few studies incorporate more than one element of this disease cycle, and comprehensive models encompassing all three domains animal, human, and environmental are limited, hindering a full understanding of transmission patterns on a global scale[31].

Hotspots for leptospirosis include Southeast Asia, the Pacific Islands, Latin America, sub-Saharan Africa, and parts of Oceania[32]. These regions frequently experience outbreaks, particularly after flooding, which allows bacteria in animal urine to spread into soil and water systems more effectively[33]. In countries like Brazil, India, Thailand, and the Philippines, leptospirosis is endemic and often linked to seasonal monsoons, natural disasters, and densely populated urban settings, which increase human exposure to environmental sources of infection[34]. The endemic regions of leptospirosis also extend to rural areas where agricultural practices, such as rice and sugarcane cultivation, expose workers to contaminated water and mud. Southeast Asian nations such as Indonesia, Malaysia, and Vietnam report consistently high cases, with incidence rates exceeding 10 cases per 100,000 people in some areas [35,36,37]. Similarly, Pacific Island nations including Fiji, Papua New Guinea, and New Caledonia are affected due to high rainfall and reliance on outdoor work in agriculture, which increase exposure risks. Poor sanitation, proximity to animal reservoirs (especially rodents and livestock), and limited access to healthcare contribute to the disease's persistence in these areas[38,39,40]. In contrast, the epidemiological landscape in Europe and North America shows lower incidence rates, though cases are occasionally reported. In these temperate regions, leptospirosis is generally non-endemic but can emerge through occupational or recreational exposure to contaminated water[41]. In the United States, for example, cases are often associated with outdoor activities such as swimming or kayaking in natural water bodies, and clusters have been linked to adventure races[42]. While endemicity is rare in these regions, sporadic outbreaks can occur, especially in tropical U.S. territories like Puerto Rico and Hawaii, where environmental conditions resemble those of more endemic tropical areas [43,44]. Low-risk regions include the Middle East and most parts of northern Europe, where arid or colder climates limit Leptospira survival outside of host organisms. However, sporadic cases can still emerge through imported infections, international travel, or activities involving wildlife[5].

Table 1. Prevalent serogroups of leptospira across the world.

Global Coordination Committee for Leptospirosis: Improving Transmission Understanding, Diagnosis, and Surveillance.

Region	*Prominent Serovar*	Typical Hosts	Reference
India	*L. icterohaemorrhagiae, L. autumnalis, L. australis*	Humans, Rodents, Livestock	[45]
Europe	*L. australis, L. hardjo*, *L. grippotyphosa*, *L. sejroe*	Cattle, Sheep, Livestock, Wildlife	[46]
Central America	*L. noguchii, L. santarosai*	Livestock, Wildlife	[47]
Latin America	*L. interrogans*, *L. noguchii*, *L. kirschneri*	Humans, Livestock, Rodents	[23]
Australia	*L. australis, L. hardjo*	Rodents, Livestock	[48]
Southeast Asia	*L. wolffii, L. pyrogenes, L. andamana*	Humans, Livestock, Wildlife	[49]
Oceania	*L. australis, L. grippotyphosa*	Rodents, Humans, Livestock	[43]
Africa	*L. icterohaemorrhagiae*, *L. kirschneri*, *L. borgpetersenii*	Humans, Rodents, Wildlife	[50]
Caribbean	*L. noguchii, L. borgpetersenii*	Livestock, Rodents	[51]
North America	*L. pomona*, *L. icterohaemorrhagiae*, *L. bratislava*	Livestock, Rodents	[52,53]
South Asia	*L. icterohaemorrhagiae*, *L. australis*, *L. autumnalis*	Humans, Rodents, Livestock	[54]

To address gaps in the global epidemiological understanding of leptospirosis, a systematic literature analysis was conducted to identify circulating Leptospira serovars reported in different regions and hosts. This review aimed to provide an overview of the specific serovars documented in both animals and humans across various geographic areas. Table 1 illustrates the distribution of key Leptospira serovars that have been identified in distinct environmental and epidemiological contexts, showing their association with different animal reservoirs and human cases. This approach highlights regional variations in serovar prevalence, enhancing insights into how transmission dynamics vary by location and host type. Understanding these patterns is crucial for developing targeted surveillance and intervention strategies, especially in high-risk regions with diverse animal reservoirs that contribute to human infection[2].

Establishing a global coordination committee focused on leptospirosis would play a crucial role in comprehensively addressing the disease's epidemiology, transmission dynamics, diagnostic challenges, and surveillance needs[2]. Leptospirosis is a zoonotic disease prevalent in tropical and subtropical regions, caused by Leptospira bacteria. It affects a range of species, including humans, livestock, and wildlife, creating a complex disease cycle and making coordinated, inter-sectoral action essential[5]. A One Health Coordination Committee, bringing together experts from human health, veterinary science, and environmental fields, could lead to significant improvements in understanding and controlling this disease globally[55].

3. Understanding transmission pathways: Leptospirosis transmission occurs primarily through contact with contaminated water, soil, or animal fluids. Animals, particularly rodents, are the primary reservoirs, although domestic animals and livestock are also significant carriers. In environments where sanitation is poor or there is frequent exposure to contaminated water, such as in farming communities or urban slums, the risk of transmission escalates[5]. Establishing a global coordination committee would enable countries and regions to collaborate on research identifying specific transmission pathways, focusing on variations across different ecosystems and climates[2].

For example, in tropical countries like India, Brazil, and Thailand, outbreaks often occur following heavy rainfall, when water sources become contaminated with Leptospira. This highlights the need for tailored strategies that factor in regional and seasonal variations in transmission[56]. A committee like A Global, Multi-Disciplinary, Multi-Sectorial Initiative to Combat Leptospirosis: Global Leptospirosis Environmental Action Network (GLEAN) could facilitate data sharing across countries and regions, allowing for a more nuanced understanding of environmental risk factors such as waterborne transmission after flooding events, and human practices that increase exposure, such as agriculture or hunting[57]. Cross-country studies would benefit from a collaborative framework that emphasizes the ecological, environmental, and human behavioral elements of leptospirosis transmission[9].

4. Improving diagnostic approaches: Accurate and timely diagnosis of leptospirosis is challenging due to its diverse clinical presentation, which often mimics other febrile illnesses like dengue, malaria, or typhoid[58]. Conventional diagnostic methods, such as microscopic agglutination tests (MAT), are complex, require trained personnel, and are often inaccessible in low-resource areas where leptospirosis is most prevalent[59].

A global coordination committee could prioritize the development and distribution of rapid, affordable diagnostic tools that can be used widely, especially in resource-constrained settings. Standardizing diagnostic criteria and protocols would also ensure consistency and accuracy across regions[55]. Leveraging a One Health approach, the committee could promote the integration of veterinary diagnostics with human health diagnostics, as diagnosing infections in animal populations can serve as an early warning system for human cases[60]. Additionally, the committee could encourage funding and research into innovative diagnostic methods, such as PCR-based tests or next-generation sequencing, which, although currently costly, could become more feasible with international cooperation and technological advancement[61].

5. Strengthening surveillance and data sharing: Leptospirosis is often underreported, with inconsistent surveillance systems between countries and even within regions of the same country. The establishment of a coordinated global committee would be instrumental in creating a unified surveillance framework that improves reporting accuracy and real-time data sharing. This would be particularly beneficial in anticipating and responding to outbreaks, as better surveillance could help identify areas where leptospirosis is emerging as a significant health concern[62].

Surveillance could be enhanced by setting up sentinel sites in high-risk areas, integrating human and animal health data, and monitoring environmental conditions conducive to Leptospira transmission[63]. A One Health Coordination Committee could help establish a centralized database where countries report cases and track outbreaks, allowing for rapid, coordinated responses to emerging threats[64]. This could also improve the understanding of leptospirosis' impact on human health and agriculture, leading to more robust prevention strategies and better allocation of resources in high-risk regions.

6. Enhancing public health education and response strategies: A One Health Coordination Committee would play an essential role in designing and implementing public health education campaigns tailored to different regions. Public awareness is a critical component in preventing leptospirosis, as individuals need to understand how to avoid exposure, recognize symptoms early, and seek treatment promptly[65]. Educational campaigns could focus on minimizing risk behaviors, such as wading in floodwaters, practicing proper sanitation, and using protective gear during high-risk activities[66]. In regions heavily impacted by leptospirosis, the committee could facilitate partnerships with local organizations to disseminate knowledge on disease prevention and build capacity for outbreak response. Health education strategies could be adapted to local languages and cultural practices, making them more accessible to rural and underserved communities where leptospirosis risk is highest[9].

Conclusions and future perspectives: The establishment of a Global One Health Coordination Committee for leptospirosis would mark a transformative step in managing this zoonotic disease worldwide. By bringing together experts from human, veterinary, and environmental sciences, the committee could address leptospirosis' multifaceted challenges[2]. This initiative would foster a deeper understanding of transmission dynamics, which vary across ecological contexts, helping identify and mitigate high-risk environments and activities[30]. Moreover, the committee could standardize and improve diagnostic techniques, ensuring that resources and rapid diagnostic tools are accessible, particularly in low-resource settings where leptospirosis is most prevalent[59].

A unified, global surveillance framework coordinated by this committee would allow for accurate and timely reporting, enabling data-driven public health responses and enhancing global preparedness[66]. By promoting a shared database, the committee would facilitate rapid detection of outbreaks, enabling early intervention strategies and targeted resource allocation in affected areas. Additionally, the committee would play an essential role in public health education, developing and disseminating culturally tailored materials to raise awareness in high-risk communities and encourage preventive behaviors[65].

Ultimately, a Global One Health Coordination Committee for leptospirosis would lay the foundation for sustainable, collaborative strategies to reduce the incidence and severity of leptospirosis. By addressing diagnostic, surveillance, and transmission complexities through an integrated approach, this committee could significantly reduce leptospirosis' global health impact, protect vulnerable populations, and establish a resilient framework for zoonotic disease control[67].

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