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Risk Factor Analysis of Leptospirosis Incidence in Endemic Areas

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ABSTRACT

Purpose: Leptospirosis is a zoonotic disease transmitted by rats, which serve as the primary vector, and is caused by the bacterium Leptospira. This disease is a serious concern in tropical regions, including Indonesia, due to its high incidence and mortality rates. This study aims to analyze various risk factors that influence the incidence of leptospirosis in endemic areas, based on the latest scientific literature.

Research Method: This study employed a systematic literature review method, searching articles published between 2020 and 2024 on the Google Scholar and PubMed platforms. From the 268 articles identified using the keywords "Leptospirosis, Rats, Risk Factors," a selection was made based on inclusion and exclusion criteria, resulting in 10 relevant articles. Five of these articles were selected for further analysis.

Results and Discussion: The results of the study indicate that several significant risk factors for leptospirosis include: the presence of Leptospira bacteria in the environment, distance of homes from waterways, standing water, garbage conditions, presence of rats, pet ownership, risky activities, use of personal protective equipment, and history of flooding.

Implications: This study contributes to the formulation of risk-based prevention policies and supports more targeted public health interventions in areas endemic to leptospirosis.

Keywords: leptospirosis; rats; risk factors; environmental factors; flooding.

Introduction

Leptospirosis is an acute infectious disease caused by the bacterium Leptospira and is classified as a zoonotic disease because it can be transmitted from animals to humans. This disease poses a significant public health problem in tropical and subtropical regions, mainly due to its strong association with poor environmental conditions, high rainfall, and inadequate sanitation (Widiastuti & Priyanto, 2020). Leptospirosis is primarily transmitted through direct or indirect contact with the urine of infected animals, particularly rats, which are the primary reservoir of Leptospira bacteria. These bacteria can enter the human body through broken skin, mucous membranes, eyes, nose, or contaminated food. Leptospirosis is also known for its initial symptoms, which are similar to those of influenza, including fever, chills, headache, and muscle pain. However, it can develop into serious complications affecting the liver and kidneys and may lead to death if not treated promptly and appropriately (Sholeh *et al.*, 2024). In Indonesia, leptospirosis is an endemic disease with cases often increasing during the rainy

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season. Data from the Ministry of Health indicate a significant increase in leptospirosis cases, from 734 cases in 2021 to 1,419 cases in 2022, resulting in 139 deaths and a Case Fatality Rate (CFR) of 9.8%, which exceeds the epidemiological threshold of 7% (Nugraha, 2022). East Java Province is the most significant contributor with a 28.3% share. The issue is further complicated by the fact that leptospirosis transmission is not solely attributed to poor sanitation but also involves various factors such as population density, the presence of rats in residential areas, and inadequate hygiene practices among the community (Ministry of Health, 2021). This is exacerbated by the lack of awareness regarding the use of personal protective equipment when working or engaging in activities in high-risk environments, such as agriculture, slaughterhouses, and flood-prone areas (Pratamawati *et al.,* 2018).

Research on leptospirosis has shown that this disease is highly influenced by various interacting risk factors, including environmental factors, individual behavior, living conditions, and occupational type. A study conducted by Pratamawati *et al.,* (2018) highlighted that the transmission of leptospirosis is closely linked to unhealthy living environments, particularly those with standing water and inadequate drainage systems. Such environments provide an ideal habitat for rats, which are the primary reservoir of Leptospira bacteria. Occupational factors are also a crucial variable in leptospirosis research. Activities involving direct contact with water or mud contaminated with animal urine pose a high risk. Some high-risk occupations identified include farmers, slaughterhouse workers, sanitation workers, and those in mining and construction (Ministry of Health of the Republic of Indonesia, 2017). Donaliazarti, (2020) notes that these occupational groups tend to have high exposure to potentially contaminated environments and often lack adequate personal protective equipment. In the context of individual behavior, a study by Sofiyani *et al.,* (2018) emphasizes the importance of preventive behaviors, such as wearing protective footwear, when working in hazardous environments. The habit of not wearing footwear, especially when working in rice fields or flood-prone areas, increases the risk of bacterial entry through minor skin cuts. Pratamawati *et al.,* (2018) also emphasize that the lack of public awareness about the importance of self-protection is a primary cause of the high incidence of leptospirosis in rural areas. The presence of pets and rodents has also been highlighted in recent studies. Ariani & Wahyono (2020) revealed that out of 34 studies in the Asia-Pacific region, 25 confirmed that the presence of rodents and pets is a significant factor in the spread of leptospirosis. The Leptospira bacteria found in animal urine can contaminate water, soil, and other surfaces, which then become transmission vectors to humans. Sholeh et al. (2024) added that leptospirosis infections often go undetected because their symptoms resemble the flu, but can progress into life-threatening liver and kidney disorders if not promptly treated.

Several studies have been conducted to identify risk factors for leptospirosis outbreaks. However, most of these studies remain partial, limited to specific geographical areas, and have not integrated a comprehensive multidisciplinary approach. For example, the study by Widiastuti & Priyanto (2020) focuses more on biological transmission aspects without delving into the interactions between community behavior and local environmental conditions. On the other hand, a study by the Indonesian Ministry of Health (2017) focused more on epidemiological and descriptive data related to the spread of cases, without providing an in-depth exploration of the causal relationships between risk variables such as occupation, hygiene behavior, and the presence of rats in residential environments. For example, Donaliazarti's (2020) research has revealed the role of occupation and clinical symptoms of leptospirosis but has not systematically linked them to environmental and social factors that accelerate disease transmission. Theoretical gaps also arise due to the lack of a solid conceptual framework to integrate risk factors. Many studies discuss aspects of risk separately without presenting an analytical model that

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comprehensively explains the relationships between these factors. Additionally, there is a lack of systematic literature reviews that highlight leptospirosis risk factors in endemic areas, considering local dynamics such as tropical climate conditions, population density, and community behavioral adaptations to infection risks. However, this systematic approach is urgently needed to provide a robust scientific framework for formulating more effective and evidence-based prevention policies.

The novelty of this study lies in its approach, which presents a systematic and comprehensive literature review of various risk factors for leptospirosis in endemic areas, encompassing biological, environmental, behavioral, and social dimensions. Unlike previous studies, which tend to be descriptive and fragmented, this research aims to establish a comprehensive understanding of the interrelationships between the presence of animal reservoirs, environmental sanitation, individual behavior, and occupational factors that contribute to the risk of leptospirosis infection. This study also aims to address gaps in the literature that have not been extensively examined in the context of tropical regions with high population density and limited sanitation. The primary objective of this study is to identify, summarize, and critically analyze various empirical findings from relevant previous studies to produce a more accurate risk factor mapping that can serve as a scientific basis for developing more effective and contextually appropriate prevention and control strategies for leptospirosis in endemic areas.

Literature Review and Hypothesis Development

Leptospirosis is an acute infectious disease caused by spiral-shaped, gram-negative bacteria of the genus Leptospira. It is classified as a zoonosis because it is transmitted from animals to humans. The disease spreads through direct contact with the urine of infected animals or indirectly through contaminated water and soil. Humans can become infected when the bacteria enter the body through open wounds on the skin or mucous membranes, such as the eyes, nose, and mouth (Bradley & Lockaby, 2023). Leptospira bacteria are known to survive in moist and wet environments for extended periods, increasing the risk of transmission, particularly in areas with poor sanitation and high rainfall. These pathogenic characteristics make leptospirosis one of the neglected tropical diseases with significant impacts on public health, particularly in agricultural communities and densely populated areas exposed to flooding or standing water (Narayan *et al.,* 2024). Clinically, leptospirosis is characterized by a wide range of symptoms, including fever, muscle pain, headache, and severe complications such as kidney damage, hepatitis, or pulmonary hemorrhage. Accurate diagnosis can be challenging due to symptoms that resemble those of other infectious diseases, such as dengue or malaria. The disease is endemic in tropical regions such as Southeast Asia, including Indonesia, and cases often surge during the rainy season or after natural disasters like floods (Caimi & Ruybal, 2020). One of the distinctive features of leptospirosis is its strong association with the environment and human activities, particularly those involving exposure to contaminated water or soil. Therefore, a comprehensive understanding of the definition and general characteristics of leptospirosis is crucial in developing risk-based prevention and control strategies.

Leptospirosis is a zoonotic infectious disease caused by bacteria from the genus Leptospira, which are Gram-negative, spiral-shaped, motile, and aerobic bacteria. These bacteria are known for their high adaptability to various environmental conditions, particularly moist and warm environments, making them highly prone to spreading in tropical regions like Indonesia (Narayan *et al.,* 2024). Its distinctive morphological structure, characterized by a long, spiral shape with hook-shaped ends

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reinforced by the presence of periplasmic flagella that facilitate active movement within host tissues and environmental media enables it to penetrate bodily tissues through damaged skin surfaces or mucous membranes, causing various systemic disorders, particularly affecting the liver and kidneys (De Brito *et al.,* 2018). Pathogenic Leptospira species include Leptospira interrogans and Leptospira borgpetersenii, which are commonly found in rodents such as rats, as well as livestock and other wild animals (Rao *et al.,* 2025). The presence of biofilm genes in these bacteria enables them to survive in the external environment of the host for extended periods, particularly in standing water, mud, and moist soil, thereby enhancing the potential for indirect transmission (Hao *et al.,* 2022).

Transmission of leptospirosis to humans can occur through two main routes: direct and indirect. Direct transmission occurs when humans come into direct contact with the urine or tissues of infected animals, most commonly rats, as well as cattle, dogs, pigs, and other wild animals that serve as natural reservoirs for Leptospira bacteria (Davignon *et al.,* 2023). In the context of livestock farming and agriculture, exposure to urine or bodily fluids from infected animals often occurs unnoticed, especially when workers fail to use personal protective equipment, such as gloves or rubber boots. Indirect transmission occurs through contact with water, soil, or mud contaminated by the urine of infected animals. Such transmission is highly prevalent in areas prone to flooding, standing water, or poor sanitation systems. Contamination through open wounds or mucous membranes, such as the eyes and nose, allows bacteria to enter the human body and spread through the bloodstream (Rao *et al.,* 2025). Tropical regions with high rainfall and high population density provide an ideal environment for these bacteria to survive and spread widely. According to Rajapakse *et al. (2025), environmental factors such as flooding and inadequate domestic waste management are the primary catalysts for the global increase in leptospirosis cases, including those in* Southeast Asia. Therefore, understanding this transmission mechanism is crucial for designing effective prevention strategies. This knowledge also supports public health risk mitigation efforts in endemic areas through behavior-based approaches and improvements in sanitation infrastructure.

Clinical symptoms of leptospirosis in humans are generally nonspecific in the early stages but can progress to more severe and life-threatening forms of the disease. The initial phase of infection is characterized by a sudden high fever, accompanied by muscle pain, particularly in the calves and lower back, nausea, vomiting, and a severe headache (Goyal *et al.,* 2021). These symptoms often resemble those of other viral infections, such as influenza or dengue fever, leading to frequent misdiagnosis in the early stages (World Health Organization, 2022). In some cases, the infection may progress to a more severe second phase known as Weil's syndrome. This phase involves systemic complications such as jaundice due to liver damage, acute kidney failure, and pulmonary hemorrhage, which can be fatal if not treated promptly (Govan *et al.,* 2025). These complications occur because Leptospira spreads through the bloodstream and attacks vital organs, particularly the kidneys and liver. A study by Davignon *et al.,* (2023) demonstrates that the presence of Leptospira in the body triggers an excessive immune response, leading to tissue damage due to systemic inflammation. Additionally, manifestations such as conjunctivitis, rashes, and joint pain are commonly observed in the early phase and serve as important indicators for clinical diagnosis, especially in endemic areas prone to periodic outbreaks.

The risk of exposure to leptospirosis is particularly high in tropical and subtropical regions, especially in areas with consistently high humidity, warm temperatures, and heavy rainfall throughout the year. This geographical environment provides an ideal habitat for Leptospira bacteria to survive in moist water and soil, thereby increasing the likelihood of transmission through indirect contact (Yan *et al.,* 2022). In conditions such as floods, standing water in residential areas, open drainage systems, and

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inadequate domestic waste management systems become primary transmission routes for bacteria originating from the urine of infected animals, particularly rats and livestock (Davignon *et al.,* 2023). Data from the Centers for Disease Control and Prevention (CDC, 2023) indicate that most leptospirosis cases in Southeast Asia, Latin America, and the Pacific occur after the rainy season or tropical storms, highlighting a strong link between extreme weather conditions and disease outbreaks. Additionally, a WHO report (2022) emphasizes that rapid urbanization without adequate development of sanitation infrastructure increases the accumulation of exposure risks in densely populated areas. Research by Govan *et al.,* (2025) further suggests that the presence of animal carriers, poor sanitation conditions, and economic activities such as agriculture and livestock farming, which involve contact with water and moist soil, further reinforce the characteristics of tropical regions as high-risk zones for leptospirosis.

Research Method

The method used in this systematic review was a critical review of full-text articles in Indonesian and English from the PubMed, Scopus, and Google Scholar databases. Articles were selected in stages using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) appraisal tool. The method began with a search for scientific literature in various databases using the keywords "human leptospirosis," "risk factor," and "Indonesia." Next, the abstracts of each relevant article were reviewed. Then, the researchers summarized the content of the articles, analyzed the results of the summaries, and compiled the findings into a written report. The literature search was conducted using Google Scholar, ScienceDirect, and Scopus platforms. The inclusion criteria for this study included articles that were freely accessible, published in either Indonesian or English, and published between 2020 and 2024, with an ISSN. The exclusion criteria included articles without full text, paid articles, literature review articles, duplicates, and articles not relevant to the keywords used.

The search process was determined using the following inclusion criteria:

- Articles published from 2020 to 2024.
- Research articles in Indonesian and English.
- Subject of research: Toddlers.
- Open access research articles.
- Research articles have full text.

Articles are searched for, organized, and then summarized for relevant articles. Relevance is determined by how clear the source of the article is and how well it relates to the topic you selected. Relevance considerations are based on the clarity of the article source and its relevance to the specified topic.

Results and Discussion

Analysis Result

The articles used as data in this study are presented in **Table A1** in the **APPENDIX** section. Table 1 presents five articles from various websites that analyzed risk factors for leptospirosis, employing an average quantitative research design with a cross-sectional approach. The articles used had at least 40 respondents. The articles used involved farmer respondents.

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Discussion

Distance from House to Drainage Canal

According to research conducted by Andriani & Sukendra, (2020) the distance between homes and drainage channels is a risk factor for leptospirosis. The risk analysis results yielded an OR of 4.27. This indicates that respondents living 700 meters from a drainage ditch have a higher risk. Rats, considered a highly prospective reservoir for Leptospira bacteria, have ample space to move at least 700 meters in a single night compared to other Leptospira reservoirs (Andriani & Sukendra, 2020). The study by Andriani & Sukendra, (2020) aligns with the research conducted by Rakebsa et al., (2018) in Yogyakarta and Bantul, which found that the distance between a house and a drainage channel is significantly associated with leptospirosis cases. However, this study contradicts the findings of Andriani & Sukendra (2020) from 2013 in the Banyumas region, which stated that there was no association between the distance between homes and drainage channels and the incidence of leptospirosis. The differences in findings in this study are attributed to variations in location and the different categories used in each study.

Condition of the Garbage Dump

Respondents in the case group with inadequate waste containers showed a percentage of 2.2%, which is lower than the control group's 32.2%. According to the results of statistical tests on the relationship between waste container conditions and leptospirosis cases, a significant correlation exists between the two variables. The odds ratio (OR) value of 2.995 indicates that individuals with inadequate waste containers have nearly three times the risk of contracting leptospirosis compared to those using adequate waste containers. These results align with Persiwi Research (201) in Patreregency, Central Java. Respondents with poor waste management practices were at a higher risk of contracting leptospirosis compared to those in areas with effective waste management. Additionally, the majority of respondents (61%) still had open waste disposal sites because they were continuously open, flooded, and infested by disease vectors, such as rats found near trash bins, which could facilitate the transmission of leptospirosis. Most respondents (61%) still have open and poorly maintained waste disposal sites, which are flooded and infested with disease vectors, allowing rats, such as garbage rats, to support the transmission of leptospirosis as they seek out residues.

The Existence of Garbage

A study conducted by Setyaningsih *et al.,* (2022) in Boyolali Regency demonstrated a significant association between the presence of waste and an increase in leptospirosis cases. Based on the results of this study, an odds ratio (OR) of 2.40 was obtained, meaning that an environment contaminated with waste is 2.40 times more likely to transmit leptospirosis. The presence of waste around homes has the potential to attract rats, which are the primary vectors for the spread of this disease, thereby increasing the likelihood of transmission (Andriani & Sukendra, 2020). However, the findings of Setyaningsih *et al.,* (2022) contradict those of Andriani & Sukendra, (2020) who reported no significant association between waste and leptospirosis cases. This discrepancy may be attributed to the differences in study locations, specifically Boyolali and Demak districts. Conversely, the findings of a study conducted in Malaysia in 2016 by Daud *et al.,* (2018) support the results of Setyaningsih *et al.,* (2022). The study showed that the presence of waste in livestock areas increases the risk of leptospirosis transmission by up to 2.4 times.

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This study indicates that an environment contaminated with waste can serve as a medium for the spread of leptospirosis, particularly in areas with high livestock populations.

The Presence of Puddles

Research conducted by Andriani & Sukendra, (2020) in Demak Regency revealed a significant relationship between the presence of standing water in the surrounding environment and an increase in the incidence of leptospirosis. In the study, the odds ratio (OR) obtained was 4.71, indicating that the presence of standing water increases the risk of leptospirosis transmission by a factor of 4.71. If the water is contaminated by urine, standing water in residential areas can serve as an indirect source of leptospirosis transmission, especially if infected animals carrying the Leptospira bacteria are present in the environment. A study by Andriani & Sukendra, (2020) in Demak Regency found that poor environmental conditions, such as standing water, increase the risk of leptospirosis. This finding aligns with the research by Maniiah *et al.,* (2016) in Semarang City, which also identified a significant association between the presence of standing water and leptospirosis cases. The statistical analysis in the study demonstrated that respondents who reported having standing water around their homes were 3.385 times more likely to be infected with leptospirosis compared to those without standing water around their homes (Andriani & Sukendra, 2020).

A similar study was conducted by Tanuwijaya, (2018) who noted that standing water in residential areas increases the risk of leptospirosis transmission by four times, especially when the water is exposed to rat urine, which is the primary reservoir of Leptospira bacteria. Similar results were found by Sari et al. (2019) in the Yogyakarta region, revealing that areas with extensive waterlogging have higher prevalence rates of leptospirosis. A significant association was also found between waterlogging in the environment and the increased prevalence of leptospirosis in the Yogyakarta region. This study suggests that areas with abundant standing water have higher rates of leptospirosis, indicating a significant relationship between the two factors. Therefore, standing water around residential areas can be a significant risk factor for leptospirosis transmission in the region.

Another study conducted by Prasetyo *et al.,* (2021) in Klaten Regency aligns with the findings of Setyaningsih *et al.,* (2022), which stated that household waste plays a significant role as a risk factor for leptospirosis cases. In this study, it was found that households with poorly managed waste had a higher risk of contracting leptospirosis because they were more likely to attract rats that could carry the leptospira bacteria. This study suggests better waste management as one of the preventive measures to reduce the risk of this disease. Furthermore, research by Wulandari *et al.,* (2020) in Magelang Regency also showed similar findings. This study highlights the significance of environmental sanitation, encompassing waste management, in mitigating the risk of leptospirosis. The study results indicate that homes located near open or poorly managed waste sites have a higher likelihood of experiencing leptospirosis infections due to interaction with rats and other animals.

The Presence of Mice in and Around the House

Research conducted by Grace Karina Rim Br Ginting & Sofwan Indarjo, (2022) in Demak Regency showed that the majority of respondents used open trash bins. This was due to the absence of lids, lost lids, or negligence in closing the trash bins, despite the facilities being available. The open condition of trash bins allows rats to access food sources in residential areas easily. Observations revealed that the presence of rats inside and around homes was more prevalent in the case group (48.9%) compared to

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the control group (41.1%). Statistical analysis indicates a significant association between the presence of rats and leptospirosis cases. Further calculation of the Odds Ratio (OR) yielded a figure of 9.514, indicating that individuals living in environments with rat presence have a 9.514 times higher risk of contracting leptospirosis compared to those not exposed to rats. These findings are supported by a study conducted by Samekto *et al.,* (2019) in Pati District, which stated that the presence of rats in the home environment is a primary risk factor for leptospirosis. Rats are known as the primary reservoir animals for this disease, contributing more than 50% to the spread of infection. Some of the rat species commonly associated with leptospira include Rattus norvegicus (sewer rat), Rattus diardii (house rat), Rattus exulans (field rat), and Suncus murinus (house shrew) (Ministry of Health of the Republic of Indonesia, 2017).

Use of Personal Protective Equipment

A study conducted by Andriani & Sukendra, (2020) showed that most respondents did not wear personal protective equipment, such as boots and gloves. Sofiyani *et al.,* (2018) explains that individuals who do not wear personal protective equipment while engaging in activities that pose a risk of leptospirosis are 2.8 times more likely to contract leptospirosis than those who do wear protective equipment. According to the Ministry of Health, the use of footwear can prevent direct contact with Leptospira bacteria, especially when engaging in activities in wet and waterlogged areas. This finding is supported by research conducted by (Mirasa *et al.,* 2017; Bhardwaj et al., 2009), which highlighted that in some areas, particularly in Yogyakarta, Demak, Semarang, Jakarta, and Madura (Java Island), one of the contributing factors to leptospirosis transmission is the lack of use of personal protective equipment when working in wet and waterlogged areas, which allows contact with urine contaminated with Leptospira bacteria. Another study conducted by Nursini, (2019) in Banten Regency also found that the use of personal protective equipment can significantly reduce the incidence of leptospirosis. Respondents who used boots and gloves had a much lower risk of infection compared to those who did not use protection.

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The Existence of Pets

In Demak Regency, a study conducted by Grace Karina Rim Br Ginting and Sofwan Indarjo in 2022 found that respondents who owned pets or livestock in the case group accounted for 30.0%, while in the control group, the rate reached 32.2%. There was no significant association between the presence of pets or livestock and the occurrence of leptospirosis. These findings are consistent with a study

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conducted by Nugroho *et al.,* (2024) in Tangerang District, Banten, which also indicated no significant association between pet ownership and leptospirosis cases. Animals carrying the Leptospira bacteria can release the bacteria through their urine or feces, which can infect humans if they come into contact with contaminated water or objects (Situmorang, 2017). Research by Schønning *et al.,* (2019) highlights that the proper management of pets and livestock can contribute to the transmission of Leptospira bacteria to humans. However, in this field study, despite respondents owning pets such as cats and birds, as well as livestock like goats, buffalo, and chickens, no evidence was found that these animals were infected with Leptospira bacteria. Therefore, the presence of these pets and livestock did not serve as a source of leptospirosis transmission in the context of this study.

The Existence of Ponds

Low-lying areas around rivers, coasts, and ponds are highly vulnerable to flooding, especially during the rainy season (Mwachui *et al.,* 2015). However, according to the statistical analysis in this study, no significant relationship was found between the presence of ponds and the occurrence of leptospirosis. This finding contradicts the results of a study conducted by Robertson et al. (2012), which reported a positive correlation between proximity to water bodies and an increased risk of leptospirosis. The difference in results is likely due to variations in the geographical characteristics of the study areas. Robertson *et al. (2012) conducted their study in Sri Lanka, an area with high population density, whereas* this study was carried out in Demak District, which is predominantly agricultural land. The absence of a significant association between the presence of fish ponds and leptospirosis cases in this study is also supported by respondent distribution data. The percentage of respondents living in areas categorized as high-risk pond areas was 19% in both the exposed and unexposed groups, indicating no significant difference in proportions between the two groups.

A total of 12.8% of respondents were categorized as living in high-risk areas near ponds. Based on the distribution, the percentage of respondents living in high-risk pond areas differed by 6.2% between the exposed and unexposed groups. Although there was a difference in proportions, the statistical test results indicated that the difference was not significant. Rats living in aquatic environments tend to build nests in tree holes along riverbanks. These holes are usually lined with dry grass to create a comfortable nest base, which the female rats use for giving birth and caring for their young. This condition increases the risk of pond water contamination by rat urine carrying Leptospira bacteria. Rats are known to be the primary reservoir of Leptospira bacteria, with more than 50% of the rat population able to continuously eliminate these bacteria through their urine throughout their lives without showing any symptoms of disease. Additionally, according to information from the Marine and Fisheries Research and Human Resources Agency, mangrove forests play a crucial ecological role in mitigating erosion. Mangroves act as a natural barrier between land and sea, strengthening soil structure and reducing the impact of abrasion caused by seawater.

Flood History

Respondents with a history of flooding in the case group were recorded at 6.7%, slightly higher than the control group at 5.6%. According to the statistical analysis results, the relationship between a history of flooding and the occurrence of leptospirosis indicates that there is no significant relationship between the two variables. This finding is consistent with the study conducted by Dewi & Yudhastuti (2019) in Gresik District, which showed similar results. A history of flooding is indeed recognized as one

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of the risk factors for leptospirosis, as during floods, animals such as rats can contaminate water through urine or feces containing the bacteria that cause the disease. However, according to the study by Naing et al. (2019), exposure to flooding significantly increases the risk of leptospirosis, with an odds ratio (OR) of 2.19, indicating a strong association between contact with floodwater and leptospira infection. Meanwhile, a study conducted by Cahyati & Kumalasari, (2020) found that among the respondents, 10 people (42%) lived in areas with a history of tidal flooding or flooding, while 14 people (58%) lived in areas that had never experienced tidal flooding or flooding. Areas prone to tidal flooding or flooding are susceptible to the formation of water pools, which can serve as a medium for the spread of bacteria or pathogens, causing various diseases, including leptospirosis.

Type of Work

According to information from the World Health Organization (WHO), one factor contributing to the transmission of leptospirosis is the type of work a person does. Certain professions are at higher risk of leptospirosis infection, including veterinarians, livestock farmers, butchers, rodent control workers, rice and sugarcane farmers, miners, fishermen, and soldiers. These occupations increase the likelihood of direct contact with bodily fluids or urine from animals infected with leptospirosis, which is the primary mode of transmission for the disease. Direct transmission from infected animals to humans is a primary risk factor for leptospirosis (Widjajanti *et al.,* 2018). In Banyumas, according to a study conducted by Andriani & Sukendra, (2020), the results of a Chi-square test indicated a significant association between job type and the occurrence of leptospirosis. Based on risk analysis, individuals with high-risk occupations have a 3.4 times higher likelihood of contracting leptospirosis compared to those with low-risk occupations. This finding is consistent with the study conducted by Raharjo et al. (2015), which also found that occupational type is closely associated with leptospirosis incidence. Another study conducted by Rakebsa *et al.,* (2018) in Yogyakarta and Bantul supports this finding, stating that occupation influences the incidence of leptospirosis. Erviana, (2014) study also noted that patients with leptospirosis often have a history of occupations with high risk, such as those involving animals and water. Many leptospirosis patients come from fishing and farming communities, where fishermen are at risk of exposure to water contaminated with Leptospira bacteria. At the same time, farmers are at risk of contact with rice fields that may be contaminated with rat urine or feces.

Level of Education

In Kebumen, a study conducted by Nuzuli Mawarni in 2024 indicated a correlation between socioeconomic factors and the variables studied, specifically the level of education and preventive behavior against leptospirosis. Similar findings were reported by Sitindaon *et al.,* (2020), who found a relationship between socioeconomic characteristics, educational level, and preventive behavior against leptospirosis (Illahi & Fibriana, 2015). Similar research was also conducted by Farid *et al.,* (2019), who found a relationship between educational level and compliance with the use of personal protective equipment (PPE). However, the use of PPE is not directly influenced by educational level, but rather by one's mindset while working. In this study, it was found that respondents with moderate education levels had the highest proportion of good preventive behavior against leptospirosis, accounting for 35.5%. Positive effects emerge when lessons during education are taught in line with existing standards. Ideally, people can incorporate and demonstrate standards of maturity in their behavior, making it easier to distinguish between correct and incorrect behavior (Purana, 2017). Education is a key factor in

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changing behavior. Education encompasses general knowledge, personal awareness, and skill training (Fatmala *et al.,* 2022).

Level of Knowledge

Most respondents had a low level of knowledge about leptospirosis, with 56 respondents (59.6%) reporting this. The results of this study are consistent with those of Murwani *et al.,* (2022), which found that the majority of respondents had a low level of knowledge about leptospirosis, with 24 respondents (48%) falling into this category. This finding aligns with the results of Pujiyanti et al. (2020), which reported that 71.43% of respondents had a low level of knowledge about leptospirosis. The results of this study are also consistent with those of Trapsilowati *et al.,* (2021), who reported that 71.43% of respondents had a low level of knowledge. This is in line with the results of the study which stated that the majority of respondents' education levels were in the low category (elementary school), which is a factor that influences the level of knowledge of respondents in the poor category, thus causing the behavior of preventing leptospirosis in the elderly in RW 11 Kampung Semanggi to be in the poor category. Based on the research findings, many respondents are still unaware of leptospirosis, its causes, symptoms, modes of transmission, prevention, and treatment, due to the limited information available to the elderly about leptospirosis.

History of Leptospirosis Risk Activities

Research conducted by Andriani & Sukendra, (2020) in Banyumas revealed a link between the history of involvement in risky social activities and the occurrence of leptospirosis. The findings suggest a significant correlation between participation in high-risk social activities and the development of leptospirosis. This finding is consistent with previous studies that identified a history of involvement in risky social activities as a risk factor for leptospirosis. Statistical analysis revealed that respondents with a history of participating in risky social activities were 12 times more likely to contract leptospirosis than those who did not engage in such activities. This relationship can be understood because involvement in risky social activities increases exposure to plants, equipment, waste, soil, mud, drainage water, and standing water, which can serve as sources of infection. Additionally, respondents involved in these activities generally do not use personal protective equipment (PPE), such as boots and gloves, when working in high-risk environments, making them 2.8 times more likely to contract leptospirosis than those who use PPE. These findings align with the research by Sofiyani et al. (2018), which demonstrated that the use of PPE can reduce the risk of exposure to Leptospira bacteria, the causative agent of leptospirosis.

Age

In Kebumen, a study conducted by Nuzuli Mawarni, (2024) found a relationship between demographic characteristics, specifically age, and preventive behavior against leptospirosis. Respondents in the early elderly age category were more likely to exhibit good preventive behavior compared to adults, with 42 respondents, or 45.2%. This study aligns with previous research, which found a relationship between age and preventive behavior against leptospirosis (Illahi & Fibriana, 2015). Age can influence an individual's knowledge about preventive behavior (Illahi & Fibriana, 2015). Age can serve as a modifying factor, shaping perceptions that influence behavior. L. Green's theory states that age is one of the characteristics of an individual in the predisposing factors of behavior. Similarly,

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Khorsandi et al. (2017) noted that older individuals are more likely to engage in disease prevention behaviors. Older age groups tend to be more mature in decision-making.

Attitude

Research conducted by Yulia and Endarto (2020) in Bima Regency revealed a significant relationship between community attitudes and preventive behavior against leptospirosis. These findings suggest that individual attitudes significantly influence a person's likelihood of taking preventive measures against the disease. In the context of this study, most of the respondents had a medium to high level of education. This level of education contributes to a better understanding among individuals in assessing risks and the importance of preventive measures. This aligns with Santoso, (2012) opinion, which posits that a person's knowledge influences their attitudes. Attitudes are a form of reaction to a stimulus that goes through a conscious evaluation process, enabling individuals to make judgments based on what they consider good or bad. A correct understanding of information about leptospirosis enables the formation of a more positive attitude towards disease prevention. However, the formation of attitudes does not solely depend on the information received, but also on various influencing factors, such as personal experience, social norms, and the environment. If these factors are positive, the attitudes formed tend to support preventive behavior. Conversely, if influenced by negative factors, attitudes toward disease prevention may become less supportive. As stated by Notoatmodjo, (2012) attitude is a tendency to act toward a particular object or situation, although it may not necessarily be manifested in direct action.

Conclusion

This study has examined various risk factors contributing to the occurrence of leptospirosis in endemic areas using a systematic literature review approach. The findings indicate that leptospirosis is a multifactorial disease influenced by environmental conditions, occupational activities, the presence of livestock, as well as individual behavior and awareness regarding disease prevention. Environmental conditions that fail to meet sanitation standards, along with community activities in the agricultural and livestock sectors, are significant factors contributing to increased exposure to Leptospira bacteria. Additionally, highland areas, which have traditionally been considered relatively safe, also exhibit similar vulnerability to lowland areas, indicating that the scope of risk is expanding and becoming more complex.

The originality of this study lies in its approach, which integrates environmental, occupational, and human behavioral factors into a systematic analytical framework. This research not only expands theoretical understanding of the determinants of leptospirosis but also makes an important contribution to public health practice and zoonotic disease control policies. The practical implications of this study underscore the need for enhanced health promotion strategies, targeted education for high-risk groups, the provision of personal protective equipment, and cross-sectoral collaboration among health departments, village governments, and primary healthcare facilities to establish more effective early detection and response systems for leptospirosis outbreaks.

This study has several limitations. The main limitation lies in the data sources, which are primarily derived from secondary publications that may not fully represent the local context in specific endemic areas. Additionally, the absence of a meta-analysis to quantitatively measure the contribution of each risk factor to leptospirosis incidence is a weakness that can serve as a foundation for future research.

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Therefore, it is recommended that future researchers conduct empirical studies based on primary data to explore causal relationships between risk factors in greater depth, including the development of predictive models for leptospirosis risk in various types of regions (urban, rural, highland, and lowland). Furthermore, it is essential to explore community-based intervention approaches to evaluate the long-term effectiveness of prevention strategies.

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APPENDIX

Table A1. Study Literature

No	Author(s)/Year	Research Title	Method	Results
1	Yuliani Setyaningsih, Nurdin Bahtiar, Apoina Kartini, Siti Fatimah Pradigdo, Lintang Dian Saraswati, 2022.	The presence of Leptospira sp. and leptospirosis risk factor analysis in Boyolali district	This type of research is descriptive, using surveys and observations with a cross-sectional design.	There is a significant association between leptospirosis cases in Boyolali District and several factors, including waste management, the presence of domestic animals, a history of injuries, and participation in outdoor activities. Leptospira bacteria were found in rivers (18.18%) and rice fields (6.67%), while cases occur almost every year in the subdistrict. Leptospira was found in wells (18.18%) and rice fields (6.67%).
2	Grace Karina Rim Br Ginting, Sofwan Indarjo 2022	Lingkungan, Perilaku Personal Hygiene dan Pemakaian APD Terhadap Kejadian Leptospirosis	The research method used in this journal is a combination of proportionate stratified random sampling and systematic random sampling.	The results of this study prove that there is a relationship between the incidence of leptospirosis and several factors, namely the condition of sewers, the condition of garbage dumps, the presence of rats, foot washing behavior in the surrounding environment, hand washing behavior, the habit of cleaning oneself in rivers, wound care behavior, the use of gloves, and the habit of wearing footwear.
3	Ragil Andriani, Dyah Mahendra sari Sukendra 2020	Faktor lingkungan dan perilaku pencegahan dengan kejafian leptospirosis di daerah endemis	The research method employed in this journal is analytical observation, combined with a cross-sectional study.	Based on the study's results, it is evident that the incidence of leptospirosis is influenced by several factors that have a significant relationship. These factors include the distance of residence from drainage channels, the presence of standing water in the surrounding environment that could be a source of transmission, the history of individual involvement in activities that are risky for leptospirosis infection, and the type of work carried out by respondents that may increase

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No	Author(s)/Year	Research Title	Method	Results
				exposure to the causative agent of the disease.
4	Cindy Anggraini, Sri Hartutik, 2024	Hubungan Tingkat Pengetahuan Dengan Perilaku Pencegahan Penyakit Leptospirosis Pasca Bencana Banjir Pada Lansia Kampung Semanggi	This type of research is descriptive, using survey and observation methods with a cross-sectional design.	Most respondents in this study were young or older women with a primary school education, unemployed or homemakers, living in densely populated areas, with inadequate knowledge, and demonstrating low levels of preventive behavior. This study concludes that there is a relationship between the level of knowledge and preventive behavior against leptospirosis among the elderly in Kampung Semanggi after the flood disaster.
5	Desy Nuzuli Rahmahwati, et al 2024	Hubungan Antara Karateristik Demogragfi dan Sosial Ekonomi Dengan Perilaku Pencegahan Penyakit Leptospirosis Pada Petani Di Kacamatan Peejagoan Kabupatn Kebumen	This type of research is descriptive, using survey and observation methods with a cross-sectional design.	This study shows a correlation between demographic characteristics (such as age and education level) and socioeconomic factors (including number of family members, income level, length of employment, working hours, land ownership, and side activities outside of farming) and the prevention of leptospirosis. Additionally, the findings reveal that most farmers in Pejagoan Subdistrict, Kebumen Regency, exhibit good leptospirosis prevention behaviors, with a proportion reaching 75.3%.