



Situation Analysis of Rabies Surveillance and Dog Bite Management in Manufahi Municipality of Timor-Leste, 2025: A Mixed-Methods Quality Data Audit

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Abstract

Objectives: Rabies has emerged as a significant public health threat in Timor-Leste, with 24 recorded human deaths since the disease first appeared in early 2024. While initially concentrated in border areas, the virus has spread to multiple municipalities, including Manufahi Municipality. This study presents a situational analysis of dog bite management concerning rabies risk, the timeliness of surveillance reports, and operational factors in Manufahi Municipality during 2025.

Methods: A mixed-methods quality data audit was employed across four community health centers. Data collection encompassed direct observations of clinical areas, semi-structured interviews with 17 essential health personnel, and a methodical review and cross-verification of outpatient and laboratory register books.

Results: The surveillance system achieved 100% timeliness in weekly reporting. In 2025, Manufahi Municipality recorded 295 dog bite cases, corresponding to an incidence of 4.63 per 1,000 population. Two patients (0.7%) died with clinical signs consistent with rabies. Children aged 5 to 14 years had the highest burden, accounting for 52.9% of cases. While vaccines arrived in June 2025, first-dose anti-rabies vaccine (ARV) coverage reached 84.4% overall (249/295) and 87.7% among eligible category II and III exposures (249/284). However, multi-dose adherence dropped to 28.9% (2 doses; 82/284) and 7.0% (3 doses; 20/284). Rabies immune globulin (RIG) coverage was 13.7% (31/226) among high-risk category III cases.

Public Health Recommendations: Improving rabies control requires standardizing reporting formats and prioritizing the digitalization of surveillance systems. Adopting a "One Health" approach and enhancing community-level vaccine accessibility are vital for sustainable disease elimination.

Keywords: dog bite management, rabies, Timor-Leste, swot analysis, quality data audit, surveillance

Introduction

Rabies is a critical public health threat in Timor-Leste. Since the first confirmed human case in March 2024, the country has recorded 24 deaths as of February 2026.^{1,2} While initially concentrated in border areas, the virus has spread to multiple inland

municipalities, including Manufahi Municipality.³ From April 2024 to July 2025, 1,987 dog bite cases were reported nationally, with 48.6% classified as severe.⁴ Despite the vaccination of over 46,000 dogs, control efforts are hampered by roaming dog populations (98.1%), low community awareness (52.3%), and vaccine shortages.^{5,6}



Epidemiologically, there has been a notable shift in the spatial distribution of dog bite cases within Timor-Leste. Historically, most reported cases were concentrated in municipalities along the border with Indonesia, including Oecusse, Suai, and Maliana, largely attributed to rabies outbreaks occurring in the Nusa Tenggara Timur Province of Indonesia. However, recent epidemiological data suggest that the transmission risk has expanded geographically, with cases now reported across multiple municipalities, including Manufahi Municipality. This spatial spread has been associated with two clinically confirmed deaths in 2025 presenting with clinical signs consistent with rabies infection.

Manufahi Municipality, one of fourteen municipalities in Timor-Leste, is in the southern part of the country. The municipality has a population of 63,697 inhabitants, comprising 32,294 males and 31,403 females. Administratively, Manufahi Municipality is subdivided into four administrative posts, 30 villages, and 139 sub-villages. The municipality has one Municipal Health Service, four Community Health Centers (CHCs), 24 health posts, one internment center, four maternity centers, and five diagnostic laboratories for health care.

The following standardized reporting protocols and mechanisms were implemented across all levels of the health system in Manufahi Municipality to ensure timely and complete public health surveillance reporting: (i) **Epidemiological Calendar:** The surveillance system operates in accordance with a structured epidemiological calendar, which serves as the primary reference framework for scheduling and coordinating all routine surveillance reporting activities; (ii) **Weekly Reporting Protocol:** A Short Message Service (SMS)-based reporting system is utilized to facilitate the timely submission of weekly surveillance data; (iii) **Monthly Reporting Protocol:** For monthly reporting, health posts are directed to submit their reports between the 5th and 6th day of each calendar month; and (iv) **Outbreak and Event-Based Reporting Protocol:** In the event of a suspected outbreak or public health event of significance, both health posts and CHC facilities are required to notify the municipal surveillance officer via SMS within 24 hours of case detection.

This study aims to describe i) report timeliness and ii) management of dog bite cases related to rabies risk, and iii) perform strengths, weaknesses, opportunities, and threats (SWOT) analysis in Manufahi Municipality during 2025. The findings will improve

outbreak investigation and response mechanisms, advance health communication practices, and utilize evidence-based data for informed decision-making.

Methods

This study utilized a mixed-methods quality data audit across four CHCs in Manufahi Municipality. The methodology integrated semi-structured interviews with 17 key health personnel, direct observations of facility infrastructure, and cross-verification of registration books against official reports to measure timeliness, accuracy, completeness, and representativeness. Timeliness of weekly surveillance reports was operationally defined as the proportion of expected weekly reports submitted by each Community Health Center (CHC) to the Municipal Surveillance Officer on or before the official national deadline—specifically, Monday at 12:00 PM following the close of each epidemiological week, as benchmarked by the national epidemiological calendar. Performance was evaluated using a standardized scorecard (known locally as "Kartaun Pontuasaun"; Supplementary Table 1) benchmarked against the national epidemiological calendar. The municipality's surveillance officer and each CHC provided quantitative secondary data on the management of dog bite cases, including anti-rabies vaccine (ARV) and rabies immune globulin (RIG) line list reports, which were analyzed to calculate incidence and proportion of deaths, while qualitative insights were synthesized through a SWOT analysis to identify systemic strengths and barriers.

This mixed-methods quality data audit was conducted in 2025 across four CHCs in Manufahi Municipality. We purposively selected 17 health professionals (managers, clinicians, and laboratory officers) with at least one year of experience in the municipality. Data collection integrated semi-structured interviews, direct facility observations, and a methodical review of outpatient and laboratory register books to assess report timeliness, accuracy, and completeness. Quantitative data were analyzed using Microsoft Excel for incidence and proportion, while qualitative insights were synthesized through a SWOT analysis.

The observation notes, document review, reports, and interview transcripts were managed and analyzed. Microsoft Excel was used to analyze secondary data from dog bite cases and post-exposure prophylaxis (PEP) for frequency, percentage, mean, incidence rate, and proportion. All interviews were transcribed to identify the themes in the SWOT analysis.

Results

Timeliness of Weekly Reporting Manufahi Municipality

We assessed and monitored the timeliness of weekly surveillance reports, aggregated from the four CHC in Manufahi Municipality during 2025. Based on the national benchmark (submission by Monday at 12:00 PM following the surveillance week), all 208 expected weekly reports (52 epidemiological weeks across four CHCs) were submitted on or before the weekly deadline, achieving 100% timeliness (208/208), as part of the ongoing evaluation of surveillance system performance.

Dog Bite Management

The incidence rate of dog bites in Manufahi Municipality for 2025 was 4.63 cases per 1,000 inhabitants. There was a high proportion among children aged 5 to 14 years, accounting for 52.9% (156/295) of all reported bites. Two patients (0.7%, 2/295) died with clinical signs consistent with rabies, although neither case was laboratory confirmed. Males accounted for 49.2% (145/295). The age group with the absolute fewest cases is actually children under one year, with only one case (0.3%). Adults aged 60 years and older recorded 16 cases (5.4%) (Table 1).

Table 1. Distribution of dog bite cases by age group and sex in Manufahi Municipality, Timor-Leste, 2025.

Age group (years)	Male n (%)	Female n (%)	Total n (%)
<1	1 (0.7)	0 (0.0)	1 (0.3)
1–4	16 (11.0)	15 (10.0)	31 (10.5)
5–14	82 (56.6)	74 (49.3)	156 (52.9)
15–24	11 (7.6)	13 (8.7)	24 (8.1)
25–39	15 (10.3)	18 (12.0)	33 (11.2)
40–59	14 (9.7)	20 (13.3)	34 (11.5)
≥60	6 (4.1)	10 (6.7)	16 (5.4)
Total	145 (100)	150 (100)	295 (100)

People bitten by dogs in the Manufahi Municipality are recommended to receive the anti-rabies vaccine (ARV) and rabies immune globulin (RIG) according to the severity of the wound. There are three severity categories. Category I (low risk) involves touching or feeding animals or receiving licks on intact skin. Category II (moderate risk) includes minor scratches or abrasions without bleeding or the nibbling of uncovered skin. Category III (high risk) consists of

single or multiple transdermal bites or scratches (those that break the skin and cause bleeding), licks on broken skin, or the contamination of mucous membranes (such as the eyes or mouth) with infected saliva.¹ ARV is recommended for those with wound categories II and III, whereas RIG is prescribed only for category III. Of the 295 dog bite cases, 226 (76.6%) were category III, 58 (19.7%) were category II, and 11 (3.7%) were category I.

According to the sources, ARV and RIG were distributed to Manufahi Municipality in June 2025, which became fully operational for the community in July 2025. The rise in cases during the last week of August 2025 occurred because once the biologicals were available, local authorities proactively informed the community to seek treatment. The cases were higher in the last week of August and decreased to an average of ten per week during the following months (Figure 1). ARV and RIG were only available in the Manufahi Municipality in July. Subsequently, the local authority announced the availability of these therapies for community members who had been bitten by a dog. The administrative post of Same recorded the highest number of dog bite cases compared to the municipality's other three administrative posts, as shown in Figure 2.

Overall, 249 of the 295 reported dog-bite cases (84.4%) received at least one dose of ARV. Among the 284 category II or III exposures for which ARV was recommended, 249 (87.7%) received at least one dose, 82 (28.9%) received at least two doses, and 20 (7.0%) received at least three doses. No patient was documented as completing the four-dose schedule. Reasons for incomplete vaccination included difficulty accessing services due to remoteness, which made it challenging for patients to return for the multiple follow-up visits required by the four-dose schedule. Moreover, availability of information, personal choices, and preferences also influences a person's decision to receive ARV and RIG.

Of the 295 dog bite cases recorded in Manufahi Municipality during 2025, 226 (76.6%) were classified as high risk. Among these 226 high-risk cases, the coverage rate for RIG was 13.7%.

Of the 295 cases, two died with clinical signs and symptoms consistent with rabies but without laboratory confirmation. Most of the biting dogs were killed by their owners or the community, and only one tested positive for rabies. Moreover, only eight dogs were confirmed to have been vaccinated.

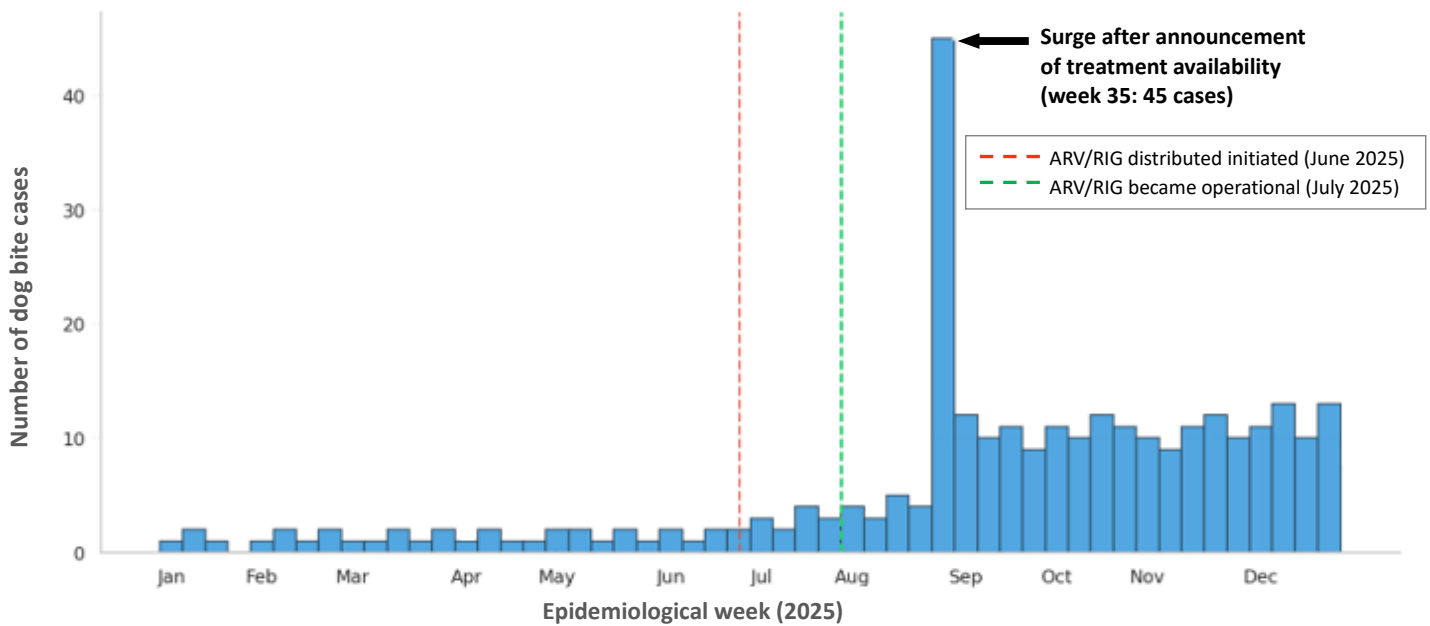


Figure 1. Distribution of reported dog bite cases by epidemiological week, Manufahi Municipality, Timor-Leste, January–December 2025.

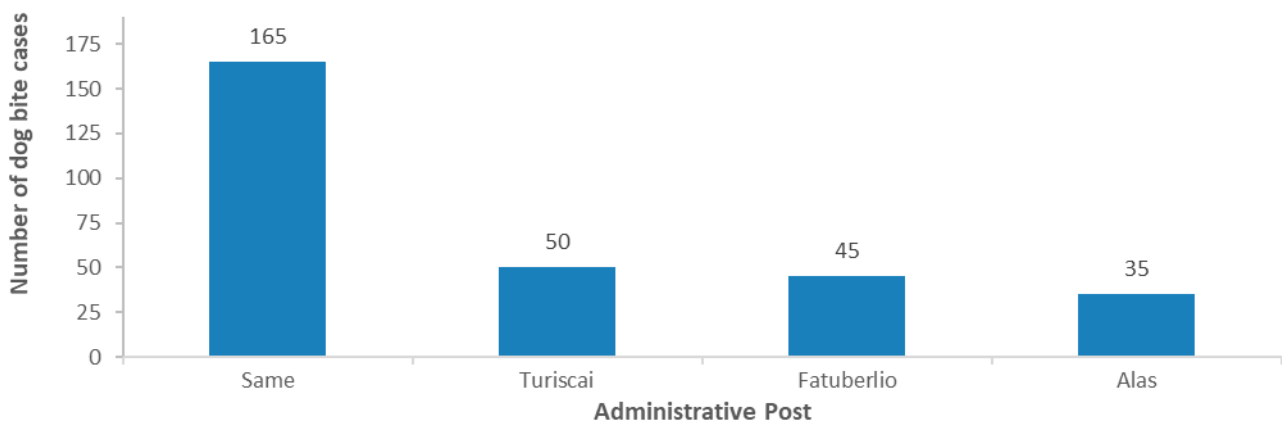


Figure 2. Dog bite cases across administrative posts in Manufahi Municipality, Timor-Leste, 2025.

SWOT Analysis of Municipality Health Services

To identify the systemic operational drivers and barriers affecting the rabies surveillance system, qualitative insights from direct facility observations and semi-structured interviews with 17 key health personnel were synthesized using a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis framework. Table 2 outlines the institutional characteristics of Manufahi Municipality's health services, highlighting a robust foundation of trained human resources, strong collegial teamwork, and timely weekly report submissions. However, the matrix also reveals that these core strengths are heavily undermined by critical, addressable vulnerabilities, including incomplete paper-based documentation in registries, inconsistent age-group

formats, a pronounced lack of digital data systems, and an urgent need for personnel training in data processing and visualization.

Actions Taken

To sustain and strengthen public health surveillance in Manufahi Municipality, the following strategic actions have been initiated. Quarterly monitoring visits have been established across all health facilities to review the performance of surveillance officers. A structured refresher training plan is being developed for epidemiological surveillance officers at all levels. Efforts are underway to standardize all reporting formats into uniform booklet forms and to prioritize the digitalization of the surveillance system to replace paper-based records.

Table 2. SWOT analysis of rabies surveillance and health services among health personnel in Manufahi Municipality, Timor-Leste, 2025.

Strengths	1. Adequate human resources are available across all health facilities within the municipality. <i>"We are already trained as professionals, including doctors, nurses, and midwives"—Surveillance officer.</i> 2. Functional community communication media and information dissemination channels are in place. 3. Active support from institutional partners and stakeholders. 4. Availability of the State General Budget (OGE—Orçamento Geral do Estado) to finance surveillance activities. 5. Availability of transportation resources to support field operations. 6. Established collegial relationships, effective teamwork, and mutual confirmation of responsibilities among all designated officers, contributing to a conducive working environment. 7. Consistent and timely submission of complete surveillance reports in accordance with established reporting protocols.
Weakness	1. Incomplete documentation in registration books, with several key variables remaining unrecorded. 2. Limited knowledge and technical capacity among personnel in the interpretation and analysis of surveillance data. <i>"...Some staff do not yet know the clinical definitions and risk categories for animal bite cases"—Surveillance officer.</i> <i>"There is a lack of understanding regarding the administration protocols for ARV and RIG"—Surveillance officer.</i> 3. Inadequate or absent community communication media in certain areas. 4. Adverse climatic conditions that periodically impede surveillance and field activities. 5. A new letter-based reporting format has not yet been fully adopted across all facilities. 6. Age group classifications in the new reporting format are inconsistent with those used in other existing formats, creating discrepancies in data comparability and analysis. 7. The absence of dedicated transportation for the surveillance officer at each Community Health Center (CHC) facility hinders timely field response. 8. There has been insufficient progress in the digitalization of systems for managing surveillance data. 9. Insufficient communication media and logistical resources for surveillance officers at each CHC facility and health post, including the absence of adequate tablets or laptops, mobile credit, standardized reporting formats, and transportation. 10. Inadequate and insufficient dedicated workspaces for the surveillance officer at each CHC facility limits operational efficiency. 11. Limited availability of transportation resources to support surveillance field operations and timely reporting.
Opportunity	1. Availability of training programs to strengthen the technical competencies of surveillance personnel. <i>"Currently, only a few personnel at the Community Health Center (CHC) level specifically Surveillance, Expanded Programme on Immunization (EPI), and health statistics and health information (Estatistika e Informasaun da Saude–EIS) officers have received specialized rabies training"—Surveillance officer.</i> 2. Continued support from institutional partners and development organizations. 3. Opportunities for study grants and comparative study visits to facilitate knowledge exchange and capacity building.
Threats	1. The lack of specific training for CHC-level surveillance officers on data processing, graphical analysis, and the creation of epidemiological data visualizations presents a significant challenge. <i>"It is uncertain if additional training can be provided for those who have not yet participated"—Surveillance officer.</i> 2. Overreliance on external partner sustainability, which poses a significant risk to the long-term continuity and independence of the surveillance system. <i>"There is concern regarding the sustainability of ARV and RIG supplies; if external support ends, there is no clear plan for managing dog bite cases"—Surveillance officer.</i>

Discussion

The surveillance system in Manufahi Municipality demonstrated exceptional timeliness, with 100% of weekly reports submitted on time across all four CHCs in 2025. This high level of performance is consistent with reports from Zambia where a web-based surveillance tool made it easier to submit reports on time (65.6%) and improved the quality of the data compared to traditional paper-based methods.

Despite timely reporting, the SWOT analysis identifies "incomplete documentation in registration books" as a significant weakness. Key variables often remain unrecorded, which undermines the data quality and reliability of the surveillance system. Furthermore, a lack of technical capacity among personnel for data interpretation and analysis suggests that while data is submitted on time, its accuracy and utility for informed decision-making are compromised.

The veterinary epidemiology in Manufahi Municipality reveals significant gaps; only eight dogs involved in the 295 reported bites were vaccinated. The high prevalence of roaming dogs (98.1%) facilitates rapid viral transmission. Although 46,000 dogs were vaccinated nationally, local efficacy is hindered by logistical constraints and a disconnect between human and animal health sectors.

A major barrier to surveillance is the community's tendency to euthanize biting animals immediately following an incident. This practice, coupled with limited veterinary resources, resulted in only one biting dog undergoing laboratory testing during the entire study period. The audit identifies a 'critical absence of veterinary follow-up,' highlighting a disconnect between human health reporting and animal health investigation. These documentation gaps and the critical absence of veterinary coordination are highlighted in the audit dimensions of the standardized scorecard (Supplementary Table 1).

The success in achieving 100% timeliness in weekly surveillance reporting in Manufahi Municipality is largely attributed to active monitoring by a dedicated municipal surveillance officer and the utilization of digital communication tools such as WhatsApp for immediate data submission. This aligns with studies in Côte d'Ivoire, which demonstrated that leveraging mobile phone technology improves compliance and the bolstering of human rabies surveillance.^{7,8}

The finding that 52.9% of dog bite cases occurred in children aged 5 to 14 years aligns with global WHO data identifying school-aged children as the most frequent victims of rabies exposure.^{9,10} The elevated incidence within this demographic may be associated with diminished disease awareness, as previous evaluations in Timor-Leste indicated that only 52.3% of people in high-risk regions were cognizant of rabies. This mirrors challenges in India, where poor awareness and socio-cultural myths often delay the initiation of life-saving treatment.¹¹

The temporal analysis of dog bite cases in 2025 revealed a significant surge during the last week of August, followed by stabilization to an average of ten cases per week in subsequent months. This observed peak likely reflects improved case detection and healthcare-seeking behavior indicative of ascertainment bias rather than a true increase in the biological incidence of dog bites. This trend directly corresponds with the rollout of the anti-rabies vaccine and rabies immune globulin in Manufahi

Municipality, which became available in June and July 2025. The subsequent notification of the community by local authorities regarding the availability of these life-saving treatments likely prompted a 'backlog' of victims to seek care. Given that research indicates only 67% of households in Timor-Leste typically report dog bites to professional health services, this sudden increase in reporting underscores how the availability of medical supplies and enhanced risk communication can influence surveillance sensitivity.⁵

Although ARV and RIG became available in June 2025, vaccination completion declined. While 87.7% of eligible cases received the first dose, only 7.0% completed three doses. Manufahi Municipality's mountainous geography and remoteness create significant barriers to follow-up visits, similar to findings in India where indirect travel costs and facility distance severely hindered PEP compliance.^{11,12}

The SWOT analysis revealed that while Manufahi Municipality has sufficient human resources and established communication channels, incomplete documentation and a lack of digitalization impeded its progress. To address these weaknesses, implementing an Integrated Bite Case Management (IBCM) approach, as piloted in Tanzania, could formally link the health and veterinary sectors to increase case detection and intersectoral communication. Also, for rabies control efforts to be successful in the long term, it is important to use an "eco-health" or "One Health" approach that puts community involvement and ownership first. Transitioning to standardized digital reporting formats is a necessary step to reduce the current overreliance on external partners and ensure data accuracy for informed decision-making.¹²

This study reveals critical gaps in veterinary epidemiology that undermine human rabies prevention in Manufahi Municipality, characterized by extremely low vaccination coverage among stray dogs, where only eight dogs involved in the 295 reported biting incidents were vaccinated. This risk is exacerbated by local dog ecology, as nearly all households allow their pets to roam free, which facilitates the rapid horizontal transmission of the virus. Furthermore, the community's tendency to put down biting dogs, coupled with the fact that only one dog underwent laboratory testing during the study period, highlights a severe lack of systematic animal surveillance and intersectoral follow-up. To address

these failures, transitioning to a "One Health" framework through IBCM is essential to formally link human health reporting with veterinary investigations. Such a strategy would improve case detection in animal populations, optimize the use of limited medical resources such as RIG and ARV, and foster the community ownership necessary for long-term rabies elimination.

Although this study did not evaluate the implementation of IBCM, the finding that only one biting dog was tested for rabies suggests a critical absence of veterinary follow-up. Integrating IBCM could provide the formal framework needed to ensure that human PEP decisions are informed by veterinary risk assessments, thereby optimizing the use of RIG and ARV in resource-limited settings such as Manufahi Municipality.

Limitations

The study faced several constraints that should be considered when interpreting the results. First, the identification of two human rabies deaths was based on clinical signs and symptoms rather than laboratory confirmation, which remains a challenge in the region. Second, the quantitative data relied on existing outpatient and laboratory register books, which were found to have incomplete documentation for several key variables. Third, the qualitative component utilizes purposive sampling of 17 key informants, which may not capture the perspectives of all healthcare providers in the municipality. Fourth, the study was limited to Manufahi Municipality, and while it provides a critical situational analysis, the findings regarding logistical barriers such as the mountainous geography and remoteness may vary in other administrative contexts within Timor-Leste. Finally, our study relied on passive surveillance, which only captures data from individuals who proactively seek care at health facilities. This likely results in a reporting bias, as cases occurring in remote areas or treated with traditional medicine may go unrecorded. Supporting this, existing research in Timor-Leste indicates that only 67% of households seek professional medical assistance following a dog bite, suggesting the 295 cases identified in Manufahi Municipality represent an underestimate of the true community burden.⁵ There is also the potential for exposure misclassification regarding the risk categories. Our audit revealed that registration books were often incomplete, with several key variables unrecorded, which may lead to errors in how the severity of a bite

was categorized. Furthermore, the lack of widespread laboratory confirmation for both human deaths and biting dogs means that some clinical cases may have been misidentified.

Public Health Recommendations

To strengthen rabies surveillance and case management in Manufahi Municipality, health authorities should prioritize standardizing all reporting formats into uniform booklets and accelerating the transition toward digital surveillance systems to replace paper-based records. Furthermore, addressing operational constraints requires establishing dedicated workspaces for facility surveillance officers alongside conducting targeted training on data visualization, analytical processing, and rabies-specific clinical exposure categories. Finally, routine performance monitoring should be sustained through quarterly supervisory visits across all health facilities, supported by a structured refresher training program for health post-level personnel.

Conclusion

The findings of this study underscore that while Manufahi Municipality achieved 100% timeliness in weekly surveillance reporting, significant gaps remain in the clinical management of dog bites. The high incidence of bites among children aged 5 to 14 years (52.9%) highlights a critical need for targeted risk communication and school-based awareness programs to address low levels of rabies knowledge. While the perfect timeliness score is a significant achievement, it did not translate into effective patient outcomes, as evidenced by the significant decline in children receiving further vaccine doses, and no child completed the required four-dose schedule. These failures are largely driven by geographical barriers, remoteness, and systemic issues such as incomplete documentation and a lack of fully digitalized data system.

To sustain and strengthen rabies control, the municipality must transition from paper-based records to a standardized digital surveillance system and invest in technical training for data visualization and analysis. Ultimately, long-term elimination of rabies in Manufahi Municipality could be advanced by adopting an IBCM approach. This strategy would address the identified gap between human health reporting and veterinary investigations, fostering the intersectoral collaboration necessary to sustain the 'One Health' model in Timor-Leste.

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Author Contributions

Quintão de Andrade: Conceptualization, investigation, methodology, project administration, writing—original draft. **Cristovão De Alexandria Barros:** Data curation, formal analysis, software, writing—original draft, writing—review & editing. **Orlando Martins:** Conceptualization, data curation, investigation, writing—review & editing. **Erti Fatima Fernandes:** Data curation, investigation, writing—review & editing. **Cláudio de Jesus Oliveira:** Investigation, validation, writing—review & editing. **Domingos Soares:** Formal analysis, methodology, software, writing—review & editing.

Ethical Approval

This study was conducted as part of routine public health surveillance and Field Epidemiology Training Program (FETP) activities in Timor-Leste. The study primarily used secondary surveillance data collected as part of routine public health practice. No ethical committee approval was sought. Interviews were conducted with health professionals to assess surveillance practices and operational factors, and no personally identifiable patient information was collected or reported.

Informed Consent

Informed consent was obtained from all health professionals who participated in the interviews.

Data Availability

The data that support the findings of this study are available from the Manufahi Municipality Health Services and the National Institute of Public Health (INSP-TL). Restrictions apply to the availability of these data, which were used under license for this

study. Data are available from the authors with the permission of the Manufahi Municipality Health Services and the National Institute of Public Health (INSP-TL).

Conflicts of Interest

There is no conflict of interest regarding this study.

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Declaration of Generative AI and AI-assisted Technologies in the Writing Process

During the preparation of this work, the authors used generative AI and AI-assisted technologies (specifically for language editing, structural refinement, and the drafting of the abstract and cover letter) to improve the clarity and readability of the manuscript. After using these services, the authors reviewed and edited the content as needed and took full responsibility for the content of the final draft.

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