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RESEARCH ARTICLE

Harnessing community knowledge and actions to strengthen rabies control programs in East Nusa Tenggara, Indonesia

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ABSTRACT

Background and Aim: Rabies remains a critical public health concern in Indonesia, particularly in high-risk provinces, such as East Nusa Tenggara. Despite governmental efforts under the One Health framework, gaps persist in vaccination coverage, public awareness, and intersectoral coordination. This study aims to assess community knowledge, attitudes, and practices (KAP) regarding rabies and evaluate rabies control strategies in Belu and Malaka regencies, incorporating both community and policymaker perspectives.

Materials and Methods: A mixed-methods approach was adopted, integrating quantitative surveys and qualitative interviews. Structured questionnaires assessed KAP levels among 225 respondents across two regencies, while logistic regression identified sociodemographic predictors of adequate rabies knowledge. Qualitative data, obtained through in-depth interviews and focus group discussions, were thematically analyzed using the context, input, process, and product evaluation model to explore stakeholder coordination, community engagement, and systemic challenges.

Results: Female respondents and those aged >50 years exhibited significantly higher knowledge of rabies (adjusted odds ratios [AOR] for males = 0.321, p = 0.003; AOR for ≤30 years = 0.390, p = 0.032). Vaccination coverage among domestic animals remained suboptimal (~50%), below the national target of ≥75%. Weak but significant positive correlations were observed between knowledge and both attitude (r = 0.144, p = 0.03) and practice (r = 0.211, p = 0.001). Qualitative findings revealed the fragmented implementation of One Health, insufficient vaccine supply, limited veterinary personnel, and poor integration of traditional knowledge into health communication strategies.

Conclusion: This study underscores the importance of tailored health education, particularly for younger and male populations, and highlights the potential of community-driven interventions to improve rabies control. Integrating traditional cultural expressions with modern outreach, strengthening intersectoral collaboration, and improving logistical support are essential for sustainable control. The use of technology (e.g., WhatsApp-based reporting) and community task forces demonstrated promise in enhancing responsiveness. Future programs should prioritize culturally adaptive strategies and expand the operational scope of One Health to mitigate rabies in endemic regions.

Keywords: community knowledge, East Nusa Tenggara, Indonesia, knowledge, attitudes, and practices, mixed-methods, One Health, rabies control, vaccination.

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INTRODUCTION

Rabies remains a critical public health challenge, causing approximately 59,000 human deaths annually worldwide, with the greatest burden occurring in Asia and Africa. As one of the most ancient and fatal zoonotic diseases, rabies poses a persistent global threat, especially in regions with limited access to preventive healthcare and post-exposure treatment. The causative agent, *Lyssavirus*, targets the central nervous system and is almost invariably fatal once clinical symptoms manifest. The disease is endemic in more than 150 countries, and nearly 40% of fatalities occur in children under the age of 15, underscoring its disproportionate impact on vulnerable populations [1, 2]. Globally, dog bites account for 99% of human rabies infections [2].

In Indonesia, rabies has been a public health concern since the first recorded human case in 1894 [3]. At present, 26 of the country's 34 provinces, including East Nusa Tenggara (NTT), are classified as high-risk zones for rabies transmission. These areas require intensive surveillance and widespread vaccination programs. Between 2021 and 2023, more than 80,000 bites from rabid or potentially rabid animals were reported, leading to an average of 68 deaths annually [4]. As of mid-2024, NTT alone had recorded 16 fatalities, reinforcing the urgency of enhanced rabies control measures.

A significant barrier to rabies elimination is the high population of free-roaming and unvaccinated animals, primarily dogs but also cats and monkeys. This situation is compounded by insufficient public awareness regarding responsible pet ownership. Vaccination coverage for domestic animals remains well below the recommended 70% threshold. In addition, the supply of rabies vaccine and anti-rabies serum (ARS) is inadequate, particularly in remote regions. Sociocultural factors also hinder prevention efforts, as prevailing beliefs and customs may conflict with established medical guidance. Numerous studies by Indonesian Ministry of Health [4], Ambarwaty *et al*. [5], Sambo *et al*. [6], Subedi *et al*. [7], and BPK [8] indicate that public knowledge of rabies remains limited, which contributes to low reporting rates and delays in seeking timely post-exposure prophylaxis.

Although Indonesia's National Master Plan for Rabies Eradication (2019) emphasizes vaccination and health education, considerable deficiencies persist in public knowledge, attitudes, and practices (KAP), particularly in isolated, high-risk provinces, such as NTT. Despite ongoing government interventions, few studies have systematically assessed rabies awareness and control measures within the One Health framework at the community level. Moreover, there is a paucity of data integrating community-based insights with perspectives from local policymakers and public health authorities. Existing literature has yet to fully examine how sociocultural dynamics and structural limitations hinder effective rabies prevention in this region.

This study aims to evaluate the KAP of residents in Belu and Malaka Regencies regarding rabies, while also examining the implementation of rabies control programs from the viewpoint of local authorities. The novelty of this research lies in its comprehensive, mixed-methods assessment of rabies awareness and management in a high-risk setting, through the combined lenses of community behavior and policy execution. By bridging the gap between grassroots realities and institutional strategies, the study provides a holistic understanding of the challenges in rabies control and offers actionable, evidence-based recommendations to support eradication initiatives in similar endemic regions.

MATERIALS AND METHODS

Ethical approval and Informed consent

The research was approved by the Ethics Committee of Poltekkes Kupang (No. LB.02.03/1/0237/2024) under the Indonesian Ministry of Health. Participant confidentiality was strictly maintained, and no vulnerable individuals were included in the study. Informed verbal consent was obtained from all study participants.

Study period and location

This study included community survey questionnaires, in-depth interviews, focus group discussions (FGDs), and data analysis conducted over a 4-month period, from August to November 2024. This study was conducted in Belu and Malaka Regencies, located in NTT Province, Indonesia. Belu Regency, which shares a direct border with Timor-Leste, spans an area of 2,445.57 km^2 and is situated at coordinates 9°–10° S and 124°–126° E [9]. Malaka Regency, established as an administrative region separate from Belu in 2013, lies in the southern part of Timor Island at coordinates 9°34' S and 124°54' E [10]. The number of dogs in these regions remains uncertain. However, a study by Manro and Yovani [11] conducted on Timor Island, including Belu, has revealed significant variations in dog population density, with an average of 128 dogs per survey site (range: 27–334 dogs).

Study design and data collection

This study adopted a mixed-methods design that combined quantitative surveys with qualitative in-depth interviews, providing a comprehensive understanding of community KAP related to rabies – bridging a methodological gap in the existing literature.

Quantitative data collection

Quantitative data were gathered using a structured questionnaire designed to assess KAP as well as potential sociodemographic factors influencing these elements. The questionnaire included 53 questions divided into four categories: Socioeconomic characteristics (8 questions), knowledge (20 questions), attitudes (15 questions), and practices (10 questions)

related to rabies. Knowledge-based questions required respondents to answer "yes" or "no" or select from pre-defined options, while attitude-based questions utilized a Likert scale with five options: Strongly agree, agree, neutral, disagree, and strongly disagree. The questionnaire was pre-tested in a different location (Kupang City), which has reported cases of bites from rabies-transmitting animals and shares similar sociodemographic characteristics. The reliability of the questionnaire assessed using Cronbach's alpha, exceeded 0.60, indicating an acceptable level of reliability. Interviews were conducted by trained enumerators who completed a 2-day training session before data collection. To minimize interviewer bias, each enumerator team was accompanied by a researcher, and the data collected were immediately validated by the research team. The final questionnaire was administered through face-to-face interviews using the local language (in Bahasa and Bahasa Tetun).

Qualitative data collection

Qualitative data were collected using an interview guide tailored to the informants' level, focusing on rabies control programs, management strategies, collaborative efforts, and case-handling procedures. The research team conducted in-depth interviews with selected informants and employed two data collection methods: Face-to-face in-depth interviews and focus group discussions (FGDs), using both Indonesian and local languages. Each FGD session included 6–12 participants. The FGD participants were selected by the research team based on the inclusion criteria, specifically informants with roles in rabies control management within the government. The selection process followed the principle of homogeneity (participants sharing similar social backgrounds to facilitate comfortable communication) while ensuring heterogeneity in perspectives to obtain diverse insights. Data were considered saturated when recurring patterns and themes emerged consistently throughout the FGDs, with no new findings or ideas introduced during the discussions. Interviews were conducted in Bahasa Indonesia and the Kupang dialect (Tetun), both of which were understood by participants without the need for translation. On average, in-depth interviews lasted 30 min, while FGDs ranged from 1 h to 2 h.

Sampling methods and sample sizes

Quantitative data

The study population consisted of households residing in areas classified as non-natural disaster zones with a high risk of transmission. The sample included individuals at high risk of contracting rabies (e.g., those living in or frequently interacting with animals that can serve as rabies reservoirs, such as stray or unvaccinated dogs) and aged over 15 years. The sample size was calculated using Slovin's formula with a 95% confidence interval (CI), a 5% margin of error, and an estimated rabies case prevalence of 50% (0.5). Based on this calculation, a minimum of 98 respondents per location was required, resulting in a total minimum sample size of 196 across the two locations. The sample selection was conducted using cluster sampling, in which specific clusters with reported rabies cases were chosen. Within these clusters, samples were randomly selected, focusing on households located near rabies case points to ensure representation from each cluster.

Qualitative data

The number of informants was determined based on the principles of adequacy and appropriateness. The adequacy principle was applied by ensuring that the information obtained sufficiently represented the overall rabies control program in regencies/cities designated as rabies non-natural disaster areas in NTT. The key informants included a diverse range of stakeholders, such as heads and program managers from the health office and community health centers, as well as heads from the agriculture and livestock office. In addition, representatives from cross-sectoral agencies, including the communications, information, and education offices, played a critical role. Community leaders, dog owners, and individuals identified as at-risk or part of vulnerable populations were also engaged to ensure a comprehensive understanding of the issues being studied. The informants were selected using purposive sampling based on the inclusion criteria and the researcher's judgment. This approach was chosen to explore the phenomenon in depth, particularly from the perspective of policymakers and other relevant supporting informants.

Data management and analysis

Quantitative data

The sociodemographic characteristics of the respondents, along with the distribution of their KAP, were analyzed using descriptive statistics. Logistic regression models were applied to explore the relationships between various factors and outcomes related to adequate knowledge, good preventive practices, and desirable attitudes. Predictor variables included sociodemographic factors, such as gender, age category, educational status, place of residence, marital status, homeownership, and knowledge level regarding desired attitudes and good practices. Factors with a $p < 0.25$ in the univariable analysis were incorporated into the multivariable logistic regression models adjusted for confounders (residency status, the number of toddlers in household and home ownership) with a $p < 0.05$ considered statistically significant. Adjusted odds ratios (AORs) and 95% CIs were calculated to assess the strength of the associations. To determine the relationship between the variables of knowledge and attitudes toward community practices related to rabies control, Spearman's correlation was used because the data were not normally distributed. All statistical

analyses were performed using the Statistical Package for the Social Sciences version 20.0 (IBM Corp., NY, USA).

Qualitative data

The discussion sessions were conducted by the interview team after the informants completed the interviews, following the interview guidelines as part of the evaluation process. The recorded interviews were transcribed verbatim by the research team. The transcribed data were repeatedly reviewed to ensure a deep understanding of the recorded material. Each transcript was thoroughly examined, with the team carefully reading and analyzing the content to identify recurring key statements for coding. Thematic analysis was carried out by YMVBA and AM, researchers involved in the interview process who were trained in qualitative research. The major themes were developed into a guiding framework. The initial transcripts were coded line by line to break down the data, with codes separated and categorized based on similar subthemes. These sub-themes were then grouped and refined into broader themes that were discussed among the researchers, particularly the qualitative research team. Data analysis was conducted manually and organized in Microsoft Excel according to major themes. The findings were structured using the context, input, process, and product (CIPP)/outcome framework to ensure a systematic and comprehensive evaluation. During the CIPP analysis stage, sub-themes and themes were further discussed by two other teams involved in qualitative research (EPA; W).

RESULTS

Characteristics and mean scores of KAP toward rabies

A total of 228 respondents from two regencies in NTT (Belu and Malaka) were successfully interviewed (Figure 1). However, three respondents were excluded from the analysis due to incomplete data, leaving 225 respondents in the final analysis. The sociodemographic characteristics and other relevant data are presented in Table 1. The dominant age group was 31–50 years, and 63.6% of the respondents were female. This is likely related to the timing of data collection, which was primarily conducted during working hours when female respondents, particularly housewives or those not employed (40.9%), were more likely to be at home.

Based on the mean scores for KAP, the average KAP scores of respondents in Belu were higher than those in Malaka, even though the number of respondents in Malaka was greater.

Factors associated with KAP

In the bivariate analysis, three factors were identified as being associated with the outcome variables (knowledge, attitude, and practice): Gender, age group, and residency status (origin settlers) (Table 2). These variables, along with other factors related to KAP - such as occupation, educational background, home ownership, and the number of toddlers in the household - were included in the multivariate model.

The analysis revealed that female respondents were more likely to have good knowledge about rabies than male respondents (AOR = 0.321; p = 0.003), indicating that males had only a 32.1% chance of possessing good knowledge. Respondents aged ≤30 years were less likely to have good knowledge compared to those aged >50 years (AOR = 0.390; p = 0.032), indicating that the ≤30 age group had a lower likelihood of having good knowledge, with only a 39% chance compared to those aged >50 years. Although respondents aged 31–50 years demonstrated good knowledge, the result was not statistically significant (p = 0.913) (Table 3).

Further analysis of the relationships among the outcome variables (Spearman correlation) revealed a weak positive correlation between knowledge and attitude (r = 0.144; p = 0.03), indicating that while there is a relationship between knowledge and attitude, it remains very weak. Similarly, a weak positive correlation was also found between knowledge and practice related to rabies (r = 0.211; p = 0.001) (Table 4).

When the relationship between knowledge and practice was analyzed on an item-by-item basis, significant associations were identified between knowledge and specific practices, including vaccinating animals, participating in mass rabies vaccination campaigns, educating others about the dangers of rabies, and conducting regular health checks on animals. However, an interesting finding was the observed negative correlation in certain cases, in which individuals with limited knowledge were still effectively engaged in these practices (Table 4).

Rabies prevention and control through the One Health approach

Figure 2 illustrates the CIPP analysis (Context, input, process, and product) used to evaluate the program and identify its strengths and weaknesses. The analysis is framed within the One Health management approach to rabies control at the study site, encompassing key aspects such as regulations, resources, systems and procedures, program implementation, and performance indicators.

The management of rabies prevention and control based on the One Health concept involves the roles and responsibilities of various stakeholders. A prompt response to managing rabies bite cases in high-risk areas has been effectively carried out through coordination among various stakeholders and the establishment of a response team. The Health and Animal Husbandry Office plays a central role in rabies control efforts and the establishment of working groups ("Pokja"), while the Local Disaster Management Agency (BPBD) acts as a supporting agency, mobilizing resources during emergency escalations.

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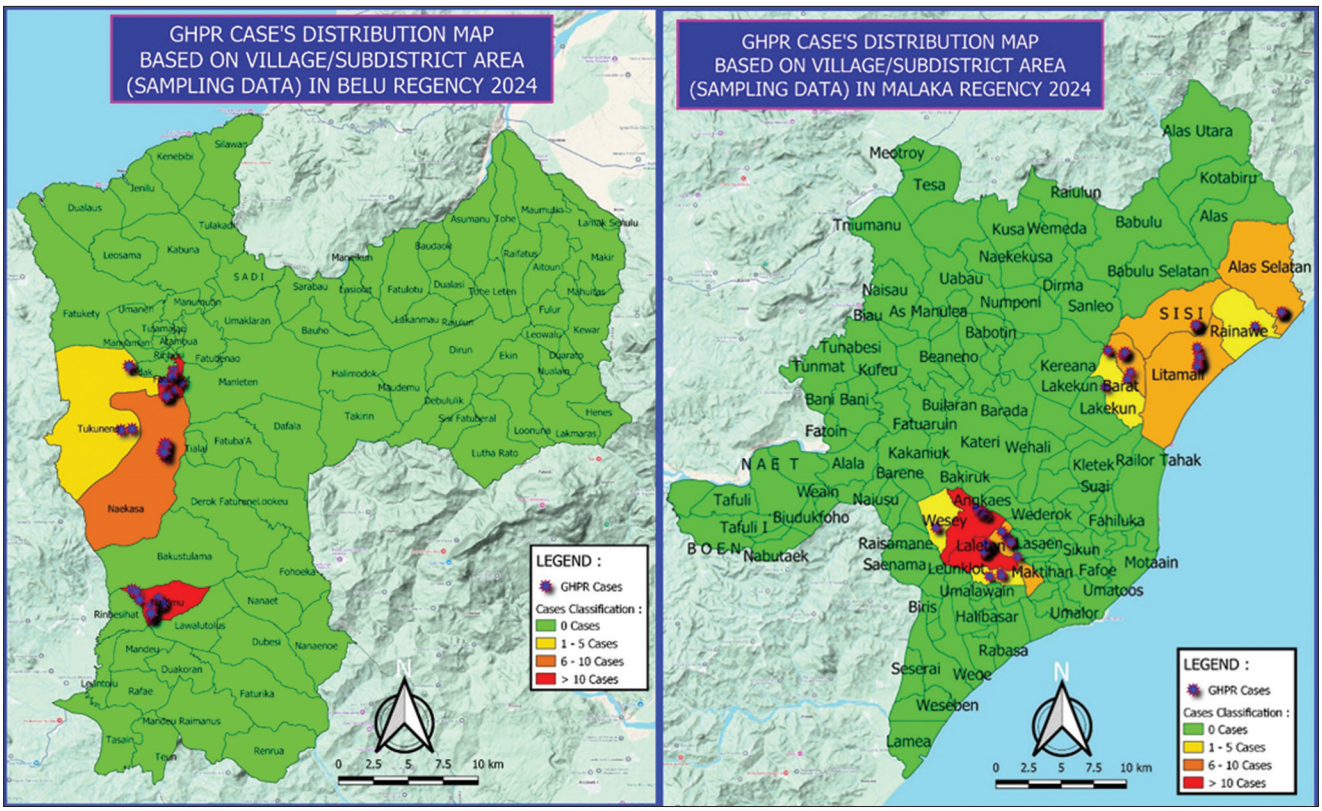

Figure 1: A map of the Belu and Malaka regencies highlighting the study area with varying GHPR cases (ranging from low to high). "The number of endemic villages in Malaka is higher than in Belu Regency" [Source: QGIS Geographic Information System. Version 3.28. https://qgis.org/].

Table 1: Characteristics and mean scores of respondents' knowledge, attitude, and practice toward rabies in the communities of Belu and Malaka.

Characteristic	n (%)			Mean score (standard deviation)					
	Total	Belu	Malaka	Knowledge		Attitude		Practice	
	n = 225	n = 92	n = 133	Belu	Malaka	Belu	Malaka	Belu	Malaka
Gender									
Male	82 (36,4)	35 (38.0)	47 (35.3)	8.5 (1.0)	8.4 (0.9)	31.2 (4.8)	29.8 (5.5)	19.0 (4.5)	17.1 (3.8)
Female	143 (63,6)	57 (62.0)	86 (64.7)	7.9 (1.5)	8.4 (0.8)	31.6 (5.3)	30 (4.6)	18.3 (5.4)	17.2 (4.3)
Age group (year)									
≤30	45 (20.0)	25 (27.2)	20 (15.0)	8.52 (0.82)	8.45 (0.6)	32.3 (4.0)	28.8 (7.0)	18.2 (4.9)	17.4 (4.5)
31–50	107 (47.6)	47 (51.1)	60 (45.1)	8.1 (1.4)	8.2 (1.1)	31.2 (4.6)	30.1 (4.2)	18.5 (5.4)	17.2 (4.2)
>50	73 (32.4)	20 (21.7)	53 (39.9)	7.7 (1.7)	8.5 (0.6)	30.9 (7.1)	30.2 (4.6)	19.3 (4.7)	17.1 (3.9)
Level of education									
Primary education	59 (26.2)	17 (7.6)	42 (31.6)	7.6 (2)	8.6 (0.6)	30 (7.8)	29.1 (5.5)	18.6 (4.6)	17.2 (3.8)
Secondary education	110 (48.9)	46 (20.4)	64 (48.1)	8 (1.3)	8.4 (0.7)	31.8 (4.5)	29.8 (4.4)	17.6 (5.6)	17.5 (4.5)
College and above	56 (24.9)	29 (13.0)	27 (20.3)	8.6 (0.7)	7.9 (1.1)	31.7 (3.9)	31.6 (4.8)	20.2 (4.2)	16.4 (3.6)
Occupational									
Un-employed	92 (40.9)	38 (41.3)	54 (40.6)	8 (1.5)	8.4 (0.8)	32.5 (3.9)	29.9 (4.5)	18.4 (5.3)	17.4 (4.5)
Public/private	62 (27.6)	26 (28.3)	36 (27.1)	8.3 (1.0)	8.1 (1.1)	32,3 (4.0)	31.1 (4.4)	19.5 (4.4)	17.0 (4.0)
Farmer/fisherman/seller	55 (24.4)	19 (20.6)	36 (27.1)	8.1 (1.6)	8.6 (0.6)	28.4 (7.2)	29.4 (4.7)	18.5 (5.2)	17.3 (3.6)
Other	16 (7.1)	9 (9.8)	7 (5.2)	8.1 (1.1)	8.6 (0.5)	30.7 (5.2)	27.1 (9.2)	17 (5.9)	16 (4,5)
Homeownership									
Yes	215 (94.3)	83 (90.2)	129 (97)	8.1 (1.4)	8.3 (0.8)	31.5 (5.2)	29.9 (4.9)	18.5 (4.9)	17.1 (4.1)
No	13 (5.7)	9 (9.8)	4 (3)	8.4 (0.9)	8.8 (0.5)	30.3 (4.4)	30.5 (2.1)	19.3 (6.4)	21.5 (2.4)
Original settlers									
Yes	213 (93,4)	82 (89.1)	128 (96.2)	8.1 (1.4)	8.4 (0.8)	31.6 (5.1)	30 (4.8)	18.6 (5)	17 (4)
No	15 (6,6)	10 (10.9)	5 (3.8)	8.3 (0.8)	8.6 (0.5)	29.8 (4.5)	27 (7.2)	18.9 (6)	21 (4.2)
Number of children in the household									
None	114 (50.1)	45 (48.9)	70 (52.6)	8.2 (1.3)	8.4 (0.7)	31.1 (6)	30.2 (5)	18 (4.8)	17.3 (4.2)
1–5 toddlers	111 (49.3)	47 (51.1)	63 (47.4)	8.1 (1.4)	8.3 (0.9)	31.8 (4.1)	29.6 (4.8)	19.2 (5.3)	17 (4)

Table 2: Factors associated with respondents knowledge, attitude, and practice toward rabies in the Belu and Malaka communities.

Characteristic	Knowledge level, n (%)			Attitude, n (%)			Practice, n (%)		
	Adequate	Inadequate	p-value	Adequate	Inadequate	p-value	Adequate	Inadequate	p-value
	n = 79	n = 146		n = 50	n = 175		n = 43	n = 182	
Gender			0.004*			0.32			0.601
Male	39 (49.4)	43 (29.5)		15 (30)	67 (38.3)		14 (32.6)	68 (37.4)	
Female	40 (50.6)	103 (69.5)		35 (70)	108 (61.7)		29 (67.4)	114 (62.6)	
Age group			0.014*			0.543			0.818
≤30	29 (36.7)	28 (19.2)		14 (28)	43 (24.6)		10 (23.3)	47 (25.8)	
31–50	27 (34.2)	68 (46.6)		23 (46)	72 (41.1)		20 (46.5)	75 (41.2)	
>50	23 (29.1)	50 (34.2)		13 (26)	60 (34.3)		13 (30.2)	60 (33)	
Level of education			0.553			0.388			0.668
Primary	20 (25.3)	39 (26.7)		13 (26)	46 (26.3)		9 (20.9)	50 (27.5)	
Secondary	36 (45.6)	74 (50.7)		28 (56)	82 (46.9)		23 (53.5)	87 (47.8)	
College and above	23 (29.1)	33 (22.6)		9 (18)	47 (26.8)		11 (25.6)	45 (24.7)	
Occupational			0.41			0.182			0.809
Un-employed	27 (34.2)	65 (44.5)		25 (50)	67 (38.3)		20 (46.5)	72 (39.6)	
Public/private	24 (30.4)	38 (26.0)		8 (16)	54 (30.9)		11 (25.6)	51 (28)	
Farmer/fisherman/pedagang	23 (29.1)	32 (21.9)		14 (28)	41 (23.4)		10 (23.3)	45 (24.7)	
Other	5 (6.3)	11 (7.5)		3 (6)	13 (7.4)		2 (4.6)	14 (7.7)	
Homeownership			0.229			0.492			0.078
Yes	72 (91.1)	140 (95.9)		46 (92.0)	166 (94.9)		38 (88.4)	174 (95.6)	
No	7 (8.9)	6 (4.1)		4 (8.0)	9 (5.1)		5 (11.6)	8 (4.4)	
Origin settlers			0.162			0.047*			0.044*
Yes	71 (89.9)	139 (95.2)		43 (86)	167 (95.4)		37 (86)	173 (95.1)	
No	8 (10.1)	7 (4.8)		7 (14)	8 (4.6)		6 (14)	9 (4.9)	
Number of children in the household			0.264			0.153			0.611
None	36 (45.6)	79 (54.1)		21 (42)	94 (53.7)		20 (46.5)	95 (52.2)	
1–5 toddlers	43 (54.4)	67 (45.9)		29 (58)	81 (46.3)		23 (53.5)	87 (47.8)	

*Significant ($p < 0.05$)

Table 3: Multivariate logistic regression predicting sociodemographic-related knowledge among communities in Belu and Malaka Regencies, NTT.

Characteristic	Univariate analysis		Multivariate analysis	
	Crude odd ratio (95% CI)	p-value	Adjusted odds ratio (95% CI)	p-value
Gender				
Male	0.428 (0.243–0.755)	0.003	0.321 (0.151–0.683)	0.003
Female	1	Ref	1	Ref
Age group		0.016		0.023
≤30	0.444 (0.217–0.909)	0.026	0.390 (0.165–0.924)	0.032
31–50	1.159 (0.596–2.253)	0.665	1.046 (0.466–2.347)	0.913
>50	1	Ref	1	Ref
Level of education		0.554		0.608
Primary	1	Ref	1	Ref
Secondary	1.054 (0.539–2.060)	0.877	1.243 (0.555–2.780)	0.597
College and above	0.736 (0.345–1.570)	0.427	0.854 (0.338–2.155)	0.738
Occupational				
Un-employed	1.545 (0.876–2.728)	0.133	0.846 (0.383–1.866)	0.679
Employ	1	Ref	1	Ref
Homeownership				
Yes	2.269 (0.735–7.001)	0.154	1.111 (0.291–4.242)	0.877
No	1	Ref	1	Ref
Residency status (origin)				
Yes	0.447 (0.156–1.282)	0.134	0.389 (0.116–1.307)	0.127
No	1	Ref	1	Ref
Number of children in the household				
None	1.408 (0.813–2.440)	0.222	1.807 (0.961–3.397)	0.066
1–5 toddlers	1	Ref	1	Ref

Ref=Reference; significant ($p < 0.05$). NTT=East Nusa Tenggara, CI=Confidence interval

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Table 4: Correlation analysis of knowledge, attitudes, and practices of respondents toward rabies in the communities of Belu and Malaka.

Variable	Correlation coefficient (r)	p-value
Knowledge ^ attitude toward rabies	0.144	0.03*
Knowledge ^ practice (administering vaccines to pets)	−0.177	0.008*
Knowledge ^ practice (participating in mass rabies vaccination awareness campaigns)	−0.196	0.003*
Knowledge ^ practice (engaging in educating others about the risks of rabies)	−0.283	0.000*
Knowledge ^ practice (providing a safe and enclosed space for pets)	0.038	0.571
Knowledge ^ practice (regularly scheduling health check-ups for pets)	−0.071	0.289
Knowledge ^ practice toward rabies	0.211	0.001*
Attitude ^ practice toward rabies	0.094	0.161

*Significant ($p < 0.05$)

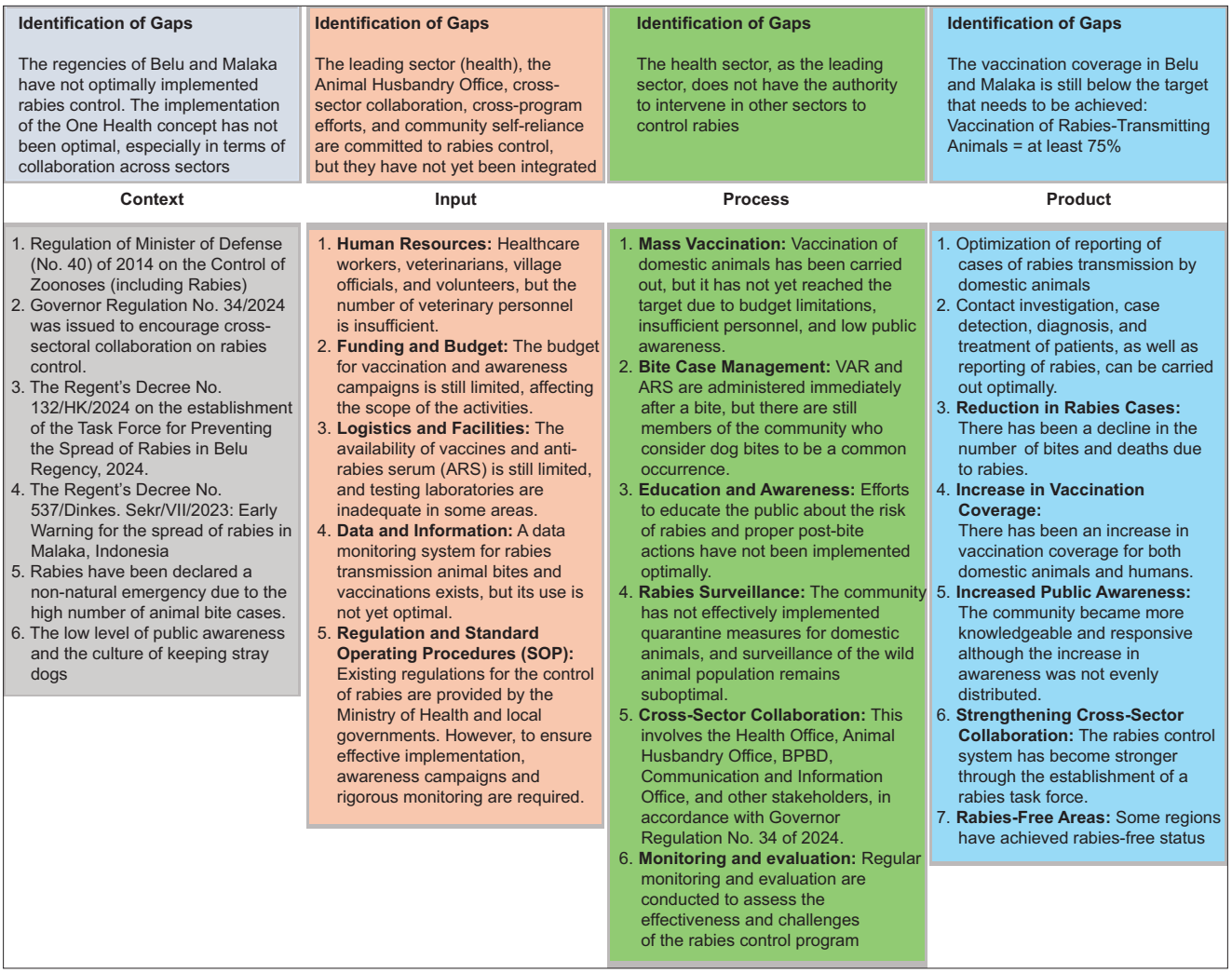

Figure 2: Context, input, process and product (CIPP) Analysis of Rabies Management in Malaka and Belu Regencies. This figure presents the identification of issues related to rabies control management in Belu and Malaka, categorized into four themes: CIPP. Each theme represents the implementation status of rabies control management in the two study locations, based on qualitative data analysis from in-depth interviews and focus group discussions.

To strengthen response mechanisms, the local government has also set up emergency posts ("Posko") at the sub-regency level. For efficient case reporting, the team uses WhatsApp groups, enabling rapid coordination and ensuring that rabies transmission cases are addressed within 24 h of an animal bite incident. A key innovation in this reporting system is the integration of digital tools, such as WhatsApp, to facilitate real-time monitoring and management of rabies cases. This approach enhances public health surveillance, particularly in remote areas, by improving response times and streamlining communication among stakeholders.

The community is advised to promptly visit the nearest public health Center ("Puskesmas") following a dog bite incident, after cleaning the wound with

antiseptic and running water. Initially, there was indifference within the community, as they viewed bites as a common occurrence. According to key informants, the service protocol at the public health center involves administering a complete vaccination regimen on days 0, 7, and 21. The first vaccine is administered during the initial visit, followed by a second dose on day 7, while the dog is monitored (the dog should be tied up) for 14 days. If the dog remains healthy and shows no symptoms, a third dose is administered on day 21. Here is one of the informants' statements:

> "If a dog bites someone,... report it to the village office. We from the village office will then report it to the Animal Husbandry Office or the Health Office, so we have a collaboration... Therefore, if there is a dog bite case, we report it immediately via regular phone or WhatsApp, as we have the contact numbers of both offices, ensuring mutual coordination…."
> (*Fatukbot village*)

Community experience with rabies case management

> "I. have a child who was bitten by a dog at night in August…. We immediately cleaned the wound with Mama Lemon (dishwashing soap). After cleaning the wound, I called Mrs. Ina Halle, a health center officer, and informed her that my child had a "tarabek" (lacerated) wound….The public health center officer immediately took my child that same night……At that time, we had received information about rabies at the village office, so since we had already heard about rabies, we immediately washed the bite with running water and soap……At the public health center, the officer cleaned the wound again, then administered the vaccine and applied Betadine to the wound. Then, my child was allowed to go home without needing hospitalization. We then visited the health center two more times for vaccination, so a total of three doses of vaccine was administered."
> (*The patient's family was bitten by a rabies-transmitting dog*)

Operational and communication challenges in rabies control

The challenges and obstacles in both regions include the fact that education and awareness campaigns about rabies have not yet reached all the villages in the Belu and Malaka regencies. Although information has been disseminated, including through social media, it has not been widespread enough. Nonetheless, some rural areas have effectively spread information about rabies using media that are adapted to the local context.

The availability of logistics (serum and vaccines) for zoonotic diseases is still provided by the provincial government. During data collection, it was found that the availability of ARS was insufficient, while the vaccine supply was adequate and available at each public health Center. At present, the vaccination coverage for dogs is approximately 50%, while the minimum target coverage is 75%. In addition, the shortage of veterinarians and limited operational capacity has posed significant challenges in rabies control.

The lack of public awareness further hinders control efforts, as some individuals remain fearful and prefer to euthanize dogs suspected of rabies rather than quarantine and monitor them according to established procedures. The following are some statements from the informants:

> "We have already collaborated with relevant stakeholders on the technical aspects of rabies control... but our involvement has been more limited. Information about rabies is disseminated through online media, but it is still not widespread enough."
> (*The Communication and Information Office*)
> "All our logistics are still being assisted and sent from the province... for zoonoses..."
> "The medicine is out of stock... the ARS (Anti-Rabies Serum) might be out, while the VAR (Rabies Vaccination) is sufficiently available at each public health Center…"
> (*The District Health Office*)
> "Currently, only about 50% of dogs have been vaccinated; it should be at least 75%..."
> "Our difficulty is the shortage of veterinarians and limited operational capacity…"
> (*The Regency Health and Animal Husbandry Office*)
> "There are members of the community that are afraid and prefer to euthanize dogs suspected of having rabies…."
> (*Community Leader*)

DISCUSSION

National strategy and regional priorities

The implementation of the national program for a rabies-free Indonesia by 2020 is based on the Association of Southeast Asian Nations (ASEAN) rabies elimination strategy within the framework of "One Health," which focuses on human, animal, and environmental health. The Ministry of Health's approach to accelerating rabies control includes technical, sociocultural, organizational, and legislative approaches [12]. This study highlights public awareness and local government strategies for controlling rabies in the Belu and Malaka Regencies of NTT. NTT ranks second in the country for reported cases of rabies-transmitting animal bites (GHPR), following Bali. Belu and Malaka reported significant GHPR incidents and related fatalities during the 2023–2024 period.

Sociodemographic determinants of KAP

The study results indicate that factors, such as gender, age group, and residential status influence

the community's KAP regarding rabies. Women tend to have better knowledge than men, a finding that contradicts some previous studies by Pal *et al*. [13], Ubeyratne *et al*. [14], and Bharani [15]. However, other studies support this finding, suggesting that women demonstrate a higher level of knowledge, even though a significant relationship has yet to be established [16–18]. This difference may be attributed to individual behavior in seeking healthcare services or social roles, where women often spend more time at home and are more likely to participate in community activities or group settings [19]. Social factors, such as the role of women in the community, may also contribute to this difference.

In addition to gender-related factors, the age group variable is significantly correlated with individuals' knowledge levels. This observation is consistent with prior studies that examined rabies awareness in relation to age [13, 20]. The findings reveal that older respondents (>50 years) demonstrated a better understanding compared to younger ones (≤30 years), which is consistent with previous research by Pal *et al*. [13], although differing findings have been reported in some other countries [15, 18, 21, 22]. Age plays a key role in cognitive development, thought processes, and life experiences, whereas gender influences biological, psychological, and sociocultural differences that further shape perception, understanding, and decision-making.

Regional disparities in KAP

This study revealed significant differences in KAP scores between respondents from the Belu and Malaka Regencies. Despite having more respondents, Malaka reported lower average KAP scores than Belu. One possible explanation for this disparity is Belu's higher level of urbanization, which provides better access to information and healthcare services. This finding aligns with previous research by Matibag *et al*. [23], indicating that urban residents tend to have significantly higher KAP levels for rabies than rural residents [23]. By incorporating perspectives from marginalized and hard-to-reach rural populations, this study contributes a unique dimension to rabies research, emphasizing the importance of inclusive public health interventions.

Factors affecting public knowledge and practice

Several factors influence public KAP on health issues, including education levels, where individuals with higher education levels tend to have greater awareness of rabies risks than those with only non-formal education [24, 25]. Other factors include community literacy rates [26], the frequency, reach, and quality of awareness campaigns (health promotion), access to information [26], proactive involvement of local health authorities and public health response [27], and the influence of local sociocultural factors [28].

This study found a positive relationship between community knowledge and attitudes and practices regarding rabies control. Higher levels of knowledge encouraged individuals to vaccinate their animals, actively participate in mass rabies vaccination campaigns, educate others about rabies risks, and regularly monitor animal health. These findings highlight the critical role that knowledge plays in driving behavioral change within communities.

However, the study also revealed that individuals with lower levels of knowledge were still actively engaged in rabies control practices in their areas. Knowledge levels varied among individuals; while most people were aware of rabies, only a small number understood wound care and post-exposure prophylaxis following dog bites [18, 29]. This variation could lead to a negative correlation between knowledge and rabies control practices. External factors, such as social norms, dog ownership [25], and the presence of rabies control programs, may also influence practices regardless of individual knowledge levels.

Gaps in One Health implementation

Rabies control efforts in the Belu and Malaka regions remain suboptimal. In addition to limited public awareness, a key barrier to effective control is the incomplete implementation of the One Health concept, particularly in cross-sector collaborations. Although the health sector, Livestock Department, various intersectoral programs, and community involvement have demonstrated a commitment to rabies control, institutional integration remains inadequate.

Lack of coordination significantly hinders vaccination efforts and responses to rabies-transmitting animal bites (GHPR), thereby reducing overall effectiveness. A critical indicator of this issue is the persistently low vaccination coverage for rabies-transmitting animals, which remains below the minimum target of 75%. Several factors contribute to this shortfall, including limited public awareness, geographical challenges in remote areas, and insufficient resources. Inadequate vaccination coverage increases the risk of rabies transmission, particularly in regions with uncontrolled pet populations [27].

Recommendations for strengthened rabies control

Strengthening rabies control in Belu and Malaka requires a more comprehensive and integrated approach rooted in the principles of One Health. This study offers a unique perspective on how sociocultural dynamics and regional challenges in these districts impact rabies control efforts, highlighting the need for culturally tailored public health strategies.

Key strategies include strengthening regulations, enhancing the capacity of healthcare and veterinary professionals, and ensuring adequate resources for vaccination programs, such as establishing rabies control posts in remote areas to facilitate logistics distribution and improve vaccination coverage, as well as promoting public education. Some intervention studies include conducting awareness campaigns, utilizing informational materials, such as posters

and leaflets [30], and leveraging technology, such as delivering information through text messages, which has been shown to effectively enhance community knowledge about rabies control [31]. By fostering a more coordinated and collaborative framework, efforts to control rabies can become more effective and sustainable, ultimately reducing the burden of the disease in these regions.

Challenges in health promotion and community engagement

Regarding health promotion, a key challenge observed in both study locations is the limited reach of education and awareness campaigns, which have not yet covered all villages. Although information has been distributed through various media, including social media, its coverage remains insufficient. However, some rural areas within the study locations have successfully adapted their information dissemination strategies to align with local contexts, making them more effective at reaching the community.

Overall, a well-coordinated approach involving local governments and community leaders plays a crucial role in bridging efforts for rabies control. In addition, the integration of community-based interventions, technological tools, and systematic standard operating procedures has demonstrated the effectiveness of a coordinated response in managing rabies in high-risk areas. Continuous efforts are needed to address existing gaps in public awareness and to sustain these collaborative measures to ensure long-term success in rabies control.

Implications and study contribution

This study provides valuable insights by comparing findings from Belu and Malaka with those from other rabies-endemic regions, highlighting how local socioeconomic and cultural contexts shape rabies prevention practices. This study not only advances theoretical understanding by proposing a new conceptual framework for integrating community-based insights into rabies control strategies but also offers practical guidelines for policymakers to implement sustainable One Health initiatives in high-risk regions.

Study limitations and future research directions

However, some limitations should be acknowledged. The relatively small sample size may not fully capture the overall understanding of the communities in the Belu and Malaka regions. Nonetheless, the selection of high-risk villages helps to minimize potential bias in the findings. In addition, the study is subject to possible recall bias in the survey responses and selection bias in the qualitative interviews. Another limitation is the lack of a comprehensive assessment of pet and stray dog population density and distribution - key factors in determining rabies risk across different areas. Future research should integrate these aspects to enhance the accuracy of rabies risk assessments and improve control strategies.

CONCLUSION

This study presents an integrative analysis of rabies KAP among community members in Belu and Malaka Regencies, NTT, within the framework of the One Health approach. By triangulating quantitative data from high-risk populations with qualitative insights from key stakeholders, the study underscores both the sociobehavioral and systemic determinants influencing rabies control in under-resourced settings. The findings reveal substantial disparities in KAP scores between regions, highlight the influence of demographic and contextual variables, and expose critical gaps in coordination, outreach, and vaccination coverage.

Importantly, the study demonstrates that while knowledge is a key driver of preventive behavior, it is neither uniformly distributed nor solely predictive of practices. This complexity necessitates a shift toward more contextually grounded and inclusive public health strategies that transcend information dissemination and address structural, logistical, and cultural barriers. The use of digital communication tools for real-time surveillance and intersectoral coordination emerged as a promising innovation in decentralized rabies response.

Policy responses should focus on institutionalizing cross-sectoral collaboration, enhancing frontline workforce capacity, and deploying tailored health communication strategies that resonate with local sociocultural dynamics. Expanding operational presence in remote areas and systematically integrating community perspectives into planning processes will be critical for achieving national rabies control goals. Future research should incorporate spatial analysis of stray and owned dog populations and explore the longitudinal impacts of targeted interventions on behavioral outcomes.

By offering an evidence-based evaluation of rabies control in two high-burden districts, this study contributes practical insights and strategic direction for enhancing the effectiveness and sustainability of rabies prevention initiatives under the One Health paradigm.

AUTHORS' CONTRIBUTIONS

YMVBA, EPA, and W: Conceptualization, methodology, formal analysis, and writing of the original draft. FT, JJPS, IB, AM, II, and RP: Carried out field surveys and contributed to data collection. EPA, WW, ALS, NAM, and LA: Quantitative analysis and interpreted the data. YMVBA, WW, AM, II, and RP: Qualitative analysis and interpreted the data. YMVBA, EPA, WW, ALS, NAM, LA, FT, JJPS, and IB: Edited and revised the manuscript. All authors have read and approved the final manuscript.

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COMPETING INTERESTS

The authors declare that they have no competing interests.

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