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Legionellosis in a Patient with Water Contamination in Healthcare and Residential Settings: A Case Report

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A B S T R A C T

Legionella pneumophila is a waterborne pathogen causing severe pneumonia through inhalation of contaminated aerosols. Data on legionellosis in Indonesia remain limited, particularly regarding environmental sources. To describe a confirmed case of legionellosis and assess potential environmental exposure from hospital and household water systems. Clinical confirmation was performed using PCR detection of L. pneumophila from respiratory specimens. Environmental swab samples were collected from aerosol- and water-associated sources in the hospital and the patient's home and tested using PCR for Legionella sp. and L. pneumophila. Seven of twelve clinical specimens were positive for L. pneumophila. Environmental sampling detected Legionella sp. in multiple hospital and household sites, although L. pneumophila was not detected. The coexistence of confirmed L. pneumophila infection and environmental Legionella contamination indicates potential dual exposure and highlights the need for strengthened water system surveillance.

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INTRODUCTION

Legionellosis is a severe pneumonia caused mainly by Legionella pneumophila, a gram-negative waterborne bacterium that proliferates in warm aquatic environments and survives within biofilms and free-living amoebae, enhancing its pathogenicity. More than 50 species of Legionella have been identified, yet L. Pneumophila particularly serogroup remains the leading cause of human infection globally. Transmission occurs through inhalation of contaminated aerosols generated from engineered water systems, making plumbing infrastructure, cooling systems, and humidifying devices critical reservoirs for infection.

Healthcare facilities are considered high-risk environments due to complex water distribution networks and frequent use of aerosol-producing medical equipment. International studies have reported extensive contamination: more than 60% of hospitals in Taiwan and over 90% of hospitals in Hungary have demonstrated colonization of their hot-water systems by Legionella species 5. These findings have prompted WHO (2023) and CDC (2024) to emphasize rigorous water management protocols as essential preventive measures for healthcare-associated legionellosis (HALD) .

In Indonesia, although legionellosis remains underrecognized, historical and contemporary data indicate ongoing transmission. Confirmed cases were reported in Bali (1996) and Tangerang (1999). Subsequent surveillance by the Ministry of Health detected L. pneumophila in 41 of 175 influenza-like illness (ILI) specimens in 2012. In 2019, environmental sampling in two private hospitals in Jakarta identified 21 isolates of L. pneumophila from water systems10. More recent national surveillance between 2023 and 2025 reported 38 PCR-confirmed cases from 235 suspected samples.

The document provided for this study describes multiple L. pneumophila–positive clinical specimens identified in June 2025 at a hospital in the Riau Islands Province, leading to combined clinical and environmental investigations. Environmental sampling performed by national and regional laboratories revealed contamination by Legionella sp. at both the hospital and the patient's home, particularly from taps, air conditioners, dispensers, water kettles, and oxygen humidifier devices

Notably, although the patient's clinical specimen tested positive for L. pneumophila, the environmental samples were positive only for Legionella sp. and negative for L. pneumophila. This pattern is consistent with molecular studies showing that genus-level PCR assays typically targeting conserved genes such as 16S rRNA are more sensitive and able to detect multiple Legionella species, while species-specific PCR requires higher DNA concentrations and may yield negative results if L. pneumophila exists in low abundance or in viable-but-non-culturable (VBNC) states. Stølhaug & Bergh (2006) demonstrated that genus-level assays detect nearly all environmental Legionella species, whereas L. pneumophila–specific melting curve analysis or mip gene PCR is less sensitive in mixed microbial communities.

Domestic water systems also represent an increasingly recognized reservoir of Legionella, particularly when characterized by intermittent heating,

stagnation, and biofilm formation. Recent reviews highlight that colonization of household plumbing systems can contribute to sporadic cases or reinforce dual exposure pathways involving both the home and healthcare environments .
In the Indonesian regulatory context, the Ministry of Health's Regulation No. 2/2023 on Environmental Health Standards mandates biological safety in healthcare water systems, whereas Health Law No. 17/2023 reinforces institutional accountability for preventing waterborne infections. The findings from this investigation underscore substantial gaps in water management practices and highlight the urgent need for systematic Legionella monitoring in healthcare and domestic settings.

Collectively, these observations show that L. pneumophila infection in the patient occurred in the context of broader environmental colonization by Legionella in both hospital and residential water systems. This case illustrates the emerging relevance of legionellosis in tropical regions and the need for robust water safety planning to prevent future cases.

THEORETICAL REVIEW

Theory of Waterborne Transmission of Legionella

The theory of waterborne transmission explains that *Legionella pneumophila* is primarily transmitted through inhalation of aerosols originating from contaminated water systems rather than through person-to-person contact. *Legionella* species are capable of proliferating in warm aquatic environments and persisting within biofilms and free-living amoebae, which enhance their survival and pathogenicity. Engineered water systems such as plumbing networks, air conditioning units, water dispensers, humidifiers, and medical respiratory devices represent critical reservoirs for *Legionella* transmission. Aerosolization from these systems enables bacterial dissemination into the human respiratory tract, particularly in healthcare settings where vulnerable populations and aerosol-generating devices are prevalent . This theoretical framework supports the investigation of both hospital and household water systems as potential exposure sources in confirmed cases of legionellosis.

Ecological Persistence and Biofilm Theory of Legionella

The ecological persistence theory postulates that *Legionella* species occupy specific aquatic niches that facilitate long-term survival, including warm temperatures, water stagnation, and biofilm formation. Within biofilms, *Legionella* can survive adverse environmental conditions and replicate intracellularly within free-living amoebae, thereby maintaining environmental persistence and virulence. This ecological adaptation explains why *Legionella* contamination is frequently detected in water systems of healthcare facilities and residential environments. Studies conducted in Indonesia and other regions have demonstrated widespread environmental contamination despite limited clinical recognition, indicating that *Legionella* may persist unnoticed in water systems over extended periods. This theory supports the presence of *Legionella* sp. in multiple environmental samples in the absence of consistent species-level detection.

Healthcare-Associated Infection (HAI) Transmission Framework

The healthcare-associated infection (HAI) framework emphasizes that infections acquired in healthcare settings arise from interactions between patients, environmental reservoirs, and medical devices. Water systems in hospitals, including taps, dispensers, oxygen humidifiers, and nebulizers, are recognized sources of *Legionella* exposure due to frequent aerosol generation and complex plumbing infrastructures . International reports indicate high levels of *Legionella* colonization in hospital water systems, prompting global recommendations for water safety planning and routine risk management. This framework supports the assessment of hospital water systems alongside household environments, particularly when multiple PCR-confirmed cases are identified within the same healthcare facility.

Molecular Detection Sensitivity Theory

The molecular detection sensitivity theory explains discrepancies between clinical and environmental findings in legionellosis investigations. Genus-level PCR assays targeting conserved genetic regions such as 16S rRNA exhibit higher sensitivity for detecting *Legionella* species in environmental samples, whereas species-specific assays for *L. pneumophila* require higher DNA concentrations and may yield negative results when bacterial load is low or organisms are in a viable-but-non-culturable (VBNC) state. Environmental studies have demonstrated that *Legionella* sp. is more frequently detected than *L. pneumophila* in water systems, even when clinical infections are confirmed . This theoretical framework supports the interpretation that negative environmental detection of *L. pneumophila* does not exclude environmental exposure and reinforces the importance of genus-level surveillance in water safety monitoring.

METHODOLOGY

Operational Definition of Variables

In this study, the variables were operationally defined to ensure consistency in data collection, laboratory analysis, and interpretation of results.

Clinical Legionellosis Case*:* A clinical case of legionellosis was defined as a patient presenting with respiratory symptoms compatible with pneumonia and having a respiratory specimen (sputum or oropharyngeal/nasopharyngeal swab) that tested positive for *Legionella pneumophila* using polymerase chain reaction (PCR). A positive result was determined by amplification of *L. pneumophila*-specific gene targets according to the laboratory's validated PCR protocol.

Environmental *Legionella* Contamination: Environmental contamination was defined as the detection of *Legionella* DNA from swab samples collected from water-related or aerosol-generating sources in hospital and household settings. Samples were considered positive for *Legionella* sp. when genus-level PCR amplification was detected, and positive for *L. pneumophila* when species-specific PCR targets were amplified.

Sampling Sites: Hospital sampling sites included taps, water dispensers, nebulizers, oxygen humidifier equipment, and other water-contact medical devices. Household sampling sites included air conditioning units, drinking water dispensers, kettles, taps, thermos containers, and feeding bottles. These sites were selected based on their potential to generate aerosols or support water stagnation.

PCR Test Result Interpretation: PCR results were classified dichotomously as positive or negative. A positive result indicated detectable *Legionella* DNA above the assay threshold, while a negative result indicated no detectable amplification. Environmental PCR results were interpreted in reference to Indonesian environmental health standards (Permenkes No. 2/2023).

Exposure Environment: Exposure environment was operationally defined as either healthcare-associated (hospital water systems and medical devices) or residential (household water systems). Detection of *Legionella* sp. in either setting was considered indicative of potential exposure.

RESULTS

Clinical Spesimens Findings

PCR testing confirmed 7 positive cases of *L. pneumophila* from 12 respiratory specimens obtained from hospital patients (Table 1). These results demonstrated consistent amplification of *L. pneumophila*-specific gene targets, validating the diagnosis of legionellosis. No other *Legionella* species were detected in clinical specimens.

Table 1. Patient Laboratory Testing Results (PCR)

Subject	Sex	Age	Specimen	PCR Results's
Subject 1	Male	95	Nasofaring–Orofaring	Negative Legionella pneumophila
Subject 2	Male	10	Orofaring	**Positive *Legionella pneumophila***
Subject 3	Male	10	Sputum	Negative Legionella pneumophila
Subject 4	Female	1	Orofaring	**Positive *Legionella pneumophila***
Subject 5	Female	1	Sputum	**Positive *Legionella pneumophila***
Subject 6	Female	0,5	Orofaring	**Positive *Legionella pneumophila***
Subject 7	Female	0,5	Sputum	Negative Legionella pneumophila
Subject 8	Male	24	Orofaring	**Positive *Legionella pneumophila***
Subject 9	Female	2	Orofaring	**Positive *Legionella pneumophila***
Subject 10	Female	2	Sputum	**Positive *Legionella pneumophila***
Subject 11	Male	1	Orofaring	**Positive *Legionella pneumophila***
Subject 12	Male	1	Sputum	Negative Legionella pneumophila

Environmental Findings

Table 2. Laboratory Test Results for Environmental Samples from Hospital and Patient's Household using PCR

Sample	Sample Type	Legionella sp.	Legionella pneumophila	Sampling Site
Swab 1	Water Hose Swab	Negative	Negative	Patient's Household
Swab 2	**AC Swab**	**Positive**	Negative	**Patient's Household**
Swab 3	**Dispenser Swab**	**Positive**	Negative	**Patient's Household**
Swab 4	Fish Pond Swab	Negative	Negative	Patient's Household
Swab 5	AC Swab	**Positive**	Negative	Patient's Household
Swab 6	AC Swab	**Positive**	Negative	Patient's Household
Swab 7	Water Kettle Swab	**Positive**	Negative	Patient's Household
Swab 8	Tap Swab	**Positive**	Negative	Patient's Household
Swab 9	Thermos and Feeding Bottle Swab	**Positive**	Negative	Patient's Household
Swab 10	Tap Swab	**Positive**	Negative	Patient's Household
Swab 11	Tap Swab	**Positive**	Negative	Hospital
Swab 12	Dispenser Swab	**Positive**	Negative	Hospital
Swab 13	Nebulizer Swab	Negative	Negative	Hospital
Swab 14	Oxygen Swab	**Positive**	Negative	Hospital
Swab 15	Tap Swab	Negative	Negative	Hospital

From the 15 environmental swab samples collected, 10 tested positive for *Legionella sp.*, whereas all samples were negative for *L. pneumophila*. Positive detections were found in both the household and the hospital environment. Household ontamination included AC units, taps, water dispensers, kettles, and feeding bottles. Hospital Contamination involved taps, dispensers, and oxygen humidifier equipment.

DISCUSSION

The patient's PCR-confirmed infection with *L. pneumophila* aligns with global evidence identifying this species as the predominant cause of legionellosis. Its ability to persist in warm water systems, survive within biofilms, and replicate in free-living amoebae underpins its virulence and environmental stability. Clinical detection through PCR is essential because infections often fail to respond to standard antibiotics used for typical pneumonia.

Environmental results showing widespread positivity for *Legionella sp.* but negativity for *L. pneumophila* are epidemiologically plausible. Genus-level PCR is more sensitive and capable of detecting minimal DNA concentrations from various *Legionella* species, whereas species-specific PCR for *L. pneumophila* may yield negative results if the organism exists in low abundance or in a viable-but-non-culturable (VBNC) state within biofilms. This phenomenon has been reported in multiple studies demonstrating that non-pneumophila species more frequently dominate water systems, while *L. pneumophila* may appear intermittently or in low titers in complex plumbing systems.

Furthermore, real-time PCR targeting conserved regions such as the 16S rRNA gene allows broad detection of *Legionella sp.*, but species-level detection requires more specific genes such as *mip* or *dotA*, which demand higher DNA concentrations. The reference method described by Stølhaug & Bergh (2006) confirms that genus-level detection is significantly broader, and environmental samples often contain a mixture of *Legionella* species that do not always include *L. pneumophila* in detectable quantities .

The coexistence of clinical *L. pneumophila* infection and environmental *Legionella sp.* contamination indicates potential dual exposure, especially because both the hospital and the household exhibited multiple contaminated sites. This pattern is consistent with WHO and CDC statements that legionellosis may arise from more than one exposure setting, particularly when aerosol-generating devices are present .

These findings highlight the need for improved water safety management, regular disinfection, temperature monitoring, and biofilm control at both institutional and domestic levels particularly for high-risk populations and vulnerable patients.

CONCLUSIONS AND RECOMMENDATIONS

This study demonstrates a confirmed *Legionella pneumophila* infection in a patient alongside widespread environmental contamination with *Legionella* sp. in both hospital and household water systems. Although *L. pneumophila* was not detected in environmental samples, the findings indicate a plausible environmental exposure pathway involving aerosol-generating water sources in multiple settings.

Based on these findings, several operational recommendations are proposed. Healthcare facilities should implement routine *Legionella* surveillance of water systems using genus-level PCR, particularly at high-risk points such as taps, dispensers, and oxygen humidifiers. Water management programs should include regular temperature control, periodic disinfection, and biofilm mitigation strategies in accordance with national environmental health regulations. In residential settings, regular cleaning and maintenance of air conditioners, water dispensers, and household water containers should be promoted, especially for households with vulnerable individuals. Strengthening laboratory capacity for molecular detection and integrating *Legionella* monitoring into existing infection prevention programs are essential to reduce the risk of healthcare-associated and community-linked legionellosis.

FURTHER STUDY

Further research is needed to better understand the dynamics of Legionella contamination across both healthcare and residential water systems. Large-scale environmental surveillance studies could help identify high-risk points within water distribution networks, including storage tanks, plumbing systems, and cooling devices. Comparative studies across different types of healthcare facilities and residential environments would also provide valuable insights into how infrastructure design, maintenance practices, and water temperature control influence Legionella proliferation.

In addition, future studies should focus on developing standardized screening and prevention strategies for vulnerable populations, particularly immunocompromised patients and the elderly. Integrating molecular typing techniques and genomic sequencing may improve source tracking during outbreaks and sporadic cases. Strengthening interdisciplinary collaboration between clinicians, environmental health experts, and public health authorities will be essential to reduce the incidence of legionellosis and improve early detection in both clinical and community settings.

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