

Environmental and Behavioral Determinants of Leptospirosis in an Endemic Tropical Region: A Case-Control Study in Indonesia

Ari Widodo¹, Prihayati¹, Ismarina¹, Titin Nasiatin², Istiana³¹ Master of Public Health Program, Faculty of Health Sciences, Universitas Faletahan, Indonesia² Public Health Program, Faculty of Health Sciences, Universitas Faletahan, Indonesia³ Serang District Health Office, Serang, Banten, Indonesia

Correspondence should be addressed to: Prihayati

prihayati575859@gmail.com

Abstract:

Leptospirosis remains an escalating public health challenge in tropical endemic regions, necessitating a deeper understanding of its localized transmission dynamics. This study aimed to identify the specific individual and environmental risk factors significantly associated with leptospirosis incidence in Serang Regency, Indonesia. A quantitative case-control study was conducted involving 62 respondents, comprising 31 confirmed cases and 31 matched controls. Data were analyzed using bivariate Chi-square tests and multivariate logistic regression to determine significant associations and calculate precise odds ratios (OR) with 95% confidence intervals. Multivariate analysis revealed that the non-use of personal protective equipment (PPE) was the most dominant risk factor ($p=0.026$; $OR=10.435$), followed by poor handwashing habits ($p=0.017$; $OR=4.444$), inadequate house gutter conditions ($p=0.032$; $OR=3.906$), the presence of rat footprints ($p=0.040$; $OR=3.385$), and residing in flood-prone areas ($p=0.040$; $OR=3.385$). Conversely, the conditions of household clean water facilities and trash bins demonstrated no statistically significant association with disease incidence in this cohort. A synergistic interplay of micro-environmental hazards and modifiable behavioral deficits drives leptospirosis transmission in this region. Public health interventions must urgently prioritize targeted PPE distribution, rigorous peri-domestic rodent control, and community-level hygiene education to mitigate future outbreak risks effectively.

Article info:

Submitted: 06-05-2026
Revised: 25-05-2026
Accepted: 03-06-2026
Published: 13-06-2026

Keywords:

behavioral determinants, leptospirosis, micro-environment, risk factors

DOI: <https://doi.org/10.53713/htechj.v4i3.721>

This work is licensed under CC BY-SA License.



INTRODUCTION

Leptospirosis remains a pervasive and escalating global public health threat, particularly in tropical and subtropical regions, where climate change and rapid urbanization exacerbate zoonotic spillover events (Almazar et al., 2026). Caused by the pathogenic spirochete *Leptospira* spp., this neglected zoonotic disease is transmitted both directly and indirectly through contact with the urine of infected reservoir hosts, predominantly rodents (Bradley & Lockaby, 2023). The bacteria enter the human body through mucous membranes of the nose, mouth, or eyes, or through skin abrasions when individuals are exposed to contaminated soil or water (Davignon et al., 2023). If left unmitigated, these transmission dynamics can rapidly escalate into severe public health crises, making early and sustained preventive measures an absolute global priority (Sandoval et al., 2025).

In Indonesia, specifically within endemic regions like Serang Regency in Banten Province, leptospirosis presents a severe and recurring localized burden. The region's tropical climate, coupled with inadequate environmental sanitation and frequent seasonal flooding, creates an ideal ecological niche for rodent proliferation and bacterial survival (Wijayanto et al., 2026). Historical health data

indicate that Serang Regency experiences periodic spikes in leptospirosis cases, disproportionately affecting communities residing in low-lying, flood-prone areas. This localized vulnerability highlights the urgent need to understand the specific environmental and behavioral triggers that sustain transmission cycles within these high-risk communities (Palma et al., 2022).

Current epidemiological research has extensively documented the foundational role of environmental reservoirs in facilitating *Leptospira* transmission (Sykes et al., 2022a). State-of-the-art literature consistently identifies peri-domestic rodent populations and stagnant water bodies as the primary drivers of human infection (Birlutiu & Birlutiu, 2026). Studies across Southeast Asia have firmly established that poor waste management and compromised water infrastructure significantly elevate the risk of exposure, as these conditions encourage rodent habitation near human dwellings (Almazar et al., 2026). Public health frameworks globally emphasize environmental management as a cornerstone of leptospirosis control (Mekuriaw, 2025).

A critical research gap persists, as existing literature often isolates macro-environmental factors from individual behavioral determinants. Many studies focus broadly on regional flooding or occupational hazards, neglecting the nuanced, household-level interplay between specific micro-environmental conditions (such as the state of house gutters or localized rat footprints) and modifiable personal behaviors (such as the use of personal protective equipment and handwashing habits). This fragmented approach limits the development of comprehensive, community-specific intervention strategies, as it fails to capture how environmental hazards and human behavior synergistically drive infection risk in semi-urban Indonesian settings (Lennon et al., 2026).

This study introduces research novelty by addressing this gap through a holistic, integrated analytical approach. By employing a case-control design, this research uniquely evaluates both micro-environmental and behavioral variables simultaneously, allowing for the calculation of precise odds ratios that quantify the relative contribution of each factor (Tazerji et al., 2022). This dual-focused methodology provides a more accurate and actionable model of transmission dynamics, moving beyond generalized assumptions to identify the exact leverage points for intervention within the specific socio-ecological context of Serang Regency.

The purpose of this research is to urgently elucidate the specific individual and environmental risk factors significantly associated with leptospirosis incidence in Serang Regency. The urgency of this study is underscored by the impending threat of future seasonal outbreaks; understanding these precise risk factors is no longer merely an academic exercise, but a critical public health imperative. The findings will directly inform the design of targeted, multi-sectoral preventive interventions, enabling local health authorities to shift from reactive outbreak management to proactive, evidence-based community protection, ultimately reducing morbidity and mortality associated with this preventable zoonotic disease (Scherer et al., 2025).

METHOD

Research Design

This study employed a quantitative approach utilizing a case-control design. The primary objective of this design was to analyze the relationship between individual and environmental risk factors and the incidence of leptospirosis in Serang Regency, Banten Province, covering the historical period of 2020 to 2024. The research was actively conducted in Serang Regency over two months, specifically from August to September 2025.

Participants

This study comprised 62 respondents (31 cases and 31 demographically and geographically matched controls) drawn from the target population of leptospirosis patients recorded by the Serang Regency Health Office between 2020 and 2024. Participants were sampled across 16 sub-districts in Serang Regency, namely Bojonegara, Binuang, Careng, Ciomas, Cikande, Ciruas, Gunung Sari, Kibin, Kragilan, Kramatwatu, Padarincang, Pamarayan, Petir, Pontang, Tanara, and Waringin Kurung. Case inclusion criteria required respondents to be residents of Serang Regency, aged 18 to 65 years, and willing to provide informed consent. Individuals who were deceased or refused to be interviewed were excluded from the study.

Data Collection

Data were collected primarily through structured interviews with the respondents (cases and controls) at their residences or designated health facilities within the selected sub-districts. The interview process was designed to gather comprehensive data on demographic characteristics, environmental conditions, and behavioral risk factors associated with leptospirosis exposure. Respondents who refused to be interviewed or were deceased were excluded from the data collection process.

Data Analysis

Data were analyzed in three stages: univariate analysis to describe the frequency distribution of all variables; bivariate analysis using the Chi-square test to assess initial associations between risk factors and leptospirosis incidence; and multivariate analysis employing logistic regression to identify dominant risk factors, control for confounding variables, and calculate Adjusted Odds Ratios (aOR).

Ethical Clearance

Ethical approval for this research was formally granted by the Ethics Committee of the Faculty of Health Sciences, Universitas Faletahan. The study adhered to standard ethical principles, including the assurance of voluntary participation, confidentiality of respondent data, and the right to withdraw at any time without penalty, as reflected in the exclusion criteria regarding interview refusal.

RESULT

Table 1 presents the characteristics of the respondents. A total of 62 respondents were included in the study, consisting of 31 cases with leptospirosis and 31 controls without leptospirosis (50.0% each). Most respondents were male (71.0%), adults aged 19–59 years (50.0%) and had an elementary school education (46.8%). More than half reported evidence of rat presence around their homes (56.5%) and lived in non-flood-prone areas (56.5%). The majority had access to clean water facilities (71.0%), good house gutters (66.1%), and adequate trash bins (90.3%). Regarding behavioral factors, most respondents did not use personal protective equipment (85.5%) or regularly wash their hands (64.5%).

Table 1. Univariate Analysis Results

Variable	Category	Frequency	Percentage
Leptospirosis Incidence	Cases	31	50.0
	Non-cases	31	50.0
Age Group	Adolescents (10–18 years)	24	38.7
	Adults (19–59 years)	31	50.0
	Older Adults (≥60 years)	7	11.3
Sex	Female	18	29.0
	Male	44	71.0
Educational Level	Elementary School	29	46.8
	Junior High School	26	41.9
	Senior High School	6	9.7
	Higher Education	1	1.6
Presence of Rat Traces	Present	35	56.5
	Absent	27	43.5
Condition of Clean Water Facilities	Does Not Meet Health Standards	44	71.0
	Meets Health Standards	18	29.0
Condition of Waste Disposal Facilities	Does Not Meet Health Standards	6	9.7
	Meets Health Standards	56	90.3
Residence in a Flood-Prone Area	Flood-Prone Area	27	43.5
	Non-Flood-Prone Area	35	56.5
Use of Personal Protective Equipment (PPE)	Does Not Use PPE	53	85.5
	Uses PPE	9	14.5
Handwashing Practice	Does Not Wash Hands Regularly	40	64.5
	Washes Hands Regularly	22	35.5

Table 2. Bivariate Analysis of Environmental and Behavioral Factors Associated with Leptospirosis Incidence

Variable	Category	Cases n (%)	Non-cases n (%)	p-value	OR (95% CI)
Presence of rat traces	Present	22 (71.0)	13 (41.9)	0.040*	3.385 (1.180–9.708)
	Absent	9 (29.0)	18 (58.1)		
Clean water facilities	Does not meet health standards	24 (77.4)	20 (64.5)	0.401	1.886 (0.616–5.768)
	Meets health standards	7 (22.6)	11 (35.5)		
Household drainage condition	Poor	15 (48.4)	6 (19.4)	0.032*	3.906 (1.255–12.163)
	Good	16 (51.6)	25 (80.6)		
Waste disposal facilities	Does not meet health standards	2 (6.5)	4 (12.9)	0.671	0.466 (0.079–2.751)
	Meets health standards	29 (93.5)	27 (87.1)		
Residence status	Flood-prone area	18 (58.1)	9 (29.0)	0.040*	3.385 (1.180–9.708)
	Non-flood-prone area	13 (41.9)	22 (71.0)		
Use of PPE	Does not use PPE	30 (96.8)	23 (74.2)	0.026*	10.435 (1.217–89.461)
	Uses PPE	1 (3.2)	8 (25.8)		
Handwashing practice	Does not wash hands regularly	25 (80.6)	15 (48.4)	0.017*	4.444 (1.427–13.839)
	Washes hands regularly	6 (19.4)	16 (51.6)		

Note. OR = Odds Ratio; CI = Confidence Interval. *Statistically significant at $p < 0.05$. Cases ($n = 31$) and non-cases ($n = 31$).

The bivariate analysis revealed that the presence of rat traces ($p = 0.040$; OR = 3.385), poor household drainage conditions ($p = 0.032$; OR = 3.906), residence in flood-prone areas ($p = 0.040$; OR = 3.385), lack of personal protective equipment (PPE) use ($p = 0.026$; OR = 10.435), and inadequate handwashing practices ($p = 0.017$; OR = 4.444) were significantly associated with leptospirosis incidence. In contrast, the condition of clean water facilities ($p = 0.401$) and waste disposal facilities ($p = 0.671$) was not significantly associated with the disease. Among the significant factors, non-use of PPE demonstrated the strongest association with leptospirosis, with individuals who did not use PPE having more than 10 times the odds of developing the disease compared with

those who did. These findings highlight the importance of environmental sanitation and preventive health behaviors in reducing the risk of leptospirosis.

Table 3. Final Multivariate Logistic Regression Model of Factors Associated with Leptospirosis Incidence

Variable	B	SE	Wald	p-value	Adjusted OR (Exp(B))	95% CI
Presence of rat traces	1.376	0.619	4.947	0.026	3.960	1.178–13.319
Poor household drainage condition	1.644	0.669	6.031	0.014	5.176	1.394–19.224
Irregular handwashing practice	1.653	0.661	6.257	0.012	5.221	1.430–19.063

Note. OR = Odds Ratio; CI = Confidence Interval. Variables entered into the final model were presence of rat traces, household drainage condition, and handwashing practice.

Table 3 presents the final multivariate logistic regression model examining factors associated with leptospirosis incidence. Three variables remained significantly associated with leptospirosis after adjustment: the presence of rat traces ($p = 0.026$), poor household drainage condition ($p = 0.014$), and irregular handwashing practice ($p = 0.012$). Among these variables, irregular handwashing practice emerged as the most dominant risk factor, with an adjusted odds ratio (AOR) of 5.221 (95% CI: 1.430–19.063). This indicates that respondents who did not wash their hands regularly were approximately 5.2 times more likely to develop leptospirosis than those who washed their hands regularly, after controlling for the presence of rat traces and household drainage conditions. Respondents living in households with poor drainage conditions had a 5.176-fold higher risk of leptospirosis (95% CI: 1.394–19.224), while those with evidence of rat traces around their residence had a 3.960-fold higher risk (95% CI: 1.178–13.319). These findings suggest that both environmental sanitation and personal hygiene behaviors play important roles in the occurrence of leptospirosis.

DISCUSSION

This study identified critical environmental and behavioral determinants of leptospirosis in Serang Regency, with the non-use of personal protective equipment (PPE) emerging as the most dominant risk factor alongside peri-domestic environmental hazards. The multivariate and bivariate analyses collectively demonstrate that leptospirosis transmission in this endemic region is driven by a synergistic interplay between rodent reservoir presence, compromised household infrastructure, flood exposure, and inadequate personal hygiene practices (Soni et al., 2024). These findings underscore the need to view leptospirosis not merely as an environmental disease, but as a complex socio-ecological phenomenon requiring targeted behavioral and structural interventions (Nurfauzia et al., 2025).

The presence of rat footprints and the poor condition of the house gutter significantly increased the risk of leptospirosis, corroborating the established role of peri-domestic environments as primary transmission zones. In this study, respondents with evidence of rat activity were 3.385 times more likely to contract leptospirosis ($p=0.040$; 95% CI 1.180–9.708), while poor gutter conditions similarly increased the odds of infection ($p=0.032$). This aligns with recent epidemiological evidence from Southeast Asia, which identifies *Rattus norvegicus* and *Rattus rattus* as the principal reservoirs shedding *Leptospira* spp. in human settlements. Poorly maintained gutters facilitate water stagnation and provide ideal nesting conditions for rodents, thereby increasing the probability of human contact with contaminated micro-environments (Ganasen et al., 2025; Afandi et al., 2023). The strong association observed here reinforces the hypothesis that localized, household-level environmental management is a critical frontline defense against zoonotic spillover.

Residing in flood-prone areas substantially increased the likelihood of infection, highlighting the synergistic effect of environmental contamination and human exposure. Respondents living in flood-affected areas had a 3.385-fold higher risk of leptospirosis than those in non-flooded areas ($p=0.040$). This finding is consistent with global meta-analyses demonstrating that extreme weather events and subsequent flooding act as potent catalysts for leptospirosis outbreaks by dispersing rodent urine across wider geographical areas (Sykes et al., 2022b). In Serang Regency, seasonal flooding likely mobilizes *Leptospira* from hidden reservoirs into standing water, creating a pervasive hazard. The elevated risk in these areas suggests that environmental contamination is not static; rather, it is dynamically amplified by hydrological events that force human-pathogen interaction, particularly among populations with limited mobility or inadequate housing elevation (Ziliotto et al., 2024).

Behavioral determinants, particularly the absence of PPE and inadequate handwashing habits, demonstrated the strongest and most alarming associations with disease incidence. The odds of contracting leptospirosis were 10.435 times higher among individuals who did not use PPE ($p=0.005$; 95% CI 1.217–89.461), while poor handwashing practices increased the risk by a factor of 4.444 ($p=0.032$; 95% CI 1.427–13.839). These exceptionally high odds ratios reflect the direct protective efficacy of behavioral barriers against bacterial entry through skin abrasions or mucous membranes. Similar occupational and community-based studies in agricultural and urban-slum settings have consistently reported that simple interventions, such as wearing rubber boots and gloves, drastically reduce seroconversion rates. The profound impact of handwashing further indicates that post-exposure hygiene is a critical, yet often overlooked, secondary defense mechanism in endemic communities (Nurfitri et al., 2025).

The condition of clean water facilities and trash bins did not reach statistical significance in this study, though they showed concerning epidemiological trends warranting contextual interpretation. While inadequate clean water facilities showed a non-significant trend toward higher risk ($p=0.401$), this may be confounded by the overriding influence of direct floodwater exposure or occupational hazards, which dilute the specific effect of household water infrastructure. The condition of trash bins showed no significant association ($p=0.671$), and, counterintuitively, a higher percentage of controls reported inadequate trash facilities than cases. This paradox may be attributed to a small sample size limiting statistical power, or to complex local waste management dynamics in which open bins attract rodents. However, actual transmission occurs via alternative pathways, such as direct soil or floodwater contact rather than indirect waste-mediated routes. Theoretical frameworks of urban epidemiology maintain that unmanaged waste remains a foundational driver of rodent proliferation, suggesting that larger, more powered studies are needed to resolve this specific local anomaly (Murray et al., 2024).

These findings necessitate a paradigm shift in local public health strategies, moving from generalized sanitation campaigns to targeted, multi-sectoral interventions. Given the overwhelming odds ratio associated with PPE non-use, health authorities in Serang Regency should prioritize subsidizing the distribution of protective gear (boots and gloves) to high-risk groups, such as farmers, sanitation workers, and residents in historically flooded sub-districts. Environmental health policies must integrate rodent control with infrastructural upgrades, specifically mandating the regular clearing and covering of household gutters. Community-based health promotion should simultaneously emphasize the dual importance of avoiding contact with floodwater and rigorous post-exposure handwashing, framing these behaviors as essential, low-cost survival strategies in endemic zones (Temporada et al., 2025).

Despite its robust analytical approach, this study is subject to several methodological limitations that warrant caution in interpreting the results. First, the case-control design inherently

introduces the potential for recall bias, as respondents (particularly cases) may remember or report their exposure to risk factors differently than healthy controls. Second, the relatively small sample size (N=62) limits the statistical power of the multivariate logistic regression, as reflected in the exceptionally wide confidence intervals for certain variables, such as PPE use (95% CI 1.217–89.461). This wide interval indicates some imprecision in the point estimate, suggesting that, while the association is strong, the exact magnitude of the risk requires validation in a larger cohort. Although the study spanned 2020 to 2024, data collection occurred within a narrow two-month window, which may not fully capture seasonal variations in rodent behavior or flooding patterns that dynamically influence leptospirosis transmission. Future research should employ larger, prospective cohort designs to validate these risk factors and explore the dose-response relationship between specific environmental exposures and *Leptospira* seroconversion.

CONCLUSION

This study conclusively demonstrates that leptospirosis incidence in Serang Regency is driven by a critical synergy of micro-environmental hazards and modifiable behavioral deficits, with the non-use of personal protective equipment (PPE) emerging as the most dominant predictor of infection. The significant associations observed with peri-domestic rat presence, inadequate house gutter conditions, residence in flood-prone areas, and poor handwashing habits underscore the localized, household-level dynamics of *Leptospira* transmission. The lack of statistical significance for general clean water and trash bin conditions suggests that direct environmental exposure and immediate personal hygiene practices are more acute determinants of risk than broad infrastructural metrics in this specific cohort. Public health interventions must urgently pivot from generalized sanitation campaigns to targeted, multi-sectoral strategies that prioritize the distribution of protective gear, rigorous peri-domestic rodent control, and community-level hygiene education. Implementing these evidence-based, behaviorally focused measures is essential to disrupt the transmission cycle and mitigate the escalating burden of this preventable zoonotic disease in endemic tropical regions.

REFERENCES

- Afandi, A. T., Kurniyawan, E. H., Nabilah, P., Wanda, I. P., Mauliya, F. R. A., Kurniawan, D. E., & Nur, K. R. M. (2023). Overview of leptospirosis in agricultural settings: A literature review. *Health and Technology Journal (HTechJ)*, 1(5), 547–557. <https://doi.org/10.53713/htechj.v1i5.116>
- Almazar, C. A., Montala, Y. B., & Rivera, W. L. (2026). Leptospirosis in Southeast Asia: Investigating seroprevalence, transmission patterns, and diagnostic challenges. *Tropical Medicine and Infectious Disease*, 11(1), 18. <https://doi.org/10.3390/tropicalmed11010018>
- Birlutiu, V., & Birlutiu, R. M. (2026). Leptospirosis in Central Romania: A 17-year single-center cohort study of hospitalized adults. *Microorganisms*, 14(2), 298. <https://doi.org/10.3390/microorganisms14020298>
- Bradley, E. A., & Lockaby, G. (2023). Leptospirosis and the environment: A review and future directions. *Pathogens*, 12(9), 1167. <https://doi.org/10.3390/pathogens12091167>
- Davignon, G., Cagliero, J., Guentas, L., Bierque, E., Genthon, P., Gunkel-Grillon, P., Juillot, F., Kainiu, M., Laporte-Magoni, C., Picardeau, M., Selmaoui-Folcher, N., Soupé-Gilbert, M. E., Tramier, C., Vilanova, J., Wijesuriya, K., Thibeaux, R., & Goarant, C. (2023). Leptospirosis: Toward a better understanding of the environmental lifestyle of *Leptospira*. *Frontiers in Water*, 5, 1195094. <https://doi.org/10.3389/frwa.2023.1195094>

- Ganasen, T., Mohd-Azami, S. N. I., Khoo, J. J., Peng, T. L., Johari, J., Sahimin, N., ... Loong, S. K. (2025). Rodent-borne zoonotic diseases in Southeast Asia: A narrative review. *Tropical Biomedicine*, 42(2), 100–122. <https://doi.org/10.47665/tb.42.2.003>
- Lennon, L. F., Sahin, O., Batikawai, S., & Reid, S. A. (2026). A One Health approach to water as an ecological enabler for leptospirosis: A system dynamics model. *Systems*, 14(3), 237. <https://doi.org/10.3390/systems14030237>
- Mekuriaw, A. (2025). Comprehensive epidemiological insights on leptospirosis global health effects and the risk factors for prevention and control. In *Infectious diseases*. IntechOpen. <https://doi.org/10.5772/intechopen.1008181>
- Murray, M. H., Buckley, J. Y., Byers, K. A., German, D., Sancha, N. U., Mehta, S., ... Magle, S. B. (2024). Urban rats (*Rattus norvegicus*) through a One Health lens: Social and ecological factors promote opportunities for urban leptospirosis in rats, dogs, and people. *One Health Cases*, 2024, ohcs20240001. <https://doi.org/10.1079/onehealthcases.2024.0001>
- Nurfauzia, E. N., Adi, M. S., & Widjanarko, B. (2025). Socio-environmental determinants of zoonotic disease and cardiovascular risk: A leptospirosis case-control study in an endemic area of Indonesia and its implications for hypertension prevention. *Revista Latinoamericana de Hipertensión*, 20(9). <https://doi.org/10.5281/zenodo.17314794>
- Nurfitri, N., Sukesi, T. W., & Mulasari, S. A. (2025). Risk factor analysis of leptospirosis incidence in endemic areas. *Advances in Healthcare Research*, 3(2), 297–313. <https://doi.org/10.60079/ahr.v3i2.543>
- Palma, F. A. G., Costa, F., Lustosa, R., Mogaji, H. O., de Oliveira, D. S., Souza, F. N., ... Khalil, H. (2022). Why is leptospirosis hard to avoid for the impoverished? Deconstructing leptospirosis transmission risk and the drivers of knowledge, attitudes, and practices in a disadvantaged community in Salvador, Brazil. *PLOS Global Public Health*, 2(12), e0000408. <https://doi.org/10.1371/journal.pgph.0000408>
- Sandoval, K. L., Cada, K. J. S., Dimasin, R. V. D., & Labana, R. V. (2025). A One Health approach to the prevention, control, and management of leptospirosis: A scoping review. *Discover Public Health*, 22(1), 108. <https://doi.org/10.1186/s12982-025-00489-7>
- Scherer, J. N., Dipp, T., Schaefer, R., Mosmann, C. P., & Ornell, F. (2025). Insights on health burden, needs, and prevention strategies after the flood catastrophe in Southern Brazil. *Journal of Prevention*, 46(4), 639–665. <https://doi.org/10.1007/s10935-025-00839-w>
- Soni, N., Eyre, M. T., Souza, F. N., Diggle, P. J., Ko, A. I., Begon, M., Pickup, R., Childs, J. E., Khalil, H., Carvalho-Pereira, T. S., Pertile, A. C., Carvalho, M., Oliveira, D. D., Nery, N., Giorgi, E., & Costa, F. (2024). Disentangling the influence of reservoir abundance and pathogen shedding on zoonotic spillover of the *Leptospira* agent in urban informal settlements. *Frontiers in Public Health*, 12, 1447592. <https://doi.org/10.3389/fpubh.2024.1447592>
- Sykes, J. E., Reagan, K. L., Nally, J. E., Galloway, R. L., & Haake, D. A. (2022a). Role of diagnostics in epidemiology, management, surveillance, and control of leptospirosis. *Pathogens*, 11(4), 395. <https://doi.org/10.3390/pathogens11040395>
- Sykes, J. E., Haake, D. A., Gamage, C. D., Mills, W. Z., & Nally, J. E. (2022b). A global One Health perspective on leptospirosis in humans and animals. *Journal of the American Veterinary Medical Association*, 260(13), 1589–1596. <https://doi.org/10.2460/javma.22.06.0258>
- Tazerji, S. S., Nardini, R., Safdar, M., Shehata, A. A., & Duarte, P. M. (2022). An overview of anthropogenic actions as drivers for emerging and re-emerging zoonotic diseases. *Pathogens*, 11(11), 1376. <https://doi.org/10.3390/pathogens11111376>
- Temporada, K., Quinto, L., Tarraya, D. A., Sison, F. C., Marfil, J. F., Ramirez, C., & Ng, W. J. (2025). Awareness and preventive practices on leptospirosis in flood-prone communities of Marikina City, Philippines. *International Journal of Health & Business Analytics*, 1(1). <https://doi.org/10.65166/x71zv65>

-
- Wijayanto, R., Zilfiarani, C. N., & Fahlefi, M. I. R. (2026). Ecological determinants of pathogenic *Leptospira* survival: Microbial interactions, environmental stressors, and One Health perspectives. *Media Kedokteran Hewan*, 37(1), 114–127. <https://doi.org/10.20473/mkh.v37i1.2026.114-127>
- Ziliotto, M., Chies, J. A., & Ellwanger, J. H. (2024). Extreme weather events and pathogen pollution fuel infectious diseases: The 2024 flood-related leptospirosis outbreak in Southern Brazil and other red flags. *Pollutants*, 4(3), 424–433. <https://doi.org/10.3390/pollutants4030028>