Original article

Outbreak, Surveillance, Investigation & Response (OSIR) Journal
ISSN 2651-1061 (Online)
https://he02.tci-thaijo.org/index.php/OSIR
Email: osir@ddc.mail.go.th

September 2026
Volume 19, Issue 3
Article no. 281458

Knowledge Assessment of Dog Bite and Rabies Management among Health Workers in the Border Region of Timor-Leste

Filipe De Nery Machado, Cristovão De Alexandria Barros*, Marcelo Amaral Mali, Adriano Barbosa, Mariano Da Silva Marques

Timor-Leste National Institute of Public Health (INSP-TL), Timor-Leste

*Corresponding author, email address: ivanzeruwsky@gmail.com

Received: 7 Apr 2026; Revised: 5 Jul 2026; Accepted: 17 Aug 2026
https://doi.org/10.59096/osir.v19i3.281458

Abstract

Objectives: Rabies emerged as a significant public health threat in Timor-Leste following the first laboratory-confirmed outbreaks in 2024. The Região Administrativa Especial de Oé-Cusse Ambeno (RAEOA) border region has been disproportionately affected, recording over 800 dog bite cases and five human deaths between 2023 and 2024. This study assessed healthcare workers' (HCWs) knowledge of rabies transmission, prevention, and dog bite management to identify gaps and strengthen the local health response.

Methods: A quantitative knowledge survey was conducted from 14 to 22 April 2024. Using convenience sampling, data was collected from 164 HCWs across seven health facilities in the RAEOA region. Descriptive statistics were presented, while inferential analysis using Analysis of Variance was performed to examine differences in knowledge scores across professional cadres and health facilities.

Results: The mean age of the 164 participants was 34 years (SD 8.84). Nurses (25.6%) and allied technicians (20.1%) comprised the largest professional groups. Overall knowledge was high, with a mean score of 80%; 37.2% achieved a perfect score of 17/17. Significant differences in knowledge scores were observed by profession (*p*-value 0.018) and workplace (*p*-value 0.006), with doctors and midwives achieving the highest mean scores. However, only 40.8% of respondents correctly identified rabies' near-100% fatality rate, and only 71.9% knew Category III wounds should not be sutured.

Public Health Recommendations: HCWs in the RAEOA region demonstrated strong knowledge of rabies transmission, prevention, and management. However, disparities across professional cadres and health facilities underscore the need for targeted, continuous training, equitable resource distribution, and strengthened surveillance systems. Rabies control efforts should adopt a One Health approach integrating human health surveillance, dog vaccination, and cross-border coordination.

Keywords: rabies, Timor-Leste, healthcare workers, knowledge assessment, dog bite management, public health

Introduction

Rabies is a significant global public health concern and remains one of the oldest known zoonotic diseases.[1] Although it is entirely preventable, the World Health Organization estimates that it causes approximately 59,000 human deaths annually, primarily in Asia and Africa.[1,2] These deaths are strongly associated with dog-mediated transmission, highlighting ongoing challenges such as limited access to vaccines, low public awareness, and significant gaps in post-exposure prophylaxis (PEP) within low- and middle-income countries.[1,3]

In Indonesia, rabies has been prevalent since the late 1800s, but it only recently re-emerged on Timor Island in 2023 after a century of absence.[4] This outbreak was severe, resulting in 3,961 animal-bite cases and 17 human deaths in 2023 alone.[5,6] In Timor-Leste, rabies became a major threat following laboratory-confirmed outbreaks in 2024.[4] Sanger sequencing provided strong molecular evidence of transboundary transmission,

All material is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International (CC-BY-NC-ND 4.0) License unless otherwise stated.

showing 100% nucleotide identity between virus isolates in Timor-Leste and those from Indonesia.[4] This underscores the critical need for coordinated cross-border surveillance and control measures on Timor Island.[2]

Região Administrativa Especial de Oé-Cusse Ambeno (RAEOA), an exclave of Timor-Leste surrounded by Indonesia's East Nusa Tenggara province, is uniquely vulnerable to these transboundary dynamics (Figure 1). Local epidemiology reflects this vulnerability; between 2023 and 2024, the region recorded 821 dog-bites, 36 laboratory-confirmed animal cases, and five human deaths.[7,8] These figures identify RAEOA as a primary hotspot for rabies transmission within Timor-Leste.[9] In immediate response to this outbreak, the national government—jointly coordinated by the Ministry of Health and the Secretary of State for Livestock—initiated several multi-sectoral outbreak control actions. These included reinforcing active epidemiological surveillance for dog bite cases, implementing mass dog vaccination campaigns targeting the primary reservoir, and launching community awareness programs to educate the public on immediate post-bite care.

However, the effectiveness of these interventions is often hindered by health system constraints and insufficient technical capacity at the municipal level. Successful rabies management relies heavily on the preparedness of healthcare workers (HCWs) to provide timely PEP and accurate case management. Currently, capacity remains uneven, presenting a significant barrier to an effective outbreak response. While the burden of dog bites and rabies in RAEOA is well-documented, there has been no previous formal assessment of the knowledge and preparedness of the region's healthcare workers regarding rabies transmission and management. Understanding the existing knowledge levels among different professional cadres is essential to identify specific gaps that may lead to suboptimal patient care or missed reporting opportunities.

The main objective of this study is to assess the knowledge of healthcare workers in RAEOA regarding rabies and dog bite management. Specifically, the study aims to: i) evaluate the baseline level of clinical knowledge regarding rabies transmission, prevention, and management across different healthcare cadres; and ii) identify specific technical gaps in clinical practice, such as post-exposure prophylaxis protocols, case reporting, and the administration of anti-rabies vaccine and immunoglobulin. Ultimately, identifying these vulnerabilities serves to inform targeted public health recommendations to strengthen training and rabies prevention strategies in the region.



Figure 1. Map of the Região Administrativa Especial de Oé-Cusse Ambeno (RAEOA) of Timor-Leste.

Methods

Study Design and Sampling

This was a cross-sectional survey. The population of the study was all 308 HCWs in the area, and convenience sampling was used to obtain participants. This sampling method was used with the reason to select only those available and on duty HCW in each health facility which represents both urban and rural areas. A total of 164 HCWs were recruited across all five community health centers (CHCs) in the region, one Regional Health Service (the regional health authority), and one regional hospital (the Oé-Cusse Referral Hospital) based on the list of participation in the previous "Rabies and Dog Bite Management Dissemination Workshops" and based on their availability. Although recruitment leveraged training attendance lists, the convenience sampling specifically sought to include all personnel on duty at the time of the survey. This resulted in a diverse cohort that included individuals who had not participated in the initial Rabies and Dog Bite Management Dissemination Workshops, such as newly recruited staff and medical students. This inclusion was vital to capture a realistic assessment of the region's overall clinical preparedness and to identify specific gaps in the reach of current training initiatives.

A structured quantitative survey questionnaire (see Supplementary Appendix 1) was used in this study. The required sample size was determined using Cochran's formula for a finite population (N=308) assuming a 95% confidence level, a margin of error of 5.32%, and a conservative response proportion of 50%, resulting in an adjusted sample size of approximately 164 HCWs who were available and on duty during the survey period.[10]

Inclusion and Exclusion Criteria

This study included all HCWs currently employed in health facilities or the Regional Health Service within the RAEOA region. Eligible participants spanned clinical cadres, such as doctors, nurses, and midwives, as well as non-clinical and allied staff, including pharmacists, laboratory technicians, public health officers, and program managers, regardless of their prior participation in the Rabies and Dog Bite Management Dissemination Workshops. Additionally, medical students currently on clinical rotation in RAEOA were included, provided they gave voluntary informed consent prior to the assessment. Non-clinical and allied professionals were included alongside clinical staff due to their close daily collaboration in patient care and case reporting. Conversely, individuals were excluded from the study if they were on leave, participating in official travel, or otherwise absent during the data collection period of 14 to 22 Apr 2024. Furthermore, any participants who submitted incomplete questionnaires lacking critical demographic data or knowledge variables on the Kobo Toolbox platform were excluded from the final analysis.

Data collection

The data was collected using Kobo Toolbox, an online and offline mode questionnaire (see Supplementary Appendix 1) from 14 to 22 Apr 2024. The participants were asked for their informed consent and their willingness to fill out the questionnaires. The survey utilized a 17-item scoring system developed based on national and international guidelines to assess knowledge across six thematic categories. Additionally, a separate, single-item question using a 5-point Likert scale (ranging from 'poor' to 'excellent') was included at the end of the survey to capture subjective feedback on participants' perceptions of previous rabies and dog bite management guideline dissemination sessions conducted by the National Institute of Public Health of Timor-Leste (INSP-TL).

Statistical Analysis

Data cleaning and descriptive statistical analyses (percentages, means, and standard deviations (SD)) were performed for the 17-item knowledge scoring system, while frequencies and percentages of the 5-point Likert scale categories were calculated to analyze the training dissemination feedback. Inferential statistical analyses were performed using Python (version 3.12) within a Google Colab environment. Data manipulation was managed via the pandas and matplotlib library, and one-way analysis of variance (ANOVA) was executed using the scipy.stats library. ANOVA was used to compare mean knowledge scores across seven professional cadres and seven health facilities.

A significance level of p-value <0.05 was established for all tests. Prior to the analysis, the fundamental assumptions for ANOVA were verified: normality was evaluated using the Shapiro-Wilk test, and homogeneity of variances was assessed using Levene's test. Where minor deviations occurred, ANOVA was maintained due to its robustness with nearly balanced groups and a sample size of 164.

Results

Demographics and Workplace Characteristics

Among the 164 participants, 89 (54.3%) were male and 75 (45.7%) were female, with a mean age of 34 years (SD 8.84). Nurses (25.6%) and allied health technicians (20.1%) represented the largest professional cadres. Approximately 60.4% of participants worked at either the Regional Health Service (30.5%) or the Oé-Cusse Referral Hospital (29.9%), with remaining personnel distributed across peripheral community health centers (Table 1).

Overall Rabies Knowledge and Dissemination Feedback

Overall rabies management knowledge was high across the sample, with a mean score of 80% (13.60 out of 17) and 61 participants (37.2%) achieving a perfect score of 17/17 (Table 2). Subjective feedback on previous guideline dissemination sessions showed ratings of 'excellent' (23.3%), 'very good' (55.8%), 'good' (19.6%), and 'fair' (1.2%) (Table 1), indicating that prior capacity-building efforts successfully established a high baseline level of clinical awareness.

Table 1. Demographic and workplace characteristics of study participants (n=164).

Demographic and workplace characteristic	Frequency (n)	Percentage (%) / statistic
Age (years)		
Mean (SD)		34.0 (8.84)
Gender		
Male	89	54.3%
Female	75	45.7%
Professional cadre		
Nurse	42	25.6%
Allied technician	33	20.1%
Medical student	24	14.6%
Doctor (medical)	19	11.6%
Public health officer	19	11.6%
Midwife	16	9.8%
Pharmacist	11	6.7%
Health facility (workplace)		
Regional Health Service	50	30.5%
Oé-Cusse Referral Hospital	49	29.9%
Baocnana CHC	15	9.2%
Oe-Silo CHC	13	7.9%
Baqui CHC	13	7.9%
Passabe CHC	12	7.3%
Quimanteco CHC	12	7.3%
INSP-TL guideline dissemination feedback		
Excellent	38	23.2%
Very good	92	56.1%
Good	32	19.5%
Fair	2	1.2%
Poor	0	0.0%

SD: standard deviation. CHC: community health center. INSP-TL: National Institute of Public Health of Timor-Leste.

Table 2. Mean rabies knowledge scores and Tukey's honestly significant difference (HSD) post-hoc pairwise comparisons by professional cadre (n=164).

Professional cadre	Sample n (%)	Mean score (SD)	Tukey's HSD pairwise comparisons (FWER=0.05)
Nurse	42 (25.6)	15.60 (1.53)	vs. Allied technician: Diff +0.86, 95% CI: -0.20, 1.92 (not significant, *p*-value 0.197)
Allied technician	33 (20.1)	14.73 (2.20)	Reference group for lowest-scoring pairwise comparisons.
Medical student	24 (14.6)	15.09 (1.38)	vs. Allied technician: Diff +0.39, 95% CI: -0.83, 1.61 (not significant, *p*-value 0.962) vs. Doctor: Diff -0.60, 95% CI -2.00, 0.80 (not significant, *p*-value 0.857)
Doctor (medical)	19 (11.6)	15.95 (1.78)	vs. Allied technician: Diff +0.99, 95% CI: -0.31, 2.30 (not significant, *p-value* 0.268) vs. Nurse: Diff -0.14, 95% CI: -1.39, 1.12 (not significant, *p*-value 0.999)
Public health officer	19 (11.6)	15.84 (1.30)	vs. Allied technician: Diff +1.13, 95% CI: -0.17, 2.44 (not significant, *p-value* 0.137)
Midwife	16 (9.8)	16.40 (0.91)	vs. Allied technician: Diff +1.64, 95% CI: 0.26, 3.03 (significant, *p*-value 0.009) vs. Medical student: Diff +1.25, 95% CI: -0.22, 2.72 (not significant, *p*-value 0.150) vs. Nurse: Diff -0.79, 95% CI: -2.12, 0.55 (not significant, *p*-value 0.580)
Pharmacist	11 (6.7)	15.55 (1.37)	vs. Allied technician: Diff +0.81, 95% CI: -0.76, 2.40 (not significant, *p*-value 0.716)
Overall sample	**164 (100.0)**	**13.60 (2.15)**	**Overall ANOVA *p*-value 0.018**

**Overall knowledge level is 80.0%; 61 participants (37.2%) achieved a perfect score of 17/17. SD: standard deviation. FWER: family-wise error rate. vs: versus. Diff: mean difference. CI: confidence interval.*

Key Clinical Knowledge Gaps

Although the overall knowledge scores were encouraging, the analysis revealed several critical clinical knowledge gaps across the thematic domains (Table 3). Notably, while 98.1% of respondents correctly identified dogs as the primary transmission vector, only 40.8% were aware that rabies is virtually 100% fatal once clinical symptoms manifest. Furthermore, a

substantial clinical gap was observed regarding post-exposure wound care, as only 71.9% of participants recognized that Category III wounds should generally not be sutured. Similarly, confusion persisted regarding immunization regimens; although 92.1% of healthcare workers correctly identified the intramuscular route for vaccine administration, only 73.8% could accurately differentiate the 3-dose pre-exposure prophylaxis (PrEP) schedule from the 5-dose post-exposure prophylaxis (PEP) regimen. Regarding passive immunization, while 83.7% of respondents understood the necessity of human rabies immunoglobulin (HRIG), multiple individuals incorrectly identified general intramuscular sites, such as the buttocks or leg, for its administration instead of direct, local infiltration around the margins of the wound. Conversely, knowledge regarding epidemiological reporting was exceptionally high, with 97.0% of participants correctly identifying the mandatory 24-hour window for case reporting across all health facilities.

Knowledge Variance by Cadre and Workplace

Mean knowledge scores varied significantly across professional cadres (p-value 0.018, Table 2). Midwives (mean 16.40, standard deviation (SD) 0.91) and doctors (mean 15.95, SD 1.78) recorded the highest scores, while allied technicians (mean 14.73, SD 2.20) and medical students (mean 15.09, SD 1.38) scored the lowest. Tukey's HSD post-hoc analysis confirmed a statistically significant pairwise difference between midwives and allied technicians (mean difference +1.64, 95% confidence interval 0.26, 3.03, p-value 0.009). No other pairwise comparisons between specific cadres reached statistical significance (all adjusted p-value >0.05, Table 2).

There was also a statistically significant difference in knowledge scores based on the health facility of employment (p-value 0.006, Table 4). The highest mean scores were observed at Passabe (16.33, SD 1.07) and Quimanteco (16.00, SD 1.18) CHCs, whereas the lowest were recorded at Oe-Silo (14.50, SD 2.65) and Baqui (14.46, SD 1.94) CHCs. The mean score at the central Oé-Cusse Referral Hospital was 15.20 (SD 1.61). Tukey's HSD post-hoc analysis for health facilities confirmed that no individual pairwise comparisons between specific workplaces reached statistical significance (all adjusted p-value >0.05, Table 4). Specifically, comparisons between the highest-performing facility, Passabe CHC, and the lowest-performing facilities—Baqui CHC (mean difference 1.77, adjusted p-value 0.065) and Oe-Silo CHC (mean difference 1.79, adjusted p-value 0.061)—were not statistically significant, both exceeding the significance threshold.

Table 3. Detailed rabies knowledge assessment by specific topic (n=164).

Knowledge topic	Key correct response information	Correct n (%)	Proficiency
Rabies definition	A preventable zoonotic disease affecting the central nervous system.	162 (98.8)	Very high
Transmission source	Dogs are responsible for 99% of rabies transmission to humans.	161 (98.1)	Very high
Transmission pathway	Spreads via saliva through direct contact with mucosa or open wounds.	162 (98.8)	Very high
Clinical symptoms	Includes hydrophobia, photophobia, fever, and muscle spasms.	153 (93.5)	High
Wound classification	Dog bite wounds are classified into three distinct clinical categories.	149 (90.8)	High
Wound management (first aid)	Wounds must be washed thoroughly with soap and water for 15 minutes.	158 (96.1)	Very high
Suturing protocol	Category III wounds should generally not be sutured.	118 (71.9)	Low
Vaccine administration route	Administered Intramuscularly (Deltoid in adults; anterolateral thigh in infants).	151 (92.1)	High
Vaccine safety	Safe for all groups, including pregnant and breastfeeding women.	154 (93.8)	High
PrEP vs. PEP schedule	3 doses for pre-exposure prophylaxis (PrEP); 5 doses for post-exposure (PEP).	121 (73.8)	Low
HRIG application	Human Rabies Immunoglobulin (HRIG) must be infiltrated around wound margins.	137 (83.7)	Moderate
Case reporting window	Suspected dog bite cases must be reported within 24 hours.	159 (97.0)	Very high
Disease fatality rate	Once clinical symptoms appear, the fatality rate is nearly 100%.	67 (40.8)	Low

Very high proficiency: ≥95%; High proficiency: 85.0%–94.9%; Moderate proficiency: 75.0%–84.9%; Low proficiency: <75.0% (indicating a critical knowledge gap).

Table 4. Mean rabies knowledge scores and Tukey's honestly significant difference (HSD) post-hoc pairwise comparisons by health facility (n=164).

Health facility	Sample n (%)	Mean score (SD)	Tukey's HSD pairwise comparisons (FWER=0.05)
Regional Health Service	50 (30.5)	15.86 (1.43)	vs. Baqui CHC: Diff +1.33, 95% CI: -0.09, 2.76 (not significant, *p*-value 0.716) vs. Oe-Silo CHC: Diff +1.35, 95% CI: -0.08, 2.77 (not significant, *p*-value 0.464)
Oé-Cusse Referral Hospital	49 (29.9)	15.20 (1.61)	vs. Passabe CHC: Diff -1.03, 95% CI: -2.51, 0.44 (not significant, *p*-value 0.360) vs. Regional Health Service: Diff +0.59, 95% CI: -0.33, 1.51 (not significant, *p*-value 0.464)
Baocnana CHC	15 (9.1)	15.80 (1.47)	vs. Baqui CHC: Diff -1.23, 95% CI: -2.96, 0.50 (not significant, *p*-value 0.344)
Oe-Silo CHC	13 (7.9)	14.50 (2.65)	Comparison group with high score variance and lower mean score.
Baqui CHC	13 (7.9)	14.46 (1.94)	Comparison group with lowest mean score.
Passabe CHC	12 (7.3)	16.33 (1.07)	vs. Baqui CHC: Diff +1.77, 95% CI: -0.06, 3.60 (not significant, *p*-value 0.065) vs. Oe-Silo CHC: Diff +1.79, 95% CI: -0.04, 3.62 (not significant, *p*-value 0.061) vs. Oé-Cusse Referral Hospital: Diff +1.13, 95% CI: -0.44, 1.91 (not significant, *p*-value 0.973)
Quimanteco CHC	12 (7.3)	16.00 (1.18)	vs. Baqui CHC: Diff +1.47, 95% CI: -0.36, 3.30 (not significant, *p*-value 0.207) vs. Oe-Silo CHC: Diff +1.48, 95% CI: -0.35, 3.31 (not significant, *p*-value 0.197)
Overall sample	**164 (100.0)**	**13.60 (2.15)**	Overall ANOVA *p*-value 0.006

SD: standard deviation. FWER: family-wise error rate. vs: versus. CHC: community health center. Diff: mean difference. CI: confidence interval.

Discussion

The primary finding of this study is a high overall knowledge level (80%) among healthcare workers in the RAEOA exclave, with 37.2% of respondents achieving a perfect score. This strong baseline proficiency serves as a direct clinical evaluation of the previous capacity-building and guideline dissemination workshops conducted by the INSP-TL. Our results indicate that these initial dissemination efforts successfully established a robust foundation for regional rabies response. These findings, consistent with regional assessments where targeted training programs significantly enhanced frontline readiness, demonstrate the efficacy of recent capacity-building initiatives.[11,12]

However, this 80% baseline represents a 'high-water mark' that obscures critical clinical gaps that could directly compromise patient survival. The first is the 'fatality paradox': although general disease awareness is high (93.5%), only 40.8% of respondents recognized that rabies is nearly 100% fatal once clinical symptoms manifest. This gap indicates a critical deficit in understanding disease severity. If healthcare providers do not fully grasp the absolute lethality of the virus, the perceived urgency for delivering immediate, aggressive treatment with PEP may diminish, resulting in preventable fatalities.

Second, the finding that 28.1% of respondents failed to identify that Category III wounds should generally not be sutured is highly concerning. Premature suturing of rabies-exposed wounds is contraindicated because it can facilitate the deep inoculation of the virus into muscle and nerve tissue, accelerating transport to the central nervous system. This gap suggests that while HCWs understand active clinical procedures (such as washing the wound for 15 minutes, 96.1%), they require more targeted education on contraindicated clinical actions.[13]

Third, clinical confusion regarding dosing schedules (73.8% proficiency) and human rabies immunoglobulin (HRIG) administration (83.7%) represents a critical vulnerability. Successful post-bite prevention relies on neutralizing the virus at the site of entry through immediate wound infiltration with HRIG. Incorrect administration (such as general intramuscular injection in the buttocks or leg) or confusion between the 3-dose pre-exposure prophylaxis (PrEP) and the 5-dose PEP regimens can lead to rapid clinical failure. These complex clinical nuances cannot be adequately addressed by brief educational outreach alone; they require hands-on, interactive workshops. [13]

The statistically significant differences in knowledge scores across professional cadres identify a clear hierarchy in training access. Midwives and doctors demonstrated the highest levels of mastery, having been the primary targets of initial educational outreach. Conversely, allied technicians and medical students achieved the lowest scores. Allied technicians are critical because they frequently serve as the initial point of contact in peripheral clinics, and their lower proficiency represents a systemic weakness in the early detection and management of suspected cases. This score variance suggests that knowledge

differences are distributed throughout the workforce rather than driven by a single outlier cadre. Ultimately, these results indicate a relatively uniform baseline of knowledge across core clinical professions, with the primary training gap concentrated between allied support technicians and specialized maternal care clinicians.

Significant workplace variations further highlight this institutional divide. High performance at Passabe CHC (mean 16.33) indicates successful localized knowledge transfer, whereas the lower scores at Baqui CHC (mean 14.46) and Oe-Silo CHC (mean 14.50) identify peripheral health facilities that remain underserved. The relatively lower average scores at the central Oé-Cusse Referral Hospital (mean 15.20) highlight that clinical settings with high staff turnover and rotating students require continuous, institutionalized training cycles rather than occasional, one-off sessions. This relatively lower performance at the central referral hospital was heavily influenced by the high proportion of rotating medical students and newly recruited staff who had not yet received the initial educational outreach. These findings underscore that workplace-level variation is systemic across the municipality rather than isolated to a single, poorly performing community health center.

While this study's primary focus is restricted to human healthcare providers, effective rabies control inherently requires a One Health approach. In the RAEOA exclave, the high proficiency in case reporting (97.0%) among HCWs serves as the primary trigger for veterinary interventions, such as canine surveillance and vaccination campaigns conducted by the Secretary of State for Livestock. Integrating human clinical surveillance with these veterinary and transboundary initiatives is critical to preventing human rabies deaths.[14–16]

Implications for Future Clinical Training

The findings of this assessment have several important implications for future capacity-building efforts in the region. First, educational campaigns must shift from broad, lecture-based guideline dissemination to practical, hands-on clinical workshops specifically designed for nurses and allied technicians. These targeted curricula should prioritize high-error areas such as Category III wound management, emphasizing the contraindication of suturing and the precise technique required for direct wound infiltration of Human Rabies Immunoglobulin. Second, to address the institutional disparities highlighted in this study, training resources must be distributed equitably across the municipality. Directing educational interventions toward peripheral community health centers will ensure that healthcare providers serving as the first point of contact are as clinically prepared as those at the regional hospital. Lastly, given the transboundary nature of the outbreak on Timor Island and the molecular evidence showing 100% nucleotide identity with Indonesian viral isolates, capacity-building must be sustained as a long-term public health priority. These clinical training efforts must be operationally linked with active cross-border epidemiological coordination and veterinary rabies control measures, including canine vaccinations, to establish a durable barrier against rabies transmission in Timor-Leste.[14,15]

Limitations

Several limitations must be acknowledged. First, convenience sampling and recruitment leveraging prior training lists introduce selection bias, potentially overestimating baseline clinical knowledge. By sampling readily available on-duty staff frequently associated with previous educational outreach, these findings likely reflect the 'high-water mark' of clinical preparedness rather than a true average of the 308-member health workforce. Second, the cross-sectional design captures only a temporal snapshot of clinical knowledge in April 2024, preventing evaluation of long-term retention or establishing a direct causal link between training and subsequent proficiency. Third, the self-administered survey via KoboToolbox presents a risk of information bias, as unsupervised respondents may have consulted external materials or collaborated with colleagues, inflating correct response rates. Finally, because the assessment was conducted exclusively within the unique epidemiological, geographic, and administrative boundaries of the RAEOA exclave, the findings may not be fully generalizable to other Timor-Leste municipalities where disease prevalence, training frequency, and resource availability differ.

Public Health Recommendations

To systematically enhance rabies management in RAEOA, several public health actions are recommended. First, health directorates should transition from lectures to continuous, cadre-specific clinical workshops targeting lower-scoring nurses and allied technicians to address critical gaps in fatality awareness, wound non-suturing, and local immunoglobulin infiltration. Second, resources and clinical supplies must be distributed equitably, prioritizing peripheral clinics like Baqui and Oe-Silo

CHCs. Third, a One Health framework should be operationalized, utilizing the high case-reporting rate (97.0%) to trigger rapid canine ring vaccinations. Lastly, joint transboundary surveillance and synchronized dog vaccinations should be established with neighboring Indonesian services.

Conclusion

This study demonstrates that while healthcare workers in the RAEOA exclave possess an encouraging overall baseline of rabies knowledge (80%), critical clinical gaps in key protocols—such as wound suturing, HRIG infiltration, and disease fatality awareness—must be urgently resolved. Strengthening the rabies outbreak response requires sustained investments to implement continuous, hands-on training for lower-scoring professional cadres and peripheral facilities. Ultimately, clinical preparedness must be technically integrated into a collaborative One Health framework that links human clinical surveillance with transboundary coordination and canine vaccination campaigns to effectively eliminate rabies fatalities on Timor Island.

Acknowledgements

The authors express their sincere gratitude to the healthcare workers across the RAEOA region and the Regional Health Director for their invaluable collaboration and active participation. We also extend appreciation to the INSP-TL for institutional support, with special thanks to Dr. Merita Monteiro, MPH (former President of INSP-TL) for her leadership.

Author Contributions

Filipe De Nery Machado: Conceptualization, investigation, methodology, project administration, supervision, visualization, writing—original draft. **Cristovão De Alexandria Barros:** Formal analysis, methodology, software, writing—original draft, writing—review & editing. **Marcelo Amaral Mali:** Conceptualization, data curation, formal analysis, supervision, writing—review & editing. **Adriano Barbosa:** Data curation, investigation, writing—review & editing. **Mariano Da Silva Marques:** Investigation, validation, writing—review & editing.

Ethical Approval

This study followed established research ethics and received formal approval from the National Institute of Public Health Timor-Leste - Research Ethics & Technical Committee (INSP TL - RETC) under reference number 2397/INSP-TL/UEPD-AL/IV/2024.

Informed Consent

Prior to data collection, all participants were informed about the study's purpose and provided voluntary informed consent before completing the online or offline questionnaires.

Data Availability

Anonymized versions of the data are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that they have no competing interests.

Funding Support

This study was conducted within the framework of national public health surveillance and capacity-building efforts led by the Ministry of Health and INSP-TL, funded by the State General Budget.

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

The authors used generative AI limitedly for language editing and structural refinement to improve readability. The authors reviewed and edited the content and assume full responsibility for the final manuscript.

References

1. World Health Organization. Rabies fact sheet [Internet]. Geneva: World Health Organization; 2024 Jun 5 [cited 2025 Aug 4]. <https://www.who.int/news-room/fact-sheets/detail/rabies>
2. Hampson K, Coudeville L, Lembo T, Sambo M, Kieffer A, Attlan M, et al. Estimating the global burden of endemic canine rabies. PLoS Negl Trop Dis. 2015;9(4):e0003709. doi:10.1371/journal.pntd.0003709.
3. Gongal G, Wright AE. Human rabies in the WHO Southeast Asia Region: forward steps for elimination. Adv Prev Med. 2011;2011:383870. doi:10.4061/2011/383870.
4. Mali MA, Machado FN, Moniz FP, Dos Santos FBA, Laot PAME, Pereira Tilman AJ, et al. The first confirmed human case of rabies, Timor-Leste, 2024. Euro Surveill. 2024;29(18):2400241. doi:10.2807/1560-7917.ES.2024.29.18.2400241.
5. Aty YMVB, Astuti EP, Tat F, Wanti W, Sadukh JJP, Budiana I, et al. Harnessing community

knowledge and actions to strengthen rabies control programs in East Nusa Tenggara, Indonesia. International Journal of One Health. 2025;11(1):159–170. doi:10.14202/ijoh.2025.159–70.

6. Yulianti S, Yupiana Y, Tabali Z, Husein WF, Sueseno PP, Wicaksono A, et al. Emergency management of the rabies incursion in West Timor, Indonesia. In: Sub-Regional Workshop on Emergency Management; 2024 Aug 5–8; Bangkok, Thailand. Tokyo: World Organisation for Animal Health; 2024.
7. Machado FN, da Costa Jong JB, Gonzaga FP, da Conceicao F, Draper AD, Pinheiro M, et al. The rapidly emerging public health threat of rabies in Timor-Leste, 2024-2025. Western Pac Surveill Response J. 2025 Sep 22;16(3):1–3. doi:10.5365/wpsar.2025.16.3.1332.
8. da Cruz ZV, Pereira AJ, Machado FN, Mertha Adnyana IMD. Spatial risk assessment of canine rabies transmission via GIS buffer analysis in Bobonaro municipality, Timor-Leste. Svāsthya: Trends in General Medicine. 2025;2(4):e137. doi:10.70347/svsthya.v2i4.137.
9. Xavier J. Timor-Leste intensifies rabies awareness and prevention campaign [Internet]. Dili: Tatoli; 2025 Jun 24 [cited 2025 Aug 14]. <https://en.tatoli.tl/2025/06/24/timor-leste-intensifies-rabies-awareness-and-prevention-campaign/>
10. Qing S, Valliant R. Extending Cochran's sample size rule to stratified simple random sampling with applications to audit sampling. Journal of Official Statistics. 2025;41(2):309–28. doi:10.1177/0282423X2412770.
11. World Health Organization. Zero by 30: the global strategic plan to end human deaths from dog-mediated rabies by 2030. Geneva: World Health Organization; 2018 [cited 2025 Aug 14]. <https://iris.who.int/handle/10665/272756>
12. Tenzin, Dhand NK, Rai BD, Changlo, Tenzin S, Tsheten K, et al. Community-based study on knowledge, attitudes and perception of rabies in Gelephu, south-central Bhutan. Int Health. 2012 Sep;4(3):210–9. doi:10.1016/j.inhe.2012.03.005.
13. Instituto Nacional de Saúde Pública de Timor-Leste [National Institute of Public Health of Timor-Leste]. Guidelines for responding to dog bites in Timor-Leste, including pre- and post-exposure rabies prophylaxis. Dili: Instituto Nacional de Saúde Pública de Timor-Leste; 2024.
14. Surveillance Department, Secretary of State for Livestock. Rabies outbreak joint field assessment report. Dili: Ministry of Health and Ministry of Agriculture and Fisheries; 2024.
15. Taylor LH, Wallace RM, Rahman D, Lindenmayer JM, Eckery DC, Mutonono-Watkiss B, Parravani E, Nel LH. The Role of Dog Population Management in Rabies Elimination-A Review of Current Approaches and Future Opportunities. Front Vet Sci. 2017;4:109. doi:10.3389/fvets.2017.00109.
16. Sambo M, Cleaveland S, Ferguson H, Lembo T, Simon C, Urassa H, et al. The burden of rabies in Tanzania and its impact on local communities. PLOS Negl Trop Dis. 2013 Nov 7;7(11):e2510. doi:10.1371/journal.pntd.0002510.