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Environmental Sanitation and Household Rodent Presence Among Suspected Leptospirosis Cases: Findings from Makassar, Indonesia

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ABSTRACT

Introduction: Leptospirosis is a zoonotic disease caused by the bacterium Leptospira interrogans. Residential areas frequently experience poor environmental sanitation, including waste accumulation, stagnant water, and rodent activity around households. Such conditions compromise environmental hygiene and facilitate the survival of Leptospira bacteria. Poor sanitation increases community exposure to environmental sources of infection, thereby elevating the risk of leptospirosis. Exposure may occur through direct or indirect contact with contaminated water or soil, particularly when stagnant water is contaminated with rodent urine. This study aimed to assess household rodent presence among suspected leptospirosis cases and to examine its association with environmental sanitation conditions. Polymerase chain reaction (PCR) testing and GIS-based spatial mapping were incorporated to support diagnostic and spatial interpretation.
Methods: This study employed a quantitative, descriptive cross-sectional observational design. The sample comprised 20 households of suspected leptospirosis patients selected through purposive sampling. Data were collected through direct household observation using a structured checklist.
Results: Chi-square analysis indicated no statistically significant associations between sanitation indicators and signs of rodent presence, including stagnant water ($p = 0.068$), waste accumulation ($p = 0.068$), rodent entry pathways ($p = 0.178$), drainage condition ($p = 0.305$), and wastewater disposal systems (SPAL) ($p = 0.136$). All examined variables demonstrated p-values greater than 0.05, indicating no statistically significant associations with observable rodent indicators. Nevertheless, the SPAL variable showed a non-significant trend toward association ($p = 0.136$), although it did not reach the conventional 5% significance threshold.
Conclusion: No statistically significant relationships were identified between household sanitation conditions including stagnant water, waste accumulation, drainage condition, wastewater disposal systems (SPAL), and clean water availability and signs of rodent presence. To mitigate rodent-related environmental health risks, communities are encouraged to improve environmental hygiene through proper waste management, routine maintenance of drainage systems, and the implementation of household-level rodent control measures.

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INTRODUCTION

According to the International Leptospirosis Society (ILS), Indonesia is one of the countries with the highest incidence of leptospirosis. It ranks third in the world, after China and India, in terms of the highest mortality rate. The mortality rate due to leptospirosis in Indonesia is relatively high, ranging from 2.5% to 16.45%, with an average of 7.1%. Meanwhile, the mortality rate can reach up to 56% among patients aged 50 years and older (1). Every year, leptospirosis causes approximately 58,000 deaths and infects around 1.03 million people worldwide. The disease is widespread globally, particularly in tropical and subtropical countries with high rainfall. High rainfall creates favorable conditions for Leptospira to survive and reproduce, thereby increasing the risk of human exposure through contaminated water and soil (2).

Leptospirosis cases increased in 2023. According to the Indonesian Health Profile, a total of 2,554 leptospirosis cases were reported across 12 provinces, including DKI Jakarta, West Java, Central Java, DI Yogyakarta, East Java, Banten, North Kalimantan, South Sulawesi, East Kalimantan, Riau Islands, Bali, and Maluku. Among these cases, 205 deaths were recorded, resulting in a mortality rate of 8%. Compared to the previous year, the number of leptospirosis cases increased, although the mortality rate decreased from 9.1% in 2022 to 8% in 2023. Several provinces such as Central Java, DI Yogyakarta, East Java, South Sulawesi, Southeast Sulawesi, East Kalimantan, and North Kalimantan reported an increase in cases, while DKI Jakarta, West Java, and Banten experienced a decline (3).

Although these epidemiological patterns underscore the significance of leptospirosis as a public health concern, they do not explain how household-level environmental conditions contribute to exposure among suspected cases. Understanding these micro-environmental factors is critical for developing targeted prevention strategies (4).

Leptospirosis is a rodent-borne disease and is categorized as an emerging disease. It requires increasing attention due to global population growth, rising human mobility, ease of food production, lifestyle and behavioral changes, expansion of residential areas, and the emergence of new pathogens caused by mutation. The causative agent of leptospirosis is Leptospira interrogans, a pathogenic bacterium that infects both humans and animals (4). Leptospirosis cases have occurred in South Sulawesi, specifically in Pangkep Regency, in 2020. The disease affected residents in several villages within Ma'rang District and became a serious public health concern that drew attention from the Pangkep Regency Government due to the increasing number of cases. According to data from the Pangkep District Health Office, 15 cases were reported, including three deaths, which occurred in Pitue Village (5).

Based on a study conducted by Manyullei et al. (2021) in Makassar City at Antang Health Center, Batua Health Center, and Bangkala Health Center in Manggala District in 2020, out of 31 samples collected, 11 blood serum samples tested positive for Leptospira. The study population included all patients who visited the three health centers and met the criteria for suspected leptospirosis, namely fever lasting more than three days, headache, and muscle pain. Data were collected from primary sources, including leptospirosis symptoms and the results of the Microscopic Agglutination Test (MAT) examination conducted at the Center for Vector and Reservoir Disease Research and Development (B2P2VRP) (6).

Leptospirosis can cause a wide range of clinical symptoms, from mild manifestations to severe and potentially fatal conditions. The symptoms of this disease often resemble those of influenza, dengue fever, or other viral hemorrhagic diseases. Most reported cases present with severe symptoms, with a mortality rate exceeding 10%. (7)The spread of this disease is influenced by the high population of rats as carriers of Leptospira bacteria, poor sanitation conditions, and widespread flooding, making several regions in Indonesia endemic for leptospirosis. Environmental factors in Indonesia have long been considered risk factors for leptospirosis infection, such as flood-prone areas, the presence of stagnant water, and wet or muddy environments. This raises concerns that infections will continue to occur if comprehensive efforts to control leptospirosis are not implemented (8).

Despite this growing body of literature, a critical knowledge gap remains. No study has specifically examined how household-level sanitation indicators relate to observable signs of rodent presence among suspected leptospirosis cases, particularly in Makassar.

This study is grounded in an eco-epidemiological framework, which conceptualizes leptospirosis transmission as the result of interactions between environmental sanitation conditions, rodent reservoir ecology, and human exposure. Applying this framework enables a more integrated understanding of how household-level environmental factors and rodent activity may contribute to potential exposure among suspected cases (8).

Residential areas commonly experience sanitation challenges such as accumulated waste, stagnant water, and rodent activity which create environmental conditions conducive to the survival of Leptospira bacteria. Poor sanitation increases human exposure to contaminated water or soil, particularly when puddles contain rat urine, thereby elevating the risk of leptospirosis transmission (7). These micro-environmental conditions underscore the need for a localized, household-level environmental assessment to better understand transmission pathways among suspected leptospirosis cases (8).

Accordingly, this study addresses the following research question "Are household-level environmental sanitation indicators associated with signs of rodent presence among suspected leptospirosis cases in the Rapokalling Health Center area of Makassar City?"

METHOD

This research adopts a systematic and well-organized methodological framework to maintain the reliability and validity of its outcomes. Every component including the research design, sampling method, data collection tools, and analytical procedures was carefully structured to produce precise and objective insights regarding environmental sanitation conditions and indicators of rodent presence in households suspected of leptospirosis. The detailed methodological components are outlined as follows:

Research type

This research utilized a quantitative descriptive design with a cross-sectional observational approach. The purpose was to portray the condition of environmental sanitation and indications of rodent presence in households of individuals suspected of having leptospirosis within a defined period.

Population and sample/ informants

The study population consisted of all individuals presenting with clinical symptoms suggestive of leptospirosis within the working area of the Rapokalling Health Center, Makassar City. Suspected cases were identified using operational clinical criteria from WHO (2014) and the Indonesian Ministry of Health guidelines. A total of 20 respondents were selected through purposive sampling, representing the entire population of suspected cases identified during the data collection period. This complete-case approach was methodologically appropriate given the limited number of eligible cases and the exploratory aim of assessing environmental risk factors, for which population-based inclusion provides adequate analytic strength without the need for statistical power estimation.

Inclusion criteria were: (1) acute fever ≥38°C for at least 3 days; (2) symptom onset within ≤10 days; and (3) at least two additional symptoms such as headache, myalgia, nausea, dizziness, or conjunctival suffusion. Alternative diagnoses (e.g., dengue, malaria, typhoid) were ruled out using standard rapid diagnostic tests available at the health center. Exclusion criteria included confirmed alternative diagnoses, pre-existing chronic renal or hepatic disorders, incomplete clinical records, or refusal to provide a blood sample. Clinical screening and case verification were conducted by trained health officers using standardized procedures to ensure diagnostic consistency prior to environmental assessment.

Research location

The study took place in the operational area of the Rapokalling Health Center, situated in Tallo District, Makassar City. The area includes four sub-districts—Rapokalling, Tammua, Buloa, and Tallo. Data collection activities were carried out during the period of June 26 to July 21, 2025.

Instrumentation or tools

Environmental data were collected using a structured observation checklist specifically developed to assess household-level risk factors for leptospirosis. The instrument included operationalized indicators across four domains: (1) housing sanitation (e.g., standing water, waste accumulation, floor dampness); (2) evidence of rodent infestation (e.g., droppings, burrows, gnaw marks); (3) environmental cleanliness (e.g., drainage condition, waste disposal practices); and (4) proximity to contamination sources (e.g., open sewers, stagnant floodwater). Each indicator used explicit observable criteria and a three-point scoring scale (0 = absent, 1 = moderate, 2 = clearly

present). Domain scores were summed to classify households into low, moderate, or high environmental risk categories. Instrument reliability was confirmed through inter-observer agreement (Cohen's kappa ≥0.80), and content validity was established through expert review and pilot testing. Additionally, Polymerase Chain Reaction (PCR) analysis was conducted to detect *Leptospira* bacteria in blood samples from suspected patients. The geographic distribution of respondents' homes was mapped using QGIS software to support spatial data processing and visualization.

Data collection procedures

Data were collected through direct field visits in which trained field officers applied the previously validated observation checklist. During each household visit, officers recorded the presence or absence of environmental risk factors using the standardized scoring system. Blood samples were simultaneously collected from suspected patients by medical staff at the Rapokalling Health Center following standard clinical procedures for PCR examination. All observational data, laboratory findings, and spatial records were compiled, cross-checked for completeness, and prepared for further analysis.

Data analysis

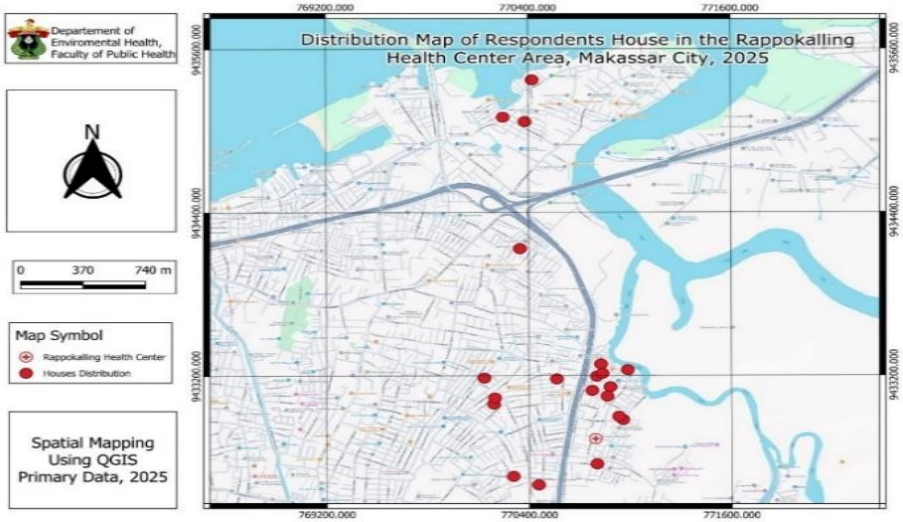
PCR analysis was integrated into the study design to provide biological confirmation of Leptospira infection and to link laboratory results with household environmental conditions. The inclusion of PCR data enabled comparison of environmental risk profiles between PCR-positive and PCR-negative households, thereby supporting the theoretical premise that environmental exposures contribute to infection. This integration allowed laboratory diagnostics to function not merely as clinical confirmation but as an analytical component for interpreting environmental risk factors within the epidemiological framework of leptospirosis.

Ethical approval

This study received ethical clearance from the Health Research Ethics Committee, Faculty of Public Health, Hasanuddin University, as evidence of adherence to established ethical principles in research involving human participants.

RESULTS

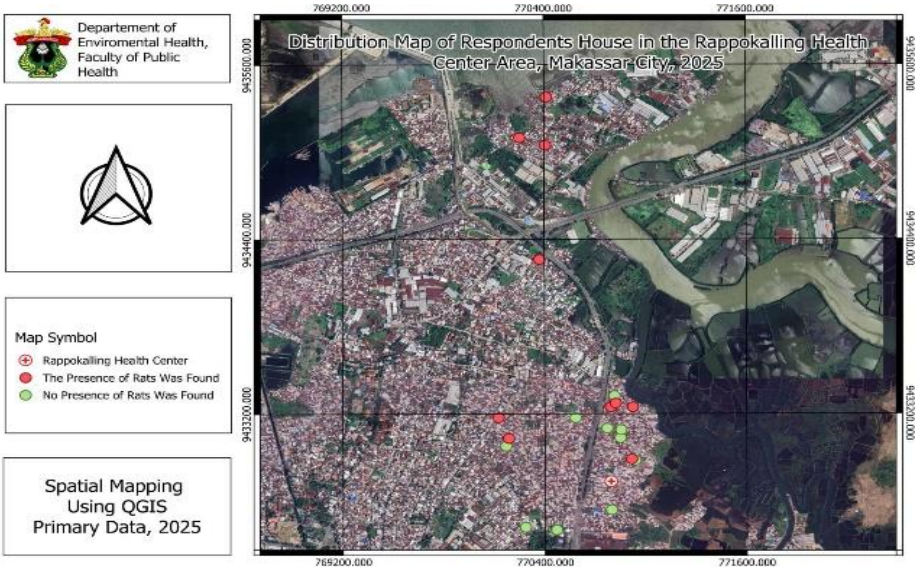
This study was conducted from June 26 to July 21, 2025, in the working area of the Rapokalling Health Center, Makassar City. The Rapokalling Health Center is located in Tallo District, Makassar City. Its working area covers four sub-districts: Rappokalling, Tammua, Buloa, and Tallo. The study involved 20 respondents selected based on the clinical criteria for suspected leptospirosis, namely fever, headache, muscle pain, dizziness, and nausea.



Source: Primary Data, 2025.

Figure 1. Map of Respondents' House Distribution in the Working Area of Rapokalling Health Center, Makassar City, 2025

Figure 1 illustrates the distribution of suspected leptospirosis respondents' houses involved in this study, consisting of 20 respondents who reported symptoms such as fever, muscle pain, headache, dizziness, and nausea. Field observations were conducted at all 20 respondents' houses to assess environmental sanitation conditions, particularly the signs of rat presence, which serve as a risk factor for the spread of Leptospira bacteria. Spatial inspection of the mapped households indicated that residences showing signs of rodent presence were concentrated in areas with poorer environmental sanitation, particularly zones with more waste accumulation and obstructed drainage. While advanced spatial statistics were not applied due to the small sample size (n = 20), the observed pattern suggests localized clustering of rodent activity. This spatial tendency supports the eco-epidemiological understanding that micro-environmental conditions shape differential leptospirosis risk.



Source: Primary Data, 2025.

Figure 2. The presence of Rats Was Found in Respondents House

Table 1. Frequency Distribution of Respondent Characteristics in the Work Area of Rappokalling Community Health Center, Makassar City, 2025

Respondent Characteristics	**n**	**%**
Gender		
Man	8	40
Woman	12	60
Age (Years)		
11-20	4	20
21-30	3	15
31-40	4	20
41-50	4	20
51-60	3	15
61-70	2	10
Work		
Laborer	5	25
Housewife	7	35
Students	5	25
Civil servant/Private employee	1	5
Other	2	10
Total	**20**	**100**

Source: Primary Data, 2025

Table 1 summarizes the demographic characteristics of the respondents. The majority were female (60%), and the most common age groups were 31–40 years and 41–50 years (each 20%). Most respondents were housewives (35%), followed by laborers and students (each 25%). These characteristics provide contextual background for interpreting household environmental conditions but were not included as analytical variables in the statistical tests.

The presence of standing water

Table 2. The presence of standing water

Statistical Test	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.333a	1	0.068
Continuity Correction	1,875	1	0.171
Likelihood Ratio	3,452	1	0.063

Source: Primary Data, 2025

A contingency table analysis was conducted to assess the relationship between the presence of stagnant water around the household and observable signs of rodent presence (Table 2). The assumptions for the chi-square test were met, as all expected cell counts were adequate. The Pearson Chi-Square test yielded a value of 3.33 (df = 1, p = 0.068), indicating no statistically significant association at the 5% significance level. Although households with stagnant water showed a slightly higher proportion of rodent indicators compared to those without stagnant water, the observed association was weak and did not reach statistical significance.

The Existence of Garbage

Table 3. The Existence of Garbage

Statistical Test	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.333a	1	0.068
Continuity Correction	1,875	1	0.171
Likelihood Ratio	3,452	1	0.063

Source: Primary Data, 2025

The relationship between the presence of scattered garbage and signs of rodent activity was examined using chi-square analysis (Table 3). The Pearson Chi-Square value was 3.33 (df = 1, p = 0.068), with supporting results from the continuity correction (p = 0.171) and likelihood ratio test (p = 0.063). These findings indicate that there was no statistically significant association between garbage presence and observable rodent indicators. Nonetheless, the distribution pattern suggested a higher frequency of rodent signs in households with scattered waste, although the magnitude of this relationship remained limited.

Rat access into the house

Table 4. Rat Access into the House

Statistical Test	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.818a	1	0.178
Continuity Correction	0.808	1	0.369
Likelihood Ratio	1,848	1	0.174

Source: Primary Data, 2025

Chi-square analysis was performed to evaluate the association between potential rat access routes into the house and signs of rodent presence (Table 4). The Pearson Chi-Square test yielded a value of 1.82 (df = 1, p = 0.178), indicating no statistically significant association. Results from the continuity correction (p = 0.369) and likelihood ratio test (p = 0.174) were consistent with this finding.

Condition of the Sewer

Table 5. Condition of the Sewer

Statistical Test	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.053a	1	0.305
Continuity Correction	0.000	1	1,000
Likelihood Ratio	1,439	1	0.230

Source: Primary Data, 2025

Chi-Square test were 1.053 with degrees of freedom (df) = 1 and a value of asymp. Sig. 2-sided = 0.305. Based on the results, there is no significant relationship between both variables tested. *Continuity Correction Test* produce value of 0.000 with a sig of 1.000 (p > 0.05), Meanwhile, the *Likelihood Ratio result* of 1.439 with a sign of 0.230 also shows the same thing

Spal Condition

Table 6. SPAL Condition

Statistical Test	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.222a	1	0.136
Continuity Correction	0.556	1	0.456
Likelihood Ratio	2,995	1	0.084

Source: Primary Data, 2025

Chi-Square test result is 2.222 with degrees of freedom (df) = 1 and a significance value of 0.136. Since the significance value is greater than 0.05, then can there is no statistically significant relationship between both variables. *Continuity Correction Test* produce the value is 0.556 with a significance of 0.456 (p > 0.05), so it also does not indicate a significant relationship. *The Likelihood Ratio* is 2.995 with significance value of 0.084 shows results that are still not significant at the 5% level, however approaching significance at the 10% level.

DISCUSSION

Visits were made to observe the sanitation conditions in the environment homes of suspected leptospirosis patients. Samples taken were from patients living in the Rapokalling Community Health Center area, consisting of from 4 sub-districts, namely Rapokalling, Tammua, Buloa, and Tallo. This study involved 20 respondents selected based on clinical criteria for suspected leptospirosis, namely fever, headache, and pain. muscle pain, dizziness, and nausea. All respondents reside in the Rapokalling Community Health Center work area, which includes four sub-districts: Rapokalling, Tammua, Buloa, and Tallo. After sampling, blood at the health center, researchers conducted visit directly to each respondent's home to observe sanitation conditions residential environment.

Research respondents have various occupation, namely laborer, housewife households, students, civil servants and private sector employees. Most of them are housewives 7 people on the stairs followed by 4 students and students, 5 of the workers are working as trader and one among them work in a factory feed and livestock, and there is 1 person working as civil servants. Based on observations of respondents' homes, various sanitation conditions were found that could potentially support the transmission of leptospirosis. Puddles were frequently found around respondent's house is good beside or in front home, also almost all the house has rubbish scattered in the gutter which is of course can attract mice, as well the presence of rats is also often found, through signs of activity like dirt and traces. Also, rat access into the house was found in large numbers a house that has gaps or cables and ropes connected into the house (9).

Based on observations of 20 respondent houses, it was found that 10 houses (50%) showed rat droppings, while the other 10 houses (50%) did not. These observations indicate that some of the respondent houses have the potential for exposure to rats as a *reservoir* for the disease leptospirosis. In terms of rat traces, only 4 houses (20%) showed rat traces, while 16 houses (80%) did not find these signs. Traces of rat presence such as footprints or tail

marks are usually only visible on certain surfaces and may be missed if the floor or ground surface is not supportive. Therefore, the possibility of rat presence remains even if not detected through visual traces.

Marks were found in 5 houses (25%), generally on objects such as cables, wood, or food packaging. Bite marks indicate exploratory activity of rats searching for food or nesting places. This not only indicates the presence of rats, but also increases the risk of environmental contamination, including the spread of *Leptospira bacteria* through rat urine left on surfaces. The odor of rat urine was detected in 6 houses (30%), and was not detected in 14 houses (70%). The distinctive odor of rat urine can be a strong indicator of an active rat population, especially if smelled in enclosed areas or warehouses. Based on the study, it was concluded that the odor does not always appear in all places inhabited by rats; detecting this odor can strengthen indirect evidence of rat presence. Based on the results of observations, researchers conducted a study on the relationship between sanitation conditions and signs of rat presence (10).

The presence of standing water

Based on the observation results of this study, from 20 respondent houses visited, it was found that 8 houses (40%) had standing water, while 12 houses (60%) did not have any standing water. The results of this study indicate that some of the respondents' living environments have conditions that allow bacteria to live and are likely present in the environment. The presence of standing water in the home environment is one of the main indicators of the risk of transmission of Leptospirosis, because *L. interrogans* bacteria can survive in stagnant water, especially in damp conditions and lack of sanitation. This bacteria can survive for weeks in water or soil contaminated with rat urine, especially at warm temperatures (around 4–30 °C) and acidic or neutral pH (<7) (11).

This indicates that standing water in the respondents' home environment does not directly influence the presence of rats. It's possible that standing water isn't always a primary resource or habitat for rats, as rats are more likely to seek out areas with food, shelter, or poor sanitation. In other words, other factors such as garbage piles, environmental cleanliness, and access to food may play a greater role in attracting rats the presence of standing water (12).

The Existence of Garbage

Based on observations, 12 houses (60%) showed scattered trash, both inside and in surrounding areas such as yards. Meanwhile, 8 houses (40%) had no scattered trash. These observations were conducted directly during the observation, by recording the presence of trash in various areas of the respondents' households. The results indicate that the majority of respondents' residential areas still lack proper waste management, and this could be an indicator of poor environmental sanitation.

In the research of Supriyadi et al. (2023) concluded that poor waste management is often associated with an increase in rat populations in residential areas, and ultimately increases the risk of transmission of leptospira spp to humans. Even when there are no active cases of infection, environmental conditions such as these are still considered risky. Rats, as the main carriers of *L. interrogans* bacteria, can spread the bacteria into the environment through their urine and feces. When the environment is polluted and humans make indirect contact such as stepping on dirty floors, coming into contact with contaminated water, or even simply being around areas frequented by rats, the risk of transmission remains open, especially if someone has open wounds on their skin (13).

The results of the waste presence variable are in line with the research of Nugroho et al. (2018) in Tangerang Regency, Banten, where observations were conducted on 35 houses located in the area of extraordinary occurrence of leptospirosis, with a focus on biotic environmental factors such as vegetation, the presence of pets, and rat density. There was no significant relationship between these environmental factors and the occurrence of leptospirosis ($p > 0.05$). This means that environmental conditions indicated to support the presence of rats, do not directly correlate with leptospirosis infection in humans. Environments that appear risky, such as abundant vegetation and the possibility of garbage accumulation, are not always followed by the occurrence of leptospirosis infection (14).

These results are in line with research by Arasy et al. (2023–2024) This research was conducted in Kendari City by capturing rats from residential areas, then conducting laboratory tests. The results showed that 50% of the captured rats tested positive for *L. interrogans bacteria*. One of the most influential environmental factors is the presence of waste, especially open household waste containing food scraps. Environments with a lot of waste tend to

be gathering places for rats, thus increasing the risk of Leptospirosis transmission. The high number of houses with scattered waste still needs to be considered. This condition indicates that the respondents' residential environment is included in the vulnerable category, and there is a need for improvements in waste management and education on household hygiene as a measure to prevent disease (15).

The presence of rat access into the house

To maintain alignment with IMRAD conventions, descriptive observations regarding rat access routes and other household sanitation indicators are consolidated within the Results section. In the Discussion, these findings are interpreted solely in relation to broader theoretical and epidemiological frameworks, ensuring that this section focuses on analytical reasoning rather than descriptive reporting.

Based on observations of rat access into homes in 20 respondents, it was found that 11 houses (55%) had ropes or cables directly connected to the house structure, which could potentially become an access route for rats to enter the house. Meanwhile, 9 houses (45%) did not have any cable or rope routes directly connected. In addition, 8 houses (40%) were found to have poles attached directly to the house structure, which could also be used by rats as an entry route, while in 12 houses (60%) no poles were found to be in direct contact with the house structure.
In all the observed houses (100%) there were no external stairs that were directly connected to the outside of the house, therefore stairs were not considered as one of the important factors that made rats able to enter the house. The presence of tree branches that were in direct contact with the house was only found in 2 houses (10%), while the majority of the others, namely 18 houses (90%) did not have tree branches that touched or attached to the house. These results indicate that most houses do not have direct vertical paths such as stairs or tree branches, the presence of cables and poles that were attached were still potential access routes for rats that need to be considered in environmental control efforts against the risk of leptospirosis.

Physical rat control involves sealing all gaps or holes that could allow rats into the house. Furthermore, hiding places such as piles of items or bushes around the house should also be removed. Tree branches that overhang buildings should be trimmed, and gardens should not be built too close to house walls. Mechanically, rats can be prevented from entering by constructing special barriers, such as installing metal plates on tree trunks. Other methods include using traps such as glue traps, clip traps, mass traps, or electric traps (16).

The results of this study align with those of Rum (2015), who examined the relationship between home environmental conditions and the presence of rats in Boyolali Regency. In his study, Rum stated that the presence of rat routes into the house, such as stairs, poles, or other connections connected to the roof of the house, did not show a significant relationship with the presence of rats in the house. This is evidenced by a p-value of 0.156, which means that statistically, rat access to the roof does not significantly affect the presence of rats (17).

A conflicting study by Costa et al. (2014) in a densely populated area of Brazil showed that the presence of rat entry routes into homes was associated with high rat numbers and increased cases of epilepsy. Houses where rat activity was found tended to have a higher risk of transmission than houses where no such activity was found. The results were inconsistent, as structures such as cables or poles attached directly to the house could provide access for rats (18).

Availability of clean water

Based on field observations of the 20 homes in this study, all had sufficient clean water for daily needs, including bathing, washing, cooking, and drinking. No homes were found without access to clean water (0%). Many used PDAM (Regional Water Company) and bottled water for their daily needs. Observations indicate that the study area has adequate clean water infrastructure.

The availability of clean water is an important indicator in efforts to prevent environmental-based diseases, including L. eptospirosis. Clean water plays a role in maintaining personal and household environmental hygiene, as well as reducing the potential for contact with water contaminated by *L. interrogans bacteria*. These results indicate that all respondents had access to clean water, so in the context of this study, the variable of clean water availability cannot be used to explain the difference in the risk of exposure to L. eptospirosis in respondents' homes. In addition, the results of PCR examinations on all blood samples also showed that no respondents were confirmed positive for Leptospirosis. This may indicate that the availability of clean water evenly distributed throughout the respondents'

homes plays a role in reducing the risk of transmission of this disease. Although all blood samples tested negative by PCR, these results remain epidemiologically meaningful. Negative findings confirm that the respondents cannot be classified as confirmed leptospirosis cases; however, they do not rule out environmental exposure, as *Leptospira* may still survive in contaminated water or soil around the households. Thus, the PCR results strengthen the interpretation that environmental sanitation indicators function primarily as exposure risk markers rather than predictors of active infection. This underscores the importance of improving household hygiene and rodent control, even when no current infections are detected (19).

Condition of the Sewer

The assessment of gutter conditions was conducted by visiting respondents' homes directly and observing the inside and surrounding areas. The results showed that the majority of homes surveyed had poor gutters, as indicated by 55% of clogged or blocked gutters. Gutter blockages are typically caused by accumulated trash, which was also found in 65% of homes. Trash in gutters not only impedes water flow but also has the potential to become a breeding ground for disease vectors such as mosquitoes and rats (20).

Furthermore, most homes (95%) have open drains, which are prone to contamination, causing unpleasant odors, and becoming breeding grounds for rats. These clogged drains can worsen environmental sanitation and increase the risk of disease transmission. The condition of blocked and open drains, along with the presence of garbage, indicates the need for improved sanitation systems and better waste management. Raising public awareness about maintaining clean gutters and implementing effective waste management programs will significantly reduce the risk of health problems caused by these unhealthy environmental conditions (21).

Although this study did not produce significant statistical associations, gutter conditions and other sanitation indicators remain important given their established role in facilitating rodent activity and potential *Leptospira* exposure. The discrepancy between theoretical expectations and the predominantly null findings in this study can be explained by several epistemic considerations. The small sample size (n = 20) and the relatively uniform distribution of sanitation conditions across households likely reduced statistical power and limited the variability needed to detect meaningful associations. Moreover, the uniformly negative PCR results indicate that no active infections were present during the study period, suggesting that the environmental conditions observed may represent potential rather than realized exposure pathways. These factors highlight that environmental risks operate probabilistically and may not manifest as infection in the absence of concurrent biological, temporal, or behavioral factors. Therefore, the null findings do not contradict established leptospirosis theory; instead, they emphasize the contextual complexity of transmission dynamics and the need for continued attention to environmental sanitation in prevention efforts (18,21)**.**

SPAL Condition

Based on the research results, all respondents' homes (100%) had closed wastewater drainage channels (SPAL). No homes were found with open SPAL. This condition indicates that the community in the research area has a fairly good awareness in building and maintaining household sanitation systems, especially in the management of domestic liquid waste. Closed SPAL functions to prevent environmental pollution, reduce unpleasant odors, and minimize the risk of direct contact between humans and waste, which can be a medium for transmitting environmental-based diseases such as leptospirosis (22).

These results align with the findings of Hengky's field research in Agas City, Batam, conducted in 2025, which examined the relationship between home environmental sanitation and occupant behavior and the presence of rats. The study found that unsuitable wastewater treatment plants (SPAL) that were open, not watertight, and caused pooling were significantly associated with an increase in rat presence ($p = 0.027$). Rats, as a reservoir of bacteria, are *Leptospira* , can facilitate the transmission of environmental-based diseases such as Leptospirosis through urine that contaminates water and soil around residential areas (23).

Theoretically, uncovered or damaged wastewater treatment plants (SPAL) could potentially act as a movement route or hiding place for rats. However, this study did not statistically support this finding. This can be explained by rats being more attracted to other factors that better support their survival, such as the availability of food from garbage, environmental cleanliness, and poorly maintained housing conditions. Building on our Manokwari seaport results, the simultaneous occurrence of elevated rat abundance and heavy ectoparasite burdens

mirrors observations from other tropical cities, where damp niches, food waste, and disrupted drainage systems sustain persistent hotspots for Leptospira transmission and vector expansion. Evidence from Makassar and Kendari indicates that peri-domestic sanitation conditions (e.g., litter accumulation, blocked drains) together with rodent ecology determine Leptospira detection in both rodents and human sera, highlighting the critical linkage between port operations and neighboring residential areas (24).

TEMU-KL can be used as an operational framework to record household risk indicators (flooding, SPAL, hygiene, evidence of rodent traces/activity), integrate them with clinical data on suspected leptospirosis cases, and then map intervention priorities (drainage improvement, rodent control, education on contact with contaminated water/soil)24. The risk of schistosomiasis increases in households with open defecation habits, lack of clean water, lack of personal protective equipment, and low program utilization; the strongest factor is the proximity of the house to snail habitats (OR≈40.7). Implications: Environmental-behavioral determinants of schistosomiasis parallel findings on household sanitation and rodent evidence in suspected leptospirosis cases in Makassar. Both emphasize the importance of household-based interventions: drainage/clean water improvements, personal protection, and vector-reservoir control in high-risk zones (25).

While previous studies on rat movement patterns and spatial clustering provide useful ecological context, their relevance to the present dataset is limited because this study did not directly measure rodent mobility or conduct spatial buffer analysis. To ensure tighter integration between literature and empirical findings, only studies that align directly with the measured variables household sanitation indicators, observed signs of rodent presence, and PCR outcomes are prioritized in the interpretation. This approach maintains analytic coherence and strengthens the linkage between the evidence generated in this study and the broader epidemiological mechanisms of leptospirosis transmission.Reducing wet waste accumulation at the source directly reduces attractants for rats and insects (26).

In line with findings from mapping the presence of rats in residential areas, proper waste management eliminates gathering points and rodent trails. Combining this waste treatment technology with household sanitation indicators and evidence of rodents reduces the chances of Leptospira exposure and sharpens the priority of intervention in suspected homes (27).

The application of community-based biofiltration complements the focus on environmental sanitation and evidence of rodents in homes suspected of leptospirosis, as this intervention improves water quality, reduces standing water, and decreases the attractiveness of food and water sources for rats. The presence and functionality of biofilter units can be used as an additional sanitation indicator alongside drainage, waste management, and yard cleanliness for risk cluster mapping. Analytically, these variables can be included as covariates in models of the relationship between sanitation, rodent traces, and suspected leptospirosis status (28).

These results demonstrate that integrating household-level sanitation indicators with documented rodent presence offers a robust, practical foundation for delineating risk clusters and sharpening place-based interventions in Makassar. This strategy yields concrete, trackable actions upgrading drainage, managing waste at its source, promoting protective behaviors, and deploying community technologies like biofiltration aligned with primary care workflows and neighborhood coordination. Acknowledging the cross-sectional design and potential reporting bias, future longitudinal studies with environmental verification (e.g., Leptospira testing in water/soil) and systematic rodent trapping are warranted to strengthen causal claims. Moving forward, unifying household, environmental, and clinical datasets within a single surveillance framework will hasten early detection and targeted corrective measures in priority areas. Collectively, the evidence is poised for translation into municipal policies and programs that sustainably lower leptospirosis risk (29).

CONCLUSION & SUGGESTION

The study found no statistically significant relationship between household environmental sanitation indicators including stagnant water, waste accumulation, drainage conditions, wastewater disposal systems (SPAL), and potential rat access routes and the presence of rodent signs in households of suspected leptospirosis cases. Although the SPAL variable showed a tendency toward significance ($p = 0.136$), it did not reach the 5% threshold. Nevertheless, descriptive observations indicate that inadequate sanitation may still facilitate rodent activity, underscoring the importance of improving environmental hygiene, waste management, and household-level rodent control as preventive efforts.

AUTHOR CONTRIBUTION STATEMENT

All authors meet the authorship criteria and have approved the final version of the manuscript. The individual contributions are summarized using the CRediT taxonomy as follows:

Author 1 – Syamsuar: Conceptualization; Methodology; Investigation; Data curation; Formal analysis; Writing – original draft; Visualization. Author 2 – Sintike: Investigation; Resources; Data curation; Writing – review & editing. Author 3 – Fajar: Methodology; Supervision; Validation; Project administration; Writing – review & editing. [Author 4 – Nasrah; Validation; Project administration; Writing – review & editing.

All authors contributed substantially to the work, critically revised the manuscript for important intellectual content, and agree to be accountable for all aspects of the study.

CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this manuscript, the authors used [tool name(s), e.g., ChatGPT (OpenAI), Grammarly, DeepL] for the purpose of [e.g., language refinement, grammar checking, improving clarity and readability]. The authors reviewed and edited all content generated or suggested by these tools and take full responsibility for the integrity, originality, and accuracy of the final manuscript.

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