Classification of pet owners based on knowledge attitude and practice about rabies and its vaccination in Duc Hue, Long An province during the period 2021 - 2023

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ABSTRACT

Rabies manifests is a zoonotic ailment affecting both humans and carnivorous animals. The administration of rabies vaccination, particularly to domesticated animals such as dogs and cats, is an efficacious prophylactic measure for safeguarding the optimal health of both animal and human populations. The conscientiousness of pet owners regarding rabies vaccination significantly contributes to the effectiveness of rabies prevention initiatives. A comprehensive survey employing the Knowledge-Attitude-Practices framework was undertaken among owners of dogs and cats to appraise the efficacy of the three-year rabies vaccination program spanning 2021 to 2023 in Duc Hue district, Long An province. The primary objectives of this inquiry were to succinctly delineate the program's outcomes and to gauge the evolution of awareness and behavioral patterns among dog and cat owners. The survey adopted a nuanced approach by categorizing participants into sub-groups, emphasizing the differentiation of outcomes across these delineated groups. Findings indicated that the vaccine coverage exceeded 80% within Duc Hue, Long An province's dog and cat population in 2023. The analytical assessment consistently identified three to four discernible population clusters annually, based on Knowledge, Attitude, and Practice scores, focusing on their alignment with the overall mean within the population. Additionally, specific attention was directed towards clusters exhibiting lower scores, with a detailed consideration of associated variables, including commune location and occupation. Identifying these clusters necessitates further exploration and warrants the development of more tailored communication and approach strategies to optimize the efficacy of the ongoing vaccination campaign.

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1. Introduction

Rabies is a viral zoonosis with potential transmission of rabid animal bites, scratches, or contact via saliva, affecting both humans and all warm-blooded animals (Tiwari et al., 2018). Nowadays, companion animals, particularly dogs and cats, are not only raised for guarding purposes but are often regarded as faithful friends and close companions of humans (Paul et al., 2010). This human-animal bond can provide significant positive benefits for both mental and physical human life (Friedmann & Son, 2009). Therefore, there is a growing inclination towards dogs and cats as pets. Nevertheless, there is generally a lack of comprehensive population data in developing countries, which elevates the risk of rabies transmission from dogs and cats (Gebremedhin et al., 2020). According to the report by WHO (2023), over 40.00% of deaths due to rabies were children under 15 years old. Globally, approximately 59,000 people die from rabies annually, with the majority (95%) being in Africa and Asia due to the shortage of post-exposure prophylaxis (PEP) services for animal-bite victims and the lack of experienced personnel and facilities for rabies surveillance (Pham et al., 2021). If the preventive measures and social awareness, especially for pet owners, are not performed appropriately, there may be several heightened likelihood of future rabies outbreaks. Rabies is entirely preventable through PEP to bite victims and is controlled through mass vaccination of domestic dogs (Vilas et al., 2017). Additionally, vaccination is a cost-effective approach compared to exposure treatment (Borse et al., 2018), and it is required to achieve at least 70.00% of vaccine coverage, sufficient to maintain herd immunity within the dog population (WHO, 2019). Maintenance of sufficient vaccination coverage in the animal population is also an important requirement for the national plan for the prevention and control of rabies in Vietnam (GOV, 2021).

In 2021, there were 78 animals infected with rabies in 11 provinces. In 2022, there were 133 animals infected with rabies in 15 provinces. From January to September 2023, 274 animals were infected with rabies recorded in 30 provinces (DAH, 2023). In addition, the rabies vaccination coverage within the dog and cat population at the national level from January to July 2023 was not high (46.27%). This rate had a significant variation between provinces. Only 12/63 province had achieved a rate of 70%; 17/63 province had a rate varied from 50 - 69%, and 34 left had a rate of less than 50%. For public health, 378 deaths due to rabies had been recorded for the period 2017 - 2021, with an average of 76 deaths per year. Sixty-nine deaths due to rabies had been recorded for 2022. From January to September 2023, 62 death cases had been notified (DAH, 2023; NIHE, 2023).

Long An province has a relatively large land area; people raise dogs and cats for companionship or home guarantee, and a considerable proportion of these animals are raised in free-range conditions. From January 2019 to December 2022, Long An province reported seven human fatalities attributed to rabies and 9 cases of dogs and cats diagnosed with rabies or suspected rabies. The majority of human deaths resulted from dog and cat bites that were not vaccinated due to insufficient awareness and knowledge about rabies (DAH, 2023). Accordingly, Duc Hue is a high-risk locality for rabies when there were cases of rabies in humans, and the vaccination coverage rate in recent years did not reach the local requirements (80.00% of the animal target population is vaccinated annually). In order

to support the local area in controlling rabies, the Faculty of Animal Science and Veterinary Medicine of Nong Lam University, Ho Chi Minh City; Boehringer Ingelheim Vietnam Company; Long An Department of Agriculture and Rural Development; Sub Department of Livestock Production and Animal Health of Long An province; along with other agencies such as District veterinary station and communal para-veterinaries have collaboratively initiated a rabies vaccination campaign for the community during the period 2021 - 2031. The program encompassed vital activities such as vaccinating dog and cat populations in 11 communes/ towns and raising awareness for pet households and elementary school students using leaflets and small performances and minigames, and conducting a Knowledge-Attitude-Practices (KAP) survey among owners. Understanding the change in knowledge, attitude, and practice is beneficial for future programs in the field, e.g., tailoring the activities according to the local needs to optimize the scarce resources and provide accurate material for teaching and learning in some related courses for students. Therefore, the study aimed to summarize and report the results achieved after three years of the campaign regarding the vaccine coverage rate, assess awareness of pet owners, and classify them based on the data collected from the KAP survey respondents

2. Materials and Methods

2.1. Time and location

This study was conducted in three stages: Stage 1 from 11 to 18 April 2021, stage 2 from 16 to 22 April 2022, and stage 3 from 14 to 22 April 2023 in 11 communes/towns belonging to Duc Hue district of Long An province (Table 1).

2.2. Sampling method

The KAP surveys were conducted collaboratively by the research team at the same time as the implementing of the vaccination campaign in Duc Hue district. The participants in this study were selected through a random sampling process, employing a sampling ratio of 1/3. This ratio dictated that one household was included in the survey for every three households that had received vaccinations. Determining the number of respondents per commune was established beforehand, considering the proportion of households in each commune and the calculated minimum sample size. Household data for each commune was obtained from the District Veterinary Station. The Statulator software, accessible at https://statulator.com, was utilized to compute the minimum sample size. The calculations were based on a confidence interval of 95.00%, an anticipated proportion of respondents possessing satisfactory knowledge, attitude, and practice at 75.00%, and an absolute error of 5.00%. Despite the initial calculation yielding a minimum sample size of 289, a decision was made to round it up to 300. Subsequent adjustments to the sample size were made in response to on-the-ground resource constraints, resulting in two subsequent increments.

Moreover, selecting a sampling rate was rationalized by the uncertainty surrounding the total count and annual variations in pet households. Aligned with the principle that an increased sample size augments results in representativeness, the actual number of collected samples surpassed the initially proposed quantity, as explicitly elucidated in the results section.

2.3. Methods

The study was conducted with two primary objectives including (1) summarizing the vaccination coverage rate in 2023 and (2) classification of dog and cat owners over the years 2021, 2022, and 2023 based on information regarding their knowledge, attitude, and practice.

The first objective was to synthesize vaccination information records from the local District Veterinary Stations of Long An's Sub-DAH (DAH, 2023). The second objective was achieved by implementing a Knowledge, Attitude, and Practice (KAP) survey, for which a structured questionnaire comprising four sections was devised. The first section encompassed demographic data and elucidated why owners abstained from vaccinating their pets. The second section comprised eight inquiries about knowledge, the third section entailed eleven questions related to attitude, and the final section encompassed eight questions concerning practice (see supplementary material 1). Following a thorough review and testing by a research team member, the questionnaire was digitally converted using the Kobotoolbox platform (https://www.kobotoolbox.org) to facilitate data collection through tablets smartphones or laptops in practice. The data collection occurred concurrently with direct interviews conducted during the vaccination process. The interviewers underwent training before field data collection. Subsequently, the acquired data was submitted and subjected to validation on the Kobo toolbox platform. The KAP survey was repeated for three years using the above-mentioned procedure. Data was encrypted and summarized automatically thanks to the available functions of Kobotoolbox.

2.4. Statistical data analysis

The responses to each question in the Knowledge, Attitude, and Practice (KAP) survey were quantified based on correctness, assigning 1 point for correct responses and 0 points for incorrect ones or no answers. The cumulative scores obtained in each section - Knowledge, Attitude, and Practice were treated as distinct active quantitative variables in the subsequent Principal Component Analysis (PCA) to represent the participants' scores. The PCA and clustering analysis (CA) methodologies were employed to stratify pet owners longitudinally. Specifically, PCA was applied to identify primary components and eliminate less significant variables in the dataset (Cornillon et al., 2012). The analysis incorporated three primary quantitative variables ("Knowledge," "Attitude" and "Practice"), supplemented by additional quantitative variables such as "number of pets" and "number of family members," alongside qualitative variables encompassing "commune location," "educational levels," "gender of pet owners," "vaccination outcome," and "age." Subsequently, CA, contingent on the PCA and distance matrix outcomes results, was executed to categorize these variables into groups, considering their co-occurrence and distances (Cornillon et al., 2012). The computer automatically determined the optimal clusters for each dataset to streamline the process. Both PCA and CA were conducted utilizing the FactoMineR package (Le et al., 2008) in the R.4.2.1 software environment.

3. Results

3.1. Evaluation of vaccination results in 2023

The outcomes of rabies vaccination and the underlying reasons for non-vaccination within the pet populations were systematically compiled for each respective year (Table 1). Notably, the results for the years 2021 and 2022 have been documented elsewhere (Truong et al., 2023); therefore, the focus of this report centers on the findings for the year 2023. Until April 22, 2023, the rabies vaccination coverage rate within households had reached 70.00%. Considering the entire investigated population, the overall vaccination rate for the pet populations stood at 81.00%. The commune of My Thanh Bac exhibited the highest percentage of vaccination coverage rate at 89.00%, while the lowest coverage rate was recorded in My Binh commune, amounting to 72.00%.

Table 1. Vaccination outcomes calculated based on households and total pet population, distributed by commune locations.

		2021				2022				2023			
Order	Commune	(1)[1]	(2)[2]	(3)[3]	(4)[4]	(1)[1]	(2)[2]	(3)[3]	(4)[4]	(1)[1]	(2)[2]	(3)[3]	(4)[4]
1	Dong Thanh	270	57.40	388	71.10	270	67.80	537	66.10	280	69.30	496	81.00
2	My Thanh Dong	842	53.60	1338	83.10	829	59.80	1450	74.60	873	53.50	1332	77.00
3	Binh Hoa Nam	423	52.20	1143	39.90	396	63.60	668	76.30	423	57.20	659	83.00
4	My Quy Tay	663	64.60	702	123.60	656	71.00	1207	83.30	487	85.00	1155	86.00
5	My Quy Dong	427	58.80	712	81.60	423	65.70	770	75.20	450	61.80	831	78.00
6	My Thanh Tay	412	74.80	462	128.80	427	82.00	782	83.20	460	92.60	975	81.00
7	My Thanh Bac	254	71.70	398	89.50	251	85.70	526	80.00	417	59.70	586	89,0
8	Binh Thanh	402	30.30	399	66.20	307	60.90	463	83.80	216	126.40	698	76.00
9	Binh Hoa Hung	278	51.80	572	49.70	298	56.40	365	85.20	186	74.20	s355	79.00
10	Binh Hoa Bac	414	53.40	608	71.70	409	105.90	630	89.40	455	58.00	616	87.00
11	My Binh	280	46.40	395	64.80	214	44.40	331	74.00	201	76.60	407	72.00
	Total	4665	56.00	7117	77.10	4480	69.70	7729	79.10	4448	69.70	8110	81.00

[1]Number of dog/cat-owning households; Data provided by the District Veterinary Station before the vaccination campaign (updated data on households after vaccination was not available for calculation);

[2]% of household vaccination coverage; data calculated by dividing the number of households that had pet vaccinated for initiative data;

[3]Total pet population; data generated after vaccination campaigne;

[4]% of pet vaccination coverage; data calculated by dividing the number of pets vaccinated by total pet population planned for vaccinating.

3.2. Reasons for non-vaccination

The reasons for not being vaccinated among pet populations in 2023 were summarized in Table 2.

Table 2. The reasons for non-vaccination

Reasons for non-vaccination	n	%
All the animals were vaccinated	902	36.74
Non-vaccination without specific reasons	743	30.26
Previously vaccinated (under 3 months)	48	1.96
Indoor and safe dogs, do not require vaccination	4	0.16
More than 2 reasons[1]	91	3.71
Other reasons (sick dog, elderly, lactating dog, etc)	296	12.06
Total	2455	100.00

[1]*Reasons were mentioned in the table.*

In 2023, some reasons for non-vaccination were mentioned such as all the animals previously vaccinated (36.74%), or non-vaccination without specific reasons (30.26%). Other reasons for non-vaccination such as sick dogs, elderly dogs, lactating dogs, and dogs not old enough for vaccination, were a relatively lower proportion.

3.3. Correlation between knowledge – attitude – behaviors variables and the clustering of pet owners over the years

3.3.1. Description of the demographic characteristics of interview participants in KAP surveys over the years

The demographic characteristics of participants in KAP surveys conducted over three years are briefly presented in Table 3. The number of participants in the KAP surveys continuously increased across 2021, 2022, and 2023, with specific counts of 314, 476, and 1067, respectively. The demographic profile of dog and cat owners in the investigated area indicated a predominant occupation in farming, with the highest educational attainment, primarily secondary education. Notably, individuals aged 30 to 50 actively participated in vaccination campaigns, constituting the highest percentage (51.30%) in 2022. The average number of pets per household predominantly remained below five with most households primarily raising dogs, followed by a combination of dogs and other pets, as delineated in Table 3.

Table 3. Demographic characteristics of households participating in KAP surveys

	2021 (n = 314) %	2022 (n = 476) %	2023 (n = 1,067) %
Age			
< 30	3.80	5.60	5.00
30-50	48.40	51.30	47.90
> 50	47.80	43.10	47.10
Educational levels			
+ High school	94.60	93.30	93.00
+ Intermediate/College/University	5.40	6.30	6.90
+ Postgraduate	0.00	0.40	0.10
Occupation			
+ Farmer	85.40	77.70	76.90
+ Authority personnel	3.80	4.00	3.10
+ Soldier	0.30	0.60	0.30
+ Private enterprise/Officer	0.00	0.90	1.20
+ Business	5.10	8.40	9.20
+ Others	5.40	8.40	9.30
Number of family members			
<3	12.40	11.80	11.30
3-5	75.20	77.70	69.60
>5	12.40	10.50	19.10
Number of owned pets			
<3	53.50	54.80	52.30
3-5	39.20	35.30	37.80
>5	7.30	9.90	9.90
Number of pet species/household			
+ Only dog ownership	89.50	88.70	85.50
+ Only cat ownership	0.00	0.60	1.10
+ Other pets	0.30	0.00	0.00
+ Household with two or more species	10.20	10.50	12.70
+ Household with no species	0.00	0.20	0.70
Number of vaccinated pets / households	2.30 (0-9) [1]	2.30 (0-15) [1]	2.00 (0-16) [1]
Number of non-vaccinated pets/household	0.60 (0-5)[1]	0.70 (0-10) [1]	1.00 (0-10) [1]

[1]*Data presented in mean (minimum-maximum) values.*

3.3.2. Correlation between knowledge – attitude – behaviors variables and the clustering of pet owners over the years

a) Pairwise correlation between variables among three years

In 2021, the correlation matrix among the active variables indicated a relatively fragile correlation between knowledge and practice (correlation coefficient [CC] = 0.19, and attitude and practice (CC = 0.12) (Table 4). The positive correlation between knowledge and attitude was also weak (CC = 0.09) (see Table 4). In 2022, a weak correlation was observed between knowledge and attitude (CC = 0.19), knowledge and practice (CC = 0.09), and attitude and practice (CC = 0.13). In 2023, the correlation matrix elucidates a close interconnection between knowledge and practice (CC = 0.35), knowledge and attitude (CC = 0.31), and attitude and practice (CC = 0.25).

Table 4. Correlation matrix among active variables in three studies years

Pairwise Correlation	2021	2022	2023
Knowledge vs. Attitude	0.07	0.19	0.35
Knowledge vs. Practice	0.19	0.09	0.31
Attitude vs. Practice	0.12	0.13	0.25

b) Cluster classification

In 2021, the cluster analysis showed that people who raised dogs and cats in the investigated area can be divided into three distinct clusters. The average scores for the population for each variable - knowledge, attitude, and practice - were 4.80, 5.50, and 4.40, respectively. The clusters had the strongest association with the knowledge variable (CC = 0.94), a less close connection with the practice variable (CC = 0.66), and the weakest association with the attitude variable (CC = 0.02). Moreover, Cluster 1 encompassed households with an average knowledge score of 3.90 and a practice score of 4.20, which were lower than the population's mean values (Table 5). In contrast, Cluster 2 included households with average knowledge and practice scores of 5.00 and 3.80, respectively, exceeding the population's averages. Notably, the attitude variable did not serve as a categorical determinant for either Cluster 1 or Cluster 2. Conversely, Cluster 3 consisted of households exhibiting exceptional scores in knowledge (5.00), attitude (5.70), and practice (4.90), all surpassing the overall mean of the population. The formation of distinct clusters was minimally influenced by qualitative and quantitative complementary variables, except for Cluster 2, where commune location exerted a significant impact. Specifically, the KAP scores in Cluster 2 were predominantly influenced by residents of the My Quy Tay and Binh Hoa Nam communes.

In 2022, the region's owners of dogs and cats manifested discernible distinctions that facilitated their categorization into three distinct clusters. The overall mean scores across the knowledge and attitude variables for the entire population were 5.30 and 4.80, respectively. Notably, the practice variable did not exhibit a robust statistical association and was excluded

from cluster classification. Regarding the interrelation between the three clusters and the principal quantitative variables (knowledge and attitude), the clusters exhibited a pronounced correlation with the knowledge variable (CC = 0.91) and a comparatively weaker association with the attitude variable (CC = 0.61). Cluster 1 comprised participants with average scores for attitude (4.90) and knowledge (3.90) that fell below the overall mean value. Cluster 2 encompassed households with a knowledge score (5.00) surpassing the overall average, yet the attitude score (4.20) lagged. Cluster 3 demonstrated commendable knowledge scores (5.00) and a positive attitude (6.50), with average scores exceeding the overall mean. Commune location and educational levels emerged as pivotal factors significantly impacting the formation of clusters. In particular, the KAP survey responses in cluster one predominantly originated from households in My Thanh Bac and My Quy Tay communes, with no statistically significant variance in educational levels within this cluster. Cluster 2 was principally influenced by individuals from My Thanh Tay commune, where the dominant educational level among contributors was university graduates. Cluster 3 was predominantly constituted by residents of My Quy Dong and My Thanh Bac, with prevailing educational levels being university or college graduates.

In 2023, individuals who maintain dogs and cats in the locality exhibited distinguishable characteristics, classifying them into four discrete clusters based on the results. The mean scores for the knowledge, attitude, and practice variables were 4.60, 8.40, and 6.40, respectively. Participants in Cluster 1 displayed below-average scores in attitude (7.50), knowledge (3.60), and practice (3.90). Cluster 2 comprised individuals with below-average scores in knowledge (4.20) and attitude (7.30) but above-average scores in practice (7.20) compared to the overall population mean. Cluster 3 consisted of individuals with commendable knowledge scores (5.00) but relatively lower practice scores (4.70), with attitude scores not factoring into the classification of this cluster. Cluster 4 included individuals with scores above the population mean in all three domains, encompassing knowledge (4.90), attitude (9.20), and practice (7.50).

Table 5. Summary of cluster score and classification

	The mean score in each cluster				Overall mean score in population
	Cluster 1	Cluster 2	Cluster 3	Cluster 4	
2021					
+Knowledge	3.90	5.00	5.00	N/A	4.80
+Attitude	N/A	N/A	5.7	N/A	5.50
+Practice	4.20	3.80	4.90	N/A	4.40
+Cluster characteristics	LK[2], LP[2]	HK[2], LP[2]	HK[2], HA[2], HP[2]		
+Significant variables[1]	Commune location (for cluster 2 only)				
2022					
+Knowledge	3.90	5.00	5.00	N/A	4.80
+Attitude	4.90	4.30	6.50	N/A	5.30
+Practice	N/A	N/A	N/A	N/A	
+Cluster characteristic	LK[2], LA[2]	HK[2], LA[2]	HK[2], HA[2]		
+Significant variables[1]	Commune location ($P = 1.08*10^{-6}$) and education levels ($P = 7.41*10^{-3}$)				
2023					
+Knowledge	3.60	4.20	5.00	5.00	4.60
+Attitude	7.50	7.30	N/A	9.20	8.40
+Practice	3.90	7.20	4.70	7.50	6.40
+Cluster characteristic	LK[2], LA[2], LP[2]	LK[2], LA[2], HP[2]	HK[2], LP[2]	HK[2], HA[2], HP[2]	
+Significant variables[1]	Commune location ($P = 1.40*10^{-08}$), occupation ($P = 1.04*10^{-05}$) and educational levels ($P = 1.83*10^{-03}$)				

[1] *p-value calculated from Chi-square test.*

[2] *"L" low; "H" high; "K" knowledge; "A" attitude; "P" practice.*

c) Significant variables contribution to cluster

In 2021, no additional variables significantly contributed to forming the three clusters, except the contribution of the commune location variable for cluster 2. In fact, the second cluster was characterized by individuals residing predominantly in My Quy Tay (45.70%) and Binh Hoa Nam (66.60%).

In the subsequent year, 2022, location and educational level were identified as significant contributors to the formation of these clusters. The first cluster (LK, LA) in 2022 was characterized by individuals residing predominantly in My Thanh Bac (42.00%) and My Quy Tay (30.00%). The second cluster (HK, LA) in 2022 was characterized by individuals residing in My Thanh Tay (55.70%) and those who had completed their undergraduate education (5.50%). The third cluster (HK, HA) in 2022 was characterized by individuals who had undergraduate degree (83.30%) and were located in My Quy Dong (69.20%).

In 2023, three additional variables-commune location, occupation, and educational levels significantly influenced the formation of these clusters. The first cluster (LK, LA, LP) was characterized by individuals predominantly residing in My Quy Tay commune, with 48.50% of individuals from My Quy Tay commune falling into this cluster. Additionally, 16.4% of individuals engaged in farming belonged to cluster 1. Similarly, the second cluster (LK, LA, HP) was characterized by individuals mainly residing in Binh Thanh (52.70%), My Quy Dong (43.40%), and Binh Hoa Nam (42.10%) communes. Moreover, 26.40% of individuals involved in farming contributed to cluster 2. The third cluster (HK, LP) was characterized by 65% of individuals from My Thanh Bac and 33.30% from Binh Hoa Bac. The final cluster (HK, HA, HP) was characterized by 75.00% of individuals from My Thanh Tay and 79.10% from Dong Thanh commune. Furthermore, 61.60% of opinions from individuals with other occupations contributed to the latter cluster.

4. Discussion

Evaluation is a crucial step of programming implementation which helps us to be able to identify strong points, weak points as well as things that need to be improved. After 3 out of 5 years of implementing vaccination campaign in the field, there was a strong requirement for us to perform a mid-term review. Overall, the vaccination coverage in Duc Hue districts increased significantly after three years, especially in 2023 (81.00%). This result satisfied the standard requirement of a 70.00% vaccine coverage rate as stated by WHO (2019). However, the quantitative antibody testing post-vaccination on animals vaccinated was lacking due to limited resources, therefore we could not guarantee the efficacity of mass vaccination in animals to prevent rabies in animals and the human population.

Our cluster analysis highlights the role of commune-location which was notably identified as having the most significant contribution to the formation of knowledge, attitude, and practice. The cluster 2 in 2021, which was identified by high knowledge and low practice come mainly from Binh Hoa Nam where the vaccination rate in animal production was low in 2021 (39.90%). This phenomenon reflected the reality that people may have good knowledge but similar findings could not be seen in their practice (Pham et al., 2019). Binh Hoa Nam was facing the problem of human resources for doing vaccination,

therefore the vaccination rate was low. Even with the support from students but lacking the cooperation of local guides (paraveterinary, village chef), the expected vaccination rate could not be achieved. Another commune contributed to cluster 2 was My Quy Tay facing another problem of vaccination - animal statistics. The high vaccination rate reflected the fact that animal population in this area in the previous year could not be estimated with certain data. It might be because in a normal situation without the support of students for vaccinating, a high estimation of animal population could lead to in mission being uncompleted and further punishment could be followed as a consequence or a part of the population could be served as a client for their private business. In 2022, our result highlighted the significant role of educational level in influencing the levels of knowledge, with clusters 2 and 3 demonstrating elevated knowledge levels associated with individuals possessing undergraduate education. In 2023, the noteworthy contribution of individuals from My Quy Tay to Cluster 1 was observed, mirroring findings from 2021. This continuity suggests that the vaccination campaign did not effectuate a substantive change in knowledge levels for individuals in this commune. Additionally, owing to an increased sample size in 2023, farmers emerged as crucial contributors to cluster 1. Clusters characterized by lower KAP's scores often constitute individuals residing in border-area communes who identified as farmers. Consequently, future strategy in Duc Hue, Long An, should prioritize these demographics. The longitudinal findings underscored the inefficacy of conventional methods, such as the distribution of leaflets to raise awareness among animal owners. Existing studies posited that individuals with favorable KAP attributes typically access information from at least three diverse sources (Bui et al., 2016; Nguyen & Nguyen, 2020). Providing free pet vaccination was argued to be critical and conducive to community mobilization in developing countries (Duamor et al., 2023). Nevertheless, the program exhibited a declining trend in attitude scores (data not presented in the manuscript), signaling a negative impact on community awareness. Despite this, the conviction remained that vaccination programs directly influence coverage rates and positively contribute to social awareness regarding rabies vaccination. Moreover, pet vaccination comprised only 7.00% of the estimated cost for rabies and rabies prevention (Shwiff et al., 2018), positioning proactive pet vaccination as a local objective for advancing a rabies-free status. Consequently, future initiatives should adopt diverse approaches to enhance effectiveness of awareness, considering avenues such as radio broadcasts, postcards, and awareness campaigns targeting secondary and high school students. A unique objective to point out during the awareness program is that pet owners are urged to proactively seek vaccination for their animals, underscoring their responsibility for both the health of their pets and the well-being of their communities.

5. Conclusions

Following the three-year rabies vaccination campaign from 2021 to 2023 in Duc Hue district, commendable achievements were noted in attaining high vaccination coverage rates. The analysis revealed the consistent presence of three to four distinct population clusters each year, predicated on KAP scores and their alignment with the overall mean in the

population. Additionally, particular attention was directed towards clusters exhibiting lower scores, with specific consideration given to associated variables such as commune location and occupation. These clusters warrant further exploration and demand more tailored strategies for communication and approach to optimize the efficacy of the vaccination campaign. The KAP surveys must be conducted continuously, serving as a pivotal tool for ongoing program evaluation, particularly in gauging the sustained impact of the initiative in the long term.

Conflict of interest

We certify that the article was conducted by the authoring team and there are no conflicts of interest to declare among authors.

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References

Borse, R. H., Atkins, C. Y., Gambhir, M., Undurraga, E. A., Blanton, J. D., Kahn, E. B., Dyer, J. L., Rupprecht, C. E., & Meltzer, M. I. (2018). Cost-effectiveness of dog rabies vaccination programs in East Africa. *Plos Neglected Tropical Diseases* 12(5), e0006490. https://doi.org/10.1371/journal.pntd.0006490.

Bui, U. V., Nguyen, N. T. T., & Vu, N. S. (2016). Knowledge and practice on prevention of human rabies in Son Dong and Tu Du communes, Lap Thach district, Vinh Phuc province, 2015. *Vietnam Journal of Preventive Medicine* XXVI(10), 183.

Cornillon, P. A., Guyader, A., Husson, F., Jegou, N., Josse, J., Kloareg, M., Lober, E. M., & Rouvière, L. (2012). *R for Statistics* (1st ed.). New York, USA: Chapman and Hall/CRC. https://doi.org/10.1201/b11828.

DAH (Department of Animal Health). (2023). *Report of rabies prevention and control conference 2023*. Gia Lai, Vietnam: Gia Lai Publisher.

Duamor, C. T., Hampson, K., Lankester, F., Lugelo, A., Changalucha, J., Lushasi, K. S., Czupryna, A., Mpolya, E., Kreppel, K., Cleaveland, S., & Wyke, S. (2023). Integrating a community-based continuous mass dog vaccination delivery strategy into the veterinary system of Tanzania: A process evaluation using normalization process theory. *One Health* 17, 100575. https://doi.org/10.1016/j.onehlt.2023.100575.

Friedmann, E., & Son, H. (2009). The Human–companion animal bond: How humans benefit. *Veterinary Clinics of North America: Small Animal Practice* 39(2), 293-326. https://doi.org/10.1016/j.cvsm.2008.10.015.

Gebremedhin, E. Z., Sarba, E. J., Getaneh, A. M., Tola, G. K., Endale, S. S., & Marami, L. M. (2020). Demography and determinants of dog and cat ownership in three towns of West Shoa zone, Oromia Region, Ethiopia. *BMC Veterinary Research* 16(1), 481. https://doi.org/10.1186/s12917-020-02699-4.

GOV (Government of the Socialist Republic of Viet Nam). (2021). Decision No. 2151/QD-TTg dated on December 21, 2021. Approve the national rabies prevention and control program from 2022 to 2030. Retrieved October 25, 2023, from https://lawnet.vn/vb/Quyet-dinh-2151-QD-TTg-2021-Chuong-trinh-quoc-gia-phong-chong-benh-Dai-2022-2030-79A0E.html.

Le, S., Josse, J., & Husson, F. (2008). FactoMineR: An R package for multivariate analysis. *Journal of Statistical Software* 25(1). https://doi.org/10.18637/jss.v025.i01.

Nguyen, T. T., & Nguyen, S. M. (2020). Status of knowledge, attitudes, and practices regarding rabies prevention in Tuy An district, Phu Yen province, 2019. *Journal of Medical Research* 128(4), 189-198.

NIHE (National Institute of Hygiene and Epidemiology). (2023). *Image of rabies in Vietnam and national program of control and eradication of rabies 2022 - 2030*. Gia Lai, Vietnam: Gia Lai Publisher.

Paul, M., King, L., & Carlin, E. P. (2010). Zoonoses of people and their pets: A US perspective on significant pet-associated parasitic diseases. *Trends in Parasitology* 26(4), 153-154. https://doi.org/10.1016/j.pt.2010.01.008.

Pham, D. Q., Phan, T. L., Nguyen, T. P. T., Doan, Q. N. M., Nguyen, H. D., Luong, Q. C., & Nguyen, T. V. (2021). An evaluation of the rabies surveillance in Southern Vietnam. *Frontiers in Public Health* 9, 610905. https://doi.org/10.3389/fpubh.2021.610905.

Pham, P. D., Cook, M. A., Cong, H. H., Nguyen, H. T., Padungtod, P., Nguyen, H. T., & Dang, S. X. (2019). Knowledge, attitudes and practices of livestock and aquaculture producers regarding antimicrobial use and resistance in Vietnam. *Plos One* 14(9), e0223115. https://doi.org/10.1371/journal.pone.0223115.

Shwiff, S. A., Brown, V. R., Dao, T. T., Elser, J., Hoang, T. X., Nguyen, T. N., Nguyen, H. T., Nguyen, H. T. T., Riewpaiboon, A., Ernst, K., Shwiff, S., & Payne, D. (2018). Estimating the economic impact of canine rabies to Viet Nam 2005 - 2014. *Plos Neglected Tropical Diseases* 12(10), e0006866. https://doi.org/10.1371/journal.pntd.0006866.

Tiwari, H. K., Vanak, A. T., O'Dea, M., & Robertson, I. D. (2018). Knowledge, attitudes and practices towards dog-bite related rabies in para-medical staff at rural primary health centers in Baramati, western India. *Plos One* 13(11), e0207025. https://doi.org/10.1371/journal.pone.0207025.

Truong, B. D., Ly, S. H., Nguyen, D. T. T., Le, T. Q., Duong, M. T., Nguyen, P. T., T., Vo, N. T., Nguyen, D. D., Tran, V. T., Vo, T. K. O., Le, T. M. K., & Vo, M. D. (2023). Evaluation rabies vaccination and changing in knowledge - attitude and practice of rabies prevention in animal in Duc Hue district - Long An province, 2021- 2022. *Journal of Veterinary Science and Technology* XXX(4), 76-79.

Vilas, V. J. D. R., Carvalho, M. J. F. D., Vigilato, M. A. N., Rocha, F., Vokaty, A., Pompei, J. A., Flores, B. M., Fenelon, N., & Cosivi, O. (2017). Tribulations of the last mile: Sides from a regional program. *Frontiers in Veterinary Science* 4. https://doi.org/10.3389/fvets.2017.00004.

WHO (World Health Organisation). (2023). Rabies. Retrieved October 25, 2023, from https://www.who.int/news-room/fact-sheets/detail/rabies.

WHO (World Health Organization). (2019). Zero by 30: the global strategic plan to end human deaths from dog-mediated rabies by 2030: United Against Rabies Collaboration: first annual progress report: global strategic plan to end human deaths from dog-mediated rabies by 2030. Retrieved October 25, 2023, from https://iris.who.int/handle/10665/328053.