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Research Article

Pet-keepers' Knowledge, Attitudes, Practices and Perceptions of Rabies in Accra, Ghana: A Principal Component Analysis Approach

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ABSTRACT

Introduction: Rabies is a major health issue in Ghana; therefore, its control and prevention rely on the knowledge, attitudes, practices, and perceptions (KAPP) of pet keepers. The present study aimed to identify key KAPP factors for rabies among pet owners using principal component analysis (PCA) and to develop predictive models for KAPP.

Materials and methods: This study surveyed 315 pet keepers at a veterinary hospital in Accra, Ghana, using a KAPP questionnaire about rabies, from August 2024 to August 2025. The questionnaire measured knowledge (11 items), attitudes (4 items), practices (5 items), and perceptions (13 items) of rabies. Respondents were then categorized as having high or low knowledge, positive or negative attitudes, good or poor practices, and favorable or unfavorable perceptions, depending on whether their scores fell above or below the established threshold. The PCA grouped correlated questionnaire items into broader, independent themes called components. Bartlett's and KMO analyses confirmed data suitability for PCA, Cronbach's alpha assessed questionnaire reliability, binary logistic regression analyzed the predictors of KAPP outcomes, and Cox and Snell and Nagelkerke R-squared evaluated model explanatory power and fit.

Results: For knowledge, 15 indicators (11 knowledge questions plus rabies-related demographic variables) were entered into PCA, and the analysis grouped them into 6 distinct themes that together explained 54% of the total variation in responses. Eight attitude indicators (including four attitude questions and rabies-related demographics) were entered into PCA, which grouped them into four themes explaining 63% of response variation. For practices, 9 indicators were reduced to 4 components, explaining 60% of the total variance, and for perceptions, 17 indicators were reduced to 7 components, explaining 60% of the total variance. The Cox and Snell values (0.71-0.75) indicated that the models explained 75% of the variation in KAPP. The Nagelkerke values (0.96-1.00) indicated a strong model fit, meaning the predictors accounted for nearly all the variability in the outcomes.

Conclusion: The present study identified important indicators needing prioritization to improve KAPP of pet owners and to help enhance rabies prevention and control in Accra, Ghana.

1. Introduction

Rabies poses a major threat to both humans and animals in Ghana because of its endemicity and prevalence[1,2]. Rabies imposes significant public health and economic burdens, including annual financial costs and loss of human life[3]. The prevalence of rabies is often attributed to a general lack of public knowledge[4], particularly in Ghana[5]. Additionally, public awareness of rabies and its prevention remains limited[6], among other factors. There have been reports of rabies cases in Ghana in dogs, cats, monkeys, bats, cattle, sheep, and goats[7], and in humans[8-10].

Knowledge, attitudes, practices, and perceptions (KAPP) studies are now widely accepted as a tool to investigate

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health-related behaviors and health-seeking practices[11,12]. A KAPP survey is described as a comprehensive tool designed to gather data on the understanding, beliefs and behaviors of a targeted population regarding a specific subject[12]. The KAP surveys are aimed at assessing what is known (knowledge), believed (attitude), and done (practice)[13]. Knowledge is defined as the capacity to acquire, retain, and use information[11], while attitude is a learned predisposition to respond favorably or unfavorably toward people, an object, an idea, or a solution[13]. Practice is the application of rules and knowledge that leads to action[11], while perception is the subjective process of acquiring, interpreting, and organizing sensory information[14]. The KAPP surveys provide quantitative and qualitative information[11], giving useful information about the extent of a known situation or condition, and confirming or disproving a hypothesis, new directions or horizons[15]. These surveys identify gaps in knowledge, cultural beliefs, and behaviors useful for control measures[12]. The KAPP studies on rabies in Ghana have been reported in Tamale[16], Sekondi-Takoradi[17], Ga East Municipality[18], Suhum Municipality[19], Sunyani Municipality[20], and the Greater Accra, Ashanti, and Bono-East regions[21].

Principal component analysis (PCA) has been used in KAPP studies to reduce complex, multivariable data into a set of summarizing components, while maintaining the original variance as much as possible[22]. A recent paper on client satisfaction with veterinary services for small animals in Ghana employed PCA[23]. The present study differed from previous reports on rabies in Ghana by focusing only on respondents who were pet keepers seeking services for their animals at an animal hospital in Accra, Ghana, rather than sampling dog owners in communities. The present study aimed to identify and prioritize the most critical determinants related to KAPP of rabies among pet owners visiting a companion animal hospital in Accra, Ghana, and to generate predictive models for KAPP scores.

2. Materials and Methods

2.1. Ethical approval

Ethical approval and permission for the study were given on 16th December 2024 by the Dean's Office, School of Veterinary Medicine, University of Ghana. The study followed international standards, including the Declaration of Helsinki. Participation was voluntary, and those unwilling to participate were excluded.

2.2. Study design

A cross-sectional approach was adopted to interview 315 clients in and around Accra who received services at the Small Animal Teaching Hospital at the University of Ghana from August 2024 to August 2025. A questionnaire, the same as that used in a study of Sekondi-Takoradi[17], was administered in person to clients visiting the hospital. After obtaining consent, the participant completed and uploaded the questionnaire online.

2.3. Variables

The study evaluated respondents' knowledge (11 items), attitudes (4 items), practices (5 items), and perceptions (13 items). The KAPP levels were graded on a scale of 1 point for a yes answer and 0 points for no or don't know responses. The mean KAPP scores were calculated and used to categorize respondents. The present study adopted the Lounis et al.[24] classification. The classes based on the mean values generated in this study were as follows. High knowledge (scores above 5.7), low knowledge (scores below 5.7), positive attitudes (above 2.3), negative attitudes (below 2.3), good practices (above 4.2), bad practices (below 4.2), and good perceptions (above 6.3), bad perceptions (below 6.3). Scores above the mean were interpreted as high knowledge, positive attitudes, and good practices or perceptions, whereas lower scores meant the opposite[24].

2.4. Statistical analysis

The Microsoft Excel file sheet of responses was imported into SPSS version 25 software for Windows. Frequencies were calculated and expressed as percentages. Two-by-two tables were used for analyses. Statistical significance was set at $p < 0.05$ using the chi-square test.

The PCA was conducted using SPSS 25 to reduce data dimensionality and identify underlying latent constructs. The suitability of the data for PCA was assessed using the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity. The KMO determined the adequacy of data by measuring the degree of coherence between variables[25]. The KMO was interpreted as excellent for values higher than 0.90, very good for values higher than 0.80, good for values higher than 0.70, acceptable for values higher than 0.60, suitable for values higher than 0.50, and unacceptable for values less than 0.50[26]. Bartlett's test indicated whether a statistically significant relationship exists among the variables in the data set[25]. A p-value below 0.05 indicated sufficient correlation among variables to proceed with dimensionality reduction, whereas a p-value of 0.0001 indicated the test was highly significant[27]. Components with eigenvalues greater than 1 were retained, consistent with the scree plots. Varimax rotation was applied to aid interpretation.

The Cox and Snell R-squared test, which estimated the proportion of variance in the dependent variable explained by the independent variables (predictors), was employed[28]. The values indicated the model's explanatory power and were combined with the Nagelkerke R-squared test, which measured how well the model fit the data. The Nagelkerke R-squared test assessed how much of the total variation in the dependent variable was explained by the independent variables in this model[29]. A value below 0.2 indicated a weak relationship or low explanatory power; a value between 0.2 and 0.4 meant a moderate relationship or decent fit, while more than 0.4 indicated a strong relationship or high explanatory power[29]. A Nagelkerke value closer to 1 meant the model explained a significant portion of the variability in the outcome, while a value closer to 0 indicated limited explanatory power[29].

Cronbach's alpha was used as a measure of the internal consistency of a test or survey[30]. Cronbach's alpha was employed to assess whether multiple questions intended to

measure the same concept function collectively to accurately evaluate that construct, and to indicate the extent of measurement error that may be present[31]. Alpha values were interpreted as follows. Excellent for values above 0.9, good for values ranging from 0.8 to 0.9, acceptable for values between 0.7 and 0.8, questionable for values between 0.6 and 0.7, poor for values between 0.5 and 0.6, and less than 0.5 for unacceptable values[32].

Binary logistic regression was carried out using SPSS to produce a model predicting respondents' KAPP as the dependent variable. Binary responses for gender, age, years animals kept, and having heard of rabies categories, along with other indices, were the independent variables. Each outcome variable (KAPP scores) related to rabies was used to determine associations with respondents' characteristics and responses[33-35]. The best subset regression model technique was used in SPSS. The Wald test statistic was also used as a measure in the binary logistic regression.

3. Results and Discussion

Table 1 provides the background information on the respondents in the study. The study surveyed 315 respondents and evaluated different indicators assessing KAPP. A greater number of male respondents (185) participated compared to female respondents (130), and a higher number of respondents were under 30 years of age (186) in comparison to those over 30 years of age (129). A large majority (91%) had heard of rabies (288). Additionally, many had kept pets for less than the average of 7.5 years.

Table 2 presents the results of the factor analyses using principal component extraction with varimax rotation, along with KMO and Bartlett's test and Cronbach's alpha test results. For knowledge, the KMO value was 0.57, Bartlett's test chi-square value was 238.4, and Cronbach's alpha value was 0.38. For attitudes, the KMO value was 0.54, Bartlett's test chi-square value was 136.8, and Cronbach's alpha was 0.41. For practices, KMO was 0., Bartlett's test chi-square value was 263.7, and Cronbach's alpha was 0.49. For perceptions, KMO was 0.61, Bartlett's test chi-square was 530.4, and Cronbach's alpha was 0.46. Sampling adequacy was assessed using KMO and Bartlett's test of sphericity. The KMO values, which ranged from 0.51 to 0.62, were interpreted as suitable to acceptable[26], indicating that the variables shared enough common variance to be used and that the data were suitable for factor analysis. Appendices 1 to 4 present the communalities for the KAPP scores. Internal consistency of components, assessed using Cronbach's alpha, ranged from 0.4 to 0.5. These values were low compared with the recommended value of greater than 0.7[36], which may be due to a low number of questions, poor item relatedness, or heterogeneous constructs[30]. These findings may reflect inadequate item relatedness and/or a heterogeneous construct.

The total variance explained for KAPP scores is presented in tables 3 to 6. These tables demonstrated the number of components and their loadings. For the knowledge score, six components were isolated (Figure 1). Component 1 explained 12.3% of the variance (Table 3), which was strongly influenced by responses to the following questions. Is rabies fatal?, Is rabies a notifiable disease?, Can a person get rabies through contact (broken skin) with the saliva of a rabid dog? Have you ever heard of World Rabies Day?, Years that owners keet their pets category, Have you ever seen a suspected case of rabies in a dog or any animal?, Can rabies be prevented by vaccination of dogs?, and Gender category of respondents. Component 2 explained 10.2% of the variance and was driven by the following questions and categories. Has vaccination of dogs against rabies ever been organized in your community?, Have you ever seen a suspected case of rabies in a dog or any animal?, Can rabies be prevented by vaccination of dogs? Have you ever been bitten by an animal?. Component 3 accounted for 8.9% of the variance and related to responses to the following questions and categories. Have you ever heard of World Rabies Day?, Can rabies be prevented by vaccination of dogs?, Is a bite from a dog the only way to get rabies?, and age category. Component 4 explained 7.9% of the variance and was associated with the following questions or categories. Have you ever been bitten by an animal?, age and gender categories of respondents, and Can rabies be transmitted by other animals?. Component 5 explained 7.5% of the variance and was associated with responses to questions and categories as follows. Has vaccination of dogs against rabies ever been organized in your community?, Can rabies be treated after the onset of clinical signs in a human victim?, and the gender category of respondents. Component 6 explained 6.8% of the variance and was driven by responses to the following questions and categories. Is rabies a notifiable disease?, Years that owners kept their pets category and can rabies be transmitted by other animals?

Table 1. Background information of the respondents interviewed about rabies in Accra, Ghana, from August 2024 to August 2025

Category	Number of respondents	Percentage	χ^2	P-value
Gender of respondents				
Male	185	58.7	9.6	0.0019*
Female	130	41.3		
Age Group of respondents				
<30	186	59.0	20.6	<0.0001*
≥30	129	41.0		
Heard of rabies				
Yes	288	91.4	216.3	<0.0001*
No	27	8.6		
Years owners keep pet				
mean < 7.5 years	199	63.2	43.7	<0.0001*
mean > 7.5 years	116	36.8		

Total number of respondents was 315. * indicates significant p-value in a column, χ^2: Chi-squared value

Table 2. Factor analysis with principal component extraction using varimax rotation for KAPP of respondents in Accra, Ghana, from August 2024 to August 2025

KAPP subunits, reliability, and sample size adequacy indices	Questions	Factor loading to extract components with EV > 1						
		I	II	III	IV	V	VI	VII
Knowledge[a] KMO = 0.57 BT χ^2 = 238.4 p = 0.0001 Cronbach's α = 0.38	Is rabies fatal?	0.52	-	-	-	-	-	
	Is rabies a notifiable disease?	0.50	-	-	-	-	-0.48	
	Can one get rabies through contact (broken skin) with the saliva of a rabid dog?	0.50	-	-	-	-	-	
	Have you ever heard of World Rabies Day?	0.48	-	0.38	-	-	-	
	Years pets kept category	0.45	-	-	-	-	-0.37	
	Have heard of rabies category	-	-	-	-	-	-	
	Has your community ever organized dog vaccination against rabies?	-	-	-	-	-0.47	-	
	Have you ever seen a suspected case of rabies in a dog or any animal?	0.34	0.53	-	-	-	-	-
	Can vaccinating dogs prevent rabies?	-	0.48	056	-	-	-	
	Is a dog bite the only way to get rabies?	-0.30	-	0.47	-	-	-	
	Have you ever been bitten by an animal?	-	0.42	-	0.71	-	-	
	Age category	-	-	-0.42	0.45	-	-	
	Gender category	-	-0.42	-	0.43	0.59	--	
	Can rabies be treated after onset of clinical signs in a human victim?	0.49	-	-	-	0.51	-	
	Can rabies be transmitted by other animals?	-	-	-	-0.30	-	0.50	
Attitude[b] KMO = 0.51 BT χ^2=136.8 p = 0.0001 Cronbach's α = 0.41	Should stray dogs and cats be put to death?	0.65	-0.39	0.14	0.28			
	Are you willing to support rabies control by volunteering to vaccinate your animals?	0.62	0.24	-0.43	-0.17			
	Should stray dogs and cats be put to death?	0.42	-0.69	-	-			
	Would you report a suspected case of rabies in your community?	0.50	0.51	0.39	0.27	-	-	-
	Years pets kept category	-	0.48	0.39	0.45			
	Age category	0.47	0.11	0.61	-			
	Have heard of rabies category	0.16	0.37	0.42	-0.58			
	Gender category	-0.22	-	0.16	0.57			
Practice[c] KMO = 0.62 BT χ^2= 263.7 p = 0.0001 Cronbach's α = 0.49	Would you report to the hospital for treatment if bitten by wild animals**?**	0.76	-	-0.31	-			
	Would you go to the hospital for treatment if your own dog bit you?	0.76	-	-	-			
	Would you go to the hospital for treatment if a stray dog bit you?	0.67	-0.38	-	-	-	-	-
	Would you go to the hospital for treatment if a vaccinated dog bit you?							
	Age category	0.63	0.59	-	0.44			
	Years pets kept category	-	0.50	-	-0.48			
	Should bite wounds be washed with soap and water?	-	-	0.67	-			
	Gender category	-	-	0.57	-			
	Have heard of rabies category	-	0.52	-	0.56			
Perception[d] KMO = 0.61 BT χ^2 = 530.4 p = 0.0001 Cronbach's α = 0.46	Are there any locally available treatment methods for dog bites and rabies?	-0.55	-	-	0.47	-	-	-
	Age category	0.49	-	-	0.40	-	-	-
	Do you believe vaccinating dogs and cats can control rabies?	0.48	-	-	-	-	-0.33	-
	Is information/education on rabies in Ghana adequate?	-0.44	0.40	0.34	-	-	0.35	-
	Is the cost of vaccinating a dog against rabies reasonable?	-	0.70	-	-	-	0.34	-
	Is vaccinating a dog against rabies affordable?	-	0.67	-	-	-	-	-
	Do you think authorities in your area are doing a good job in controlling rabies in dogs?	-0.36	0.49	-	-	-	-0.40	-
	Is it important to control the dog population in an area?	-	0.41	-	-0.34	-	0.36	-
	Should rabies vaccination for dogs and cats be free, with the government covering the cost?	-	-	0.57	-	-	-	0.45
	Years pets kept category	-	-	0.54	-	-0.50	-	-
	Should dogs be allowed to roam freely around in the community?	-0.38	-	0.50	0.35	-	-	-
	Do you think pet owners would pay a reasonable fee for rabies vaccination?	-	0.31	0.42	-	-	-	-
	Do you believe that rabies can be treated by traditional healing?	-0.37	0.35	-	0.52	-	-0.38	-
	Have you heard of rabies category	0.42	-	-	0.45	-	-	-
	Do you believe it is good to vaccinate dogs against rabies?	0.46	-	-	-	0.57	-	-
	Do you think rabies in dogs is a problem in your community?	-0.39	-	-	-	0.54	0.33	-
	Gender category	-	-	-0.35	-	-	-	0.65

[a]: About 54% of the total variance in the knowledge score was explained by 6 components. [b]: About 63% of the total variance in attitude score was explained by 4 components. [c]: About 60% of the total variance in practices score was explained by 4 components. [d]: About 60% of the total variance in perception score was explained by 7 components. EV: Eigenvalue, KMO: Kaiser-Meyer-Olkin, BT χ^2: Bartlett's test chi-square, p-value of 0.0001 indicated the test was highly significant, -: Cell has no value

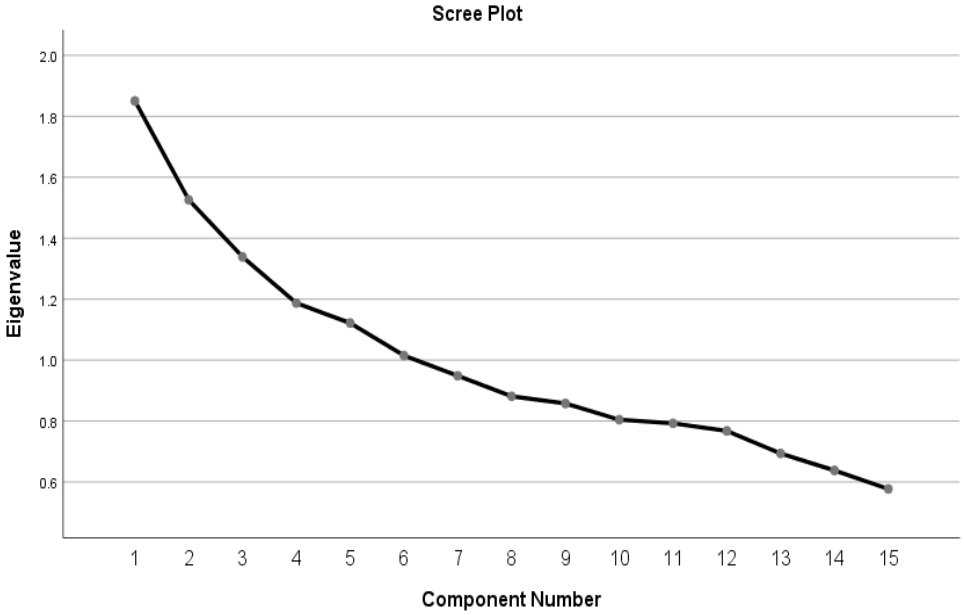


Figure 1. Scree plot of respondents' knowledge score about rabies in Accra, Ghana, from August 2024 to August 2025

Table 3. Total variance of respondents' knowledge score about rabies in Accra, Ghana, from August 2024 to August 2025

Components	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	Variance (%)	Cumulative (%)	Total	Variance (%)	Cumulative (%)	Total	Variance (%)	Cumulative (%)
1	1.85	12.34	12.34	1.85	12.34	12.34	1.42	9.45	9.45
2	1.53	10.17	22.51	1.53	10.17	22.51	1.41	9.42	18.87
3	1.34	8.93	31.44	1.34	8.93	31.44	1.39	9.26	28.14
4	1.19	7.91	39.35	1.19	7.91	39.35	1.35	9.01	37.15
5	1.12	7.48	46.83	1.12	7.48	46.83	1.26	8.41	45.56
6	1.00	6.77	53.60	1.02	6.77	53.60	1.21	8.01	53.60
7	0.95	6.32	59.92	-	-	-	-	-	-
8	0.88	5.88	65.79	-	-	-	-	-	-
9	0.86	5.72	71.51	-	-	-	-	-	-
10	0.80	5.36	76.88	-	-	-	-	-	-
11	0.79	5.28	82.16	-	-	-	-	-	-
12	0.77	5.12	87.28	-	-	-	-	-	-
13	0.69	4.62	91.90	-	-	-	-	-	-
14	0.64	4.25	96.15	-	-	-	-	-	-
15	0.58	3.85	100.00	-	-	-	-	-	-

Extraction method: Principal component analysis, -: Cell has no value

The attitude score had 4 components evolving (Figure 2; Table 4). Component 1, which explained 19.60% of the variance, was strongly related to all the indicators used except the years animals kept category. Component 2 explained 16.60% of the variance and covered all indicators except the gender category. Similarly, Component 3 explained 13.56% of the variance and included all indicators except responses to one question (Should stray dogs and cats be put to death?). Likewise, Component 4 explained 13.1% of the variance and loaded on all indicators except responses to one question (Should stray dogs and cats be put to death?) and age categories. Similarly, the practices score had 4 components emerging (Figure 3; Table 5). Component 1 explained 23% of the variance. Component 2 explained 13.8% of the variance. Component 3 explained 12.1% of the variance, and component 4 explained 11.4% of the variance and loaded on responses to questions on age, years pets kept, and respondents' gender category. Seven components were generated for the perceptions score (Figure 4; Table 6). Component 1 explained 12.7% of the variance, and component 2 explained 12.2%. Component 3 explained 8% of the variance, component 4 explained 7.3%, component 5 explained 6.8%, and component 6 explained 6.6%. Component 7 accounted for 5.9% of the variance and encompassed responses to the question, including Should rabies vaccination for dogs and cats be free, with costs covered by the government? as well as respondents' gender category.

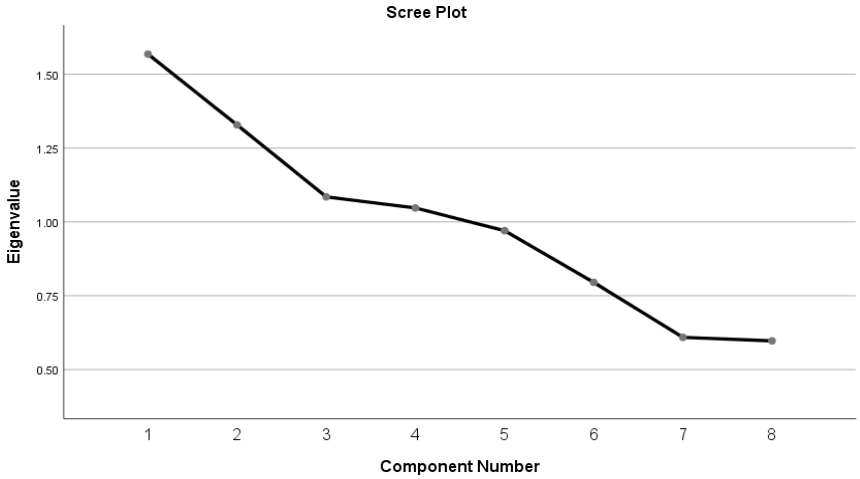


Figure 2. Scree plot of respondents' attitude score about rabies in Accra, Ghana, from August 2024 to August 2025

Table 4. Total variance of respondents' attitude score about rabies in Accra, Ghana, from August 2024 to August 2025

Components	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	Variance (%)	Cumulative (%)	Total	Variance (%)	Cumulative (%)	Total	Variance (%)	Cumulative (%)
1	1.57	19.60	19.60	1.57	19.60	19.60	1.40	17.53	17.53
2	1.33	16.60	36.21	1.33	16.60	36.21	1.36	17.04	34.57
3	1.09	13.56	49.77	1.09	13.56	49.77	1.17	14.59	49.16
4	1.05	13.00	62.86	1.05	13.09	62.86	1.10	13.70	62.86
5	0.97	12.13	74.98	-	-	-	-	-	-
6	0.80	9.94	84.92	-	-	-	-	-	-
7	0.61	7.61	92.54		-	-	-	-	-
8	0.60	7.46	100.00		-	-	-	-	-

Extraction method: Principal component analysis, -: Cell has no value

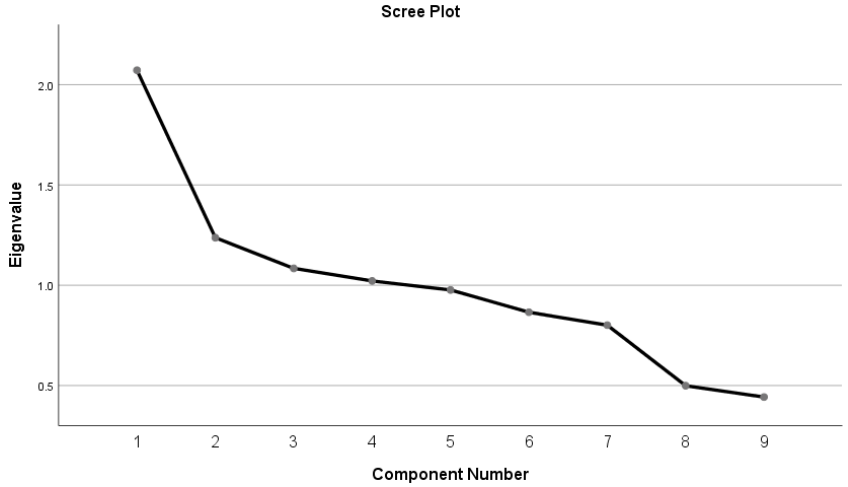


Figure 3. Scree plot of respondents' practice score about rabies in Accra, Ghana, from August 2024 to August 2025

Table 5. Total variance of respondents' practice score about rabies in Accra, Ghana, from August 2024 to August 2025

Components	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	Variance (%)	Cumulative (%)	Total	Variance (%)	Cumulative (%)	Total	Variance (%)	Cumulative (%)
1	2.07	23.02	23.02	2.07	23.02	23.02	1.69	18.80	18.80
2	1.24	13.75	36.77	1.24	13.75	36.77	1.49	16.59	35.38
3	1.08	12.05	48.81	1.08	12.05	48.81	1.14	12.64	48.02
4	1.02	11.35	60.16	1.02	11.35	60.16	1.09	12.14	60.16
5	0.98	10.85	71.01	-	-	-	-	-	-
6	0.87	9.62	80.63	-	-	-	-	-	-
7	0.80	8.90	89.53	-	-	-	-	-	-
8	0.50	5.55	95.08		-	-	-	-	-
9	0.44	4.92	100.00		-	-	-	-	-

Extraction method: Principal component analysis, -: Cell has no value

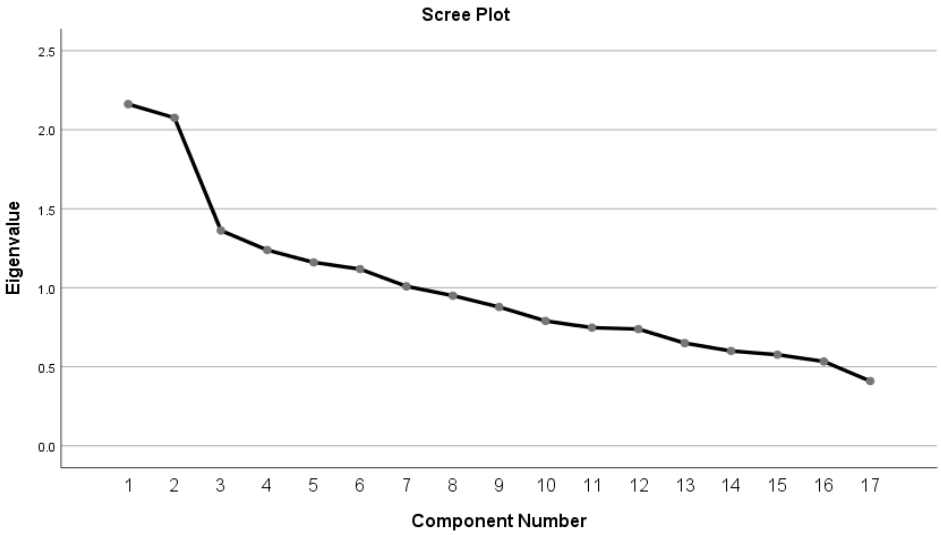


Figure 4. Scree plot of respondents' perception score about rabies in Accra, Ghana, from August 2024 to August 2025

Table 6. Total variance of respondents' perception score about rabies in Accra, Ghana, from August 2024 to August 2025

Components	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	Variance (%)	Cumulative (%)	Total	Variance (%)	Cumulative (%)	Total	Variance (%)	Cumulative (%)
1	2.16	12.72	12.72	2.16	12.72	12.72	1.71	10.06	10.06
2	2.08	12.21	24.93	2.08	12.21	24.93	1.69	9.96	20.02
3	1.36	8.02	32.94	1.36	8.02	32.94	1.56	9.17	29.19
4	1.24	7.29	40.23	1.24	7.29	40.23	1.56	9.15	38.34
5	1.16	6.83	47.05	1.16	6.83	47.05	1.27	7.45	45.79
6	1.12	6.58	53.63	1.12	6.58	53.63	1.20	7.04	52.84
7	1.01	5.94	59.57	1.01	5.94	59.57	1.14	6.73	59.57
8	0.95	5.59	65.16	-	-	-	-	-	-
9	0.878	5.17	70.32	-	-	-	-	-	-
10	0.790	4.65	74.97	-	-	-	-	-	-
11	0.748	4.40	79.37	-	-	-	-	-	-
12	0.739	4.34	83.71	-	-	-	-	-	-
13	0.650	3.82	87.53	-	-	-	-	-	-
14	0.600	3.53	91.06	-	-	-	-	-	
15	0.577	3.39	94.45	-	-	-	-	-	-
16	0.534	3.14	97.59	-	-	-	-	-	-
17	0.410	2.41	100.00	-	-	-	-	-	-

Extraction method: Principal component analysis, -: Cell has no value

Tables 7 to 10 provided the rotated component matrices for KAPP, respectively. These results indicated the correlations between the questionnaire variables and the newly created underlying factors after rotation. The components represented distinct, non-overlapping themes that explained the key drivers of KAPP. Table 7 presents the rotated component matrix for the knowledge score using orthogonal rotation (varimax), indicating that 6 components were extracted based on the group items.

Table 7. Rotated component matrix of respondents' knowledge score about rabies in Accra, Ghana, from August 2024 to August 2025

Questions/category	Components					
	1	2	3	4	5	6
Can rabies be transmitted by other animals?	0.72	-	-	-	-	-
Is a bite from a dog the only way to get rabies?	-0.71	-	-	-	-	-
Can a person get rabies through contact (broken skin) with the saliva of a rabid dog?	0.57	-	-	-	-	-
Is rabies a notifiable disease?	-	0.71	-	-	-	-
Years pet kept category	-	0.55	-	-	-	-
Is rabies fatal?	-	0.51	0.39	-	-	-
Have you ever heard of World Rabies Day?	-	0.47	0.35	0.32	-	-
Age category	-	-	0.68	-	-	0.36
Can rabies be prevented by vaccination of dogs?	-	-	0.64	-	-	-
Has vaccination of dogs against rabies ever been organized in your community?	-	-	-	0.77	-	-
Have you heard of the rabies category?	-	-	-	-0.55	-	-
Gender category	-	-	-		0.77	-
Have you ever seen a suspected case of rabies in a dog or any animal?	-	-	-	0.31	0.55	-
Have you ever been bitten by an animal?	-	-	-	-	-	0.80
Can rabies be treated after clinical signs appear in a human victim?	-	-	-	-	0.48	-0.54

Extraction method: Principal component analysis, Rotation method: Varimax with Kaiser normalization, rotation converged in 11 iterations, -: Cell has no value

Table 8 shows the rotated component matrix values for the attitude score using the Varimax method. Four components were extracted based on the group items. Table 9 presents the different values for the rotated component matrix for the practices score using the Varimax method, in which 4 components were extracted based on the group items. Table 10 demonstrates the rotated component matrix values for the perceptions score using the Varimax method. In total, 7 components were extracted based on the group items.

Table 8. Rotated component matrix of respondents' attitudes score about rabies in Accra, Ghana, from August 2024 to August 2025

Questions/category	Components			
	1	2	3	4
Would you allow your dog to be put to death if suspected of having rabies?	0.79	0.20	-	0.11
Should stray dogs and cats be put to death?	0.76	-0.12	-	-0.24
Would you report a suspected case of rabies in your community?		0.83	-	0.21
Are you willing to support rabies control by volunteering to vaccinate your animals?	0.13	0.77	0.11	-0.28
Have heard of rabies category	-0.20	-	0.79	-0.16
Age category	0.36	-	0.64	0.24
Years pet kept category	-	0.13	0.24	0.71
Gender category	-	-0.15	-0.25	0.56

Extraction method: Principal component analysis, Rotation method: Varimax with Kaiser normalization, rotation converged in 7 iterations, -: Cell has no value

Table 9. Rotated component matrix of respondents' practice score about rabies in Accra, Ghana, from August 2024 to August 2025

Questions/category	Components			
	1	2	3	4
Would you go to the hospital for treatment if a vaccinated dog bit you?	0.80	-	-	-
Would you go to the hospital for treatment if your own dog bit you?	0.78	-	-	-
Would you go to the hospital for treatment if a stray dog bit you?	-	0.72	-	-
Would you go to the hospital for treatment if bitten by a wild animal**?**	0.45	0.69	-	-
Years pet kept category	-	0.61	-	-
Have heard of rabies category	-	-	0.77	-
Age category	-	-	0.74	0.31
Should bite wounds be washed with soap and water?	-	-	-	0.75
Gender category	-	-	-	0.51

Extraction method: Principal component analysis, Rotation method: Varimax with Kaiser normalization, Rotation converged in 14 iterations, -: Cell has no value

Table 10. Rotated component matrix of respondents' perception scores about rabies in Accra, Ghana, from August 2024 to August 2025

Questions/category	Components						
	1	2	3	4	5	6	7
Is vaccinating a dog against rabies affordable?	0.82	-	-	-	-	-	-
Is the cost of vaccinating a dog against rabies reasonable?	0.81	-	-	-	-	-	-
Is information/ education on rabies in Ghana adequate?		0.67	-	-	-	-	-
Have heard of rabies category		-0.61	-	-	-	-	-
Age category	0.43	-0.52	-	-	-	-	-
Do you think authorities in your area are doing a good job in controlling rabies in dogs?	-	0.49	0.31	-	-	-0.33	
Are there any locally available treatment methods for dog bites and rabies?	-	-	0.83	-	-	-	-
Do you believe that rabies can be treated by traditional healing?	-	-	0.74	-	-	-	-
Do you believe it is good to vaccinate dogs against rabies?	-	-	-	0.64	-	-	-
Do you believe it is good to vaccinate dogs against rabies?	-	-	-	0.63	-	-	-
Is it important to control the dog population in an area?	-	0.31	-	0.62	-	-	-
Years pet kept category	-	-	-	-	0.77	-	-
Do you think rabies in dogs is a problem in your community?	-	0.36	-	-	-0.60	-	-
Do you think pet owners are willing to pay a reasonable fee for rabies vaccination?	0.31	-	-	-	0.35	-	-
Should rabies vaccination for dogs and cats be free, with the government covering the cost?	-	-	-	-	-	0.86	-
Gender category	-	-	-	-	-	-	-0.79
Should dogs be allowed to roam freely around in the community?	-	-	0.31	-0.38	-	-	0.54

Extraction method: Principal component analysis, Rotation method: Varimax with Kaiser normalization, rotation converged in 8 iterations, -: Cell has no value

The use of PCA in the present study was advantageous because it reduced dimensionality by transforming numerous individual questions into broader, uncorrelated components. PCA also helped validate constructs by assessing whether the domains (grouped questions) accurately measured their intended constructs, and identify primary drivers by determining which variables exerted the greatest influence. These advantages and steps align with previously published studies that have fully covered the method and its benefits[37,38]. Similar studies have reported the application of PCA in Africa[22,23]. Turkson et al.[23] utilized PCA in Accra, Ghana, to reduce 17 indicators measuring overall client satisfaction with veterinary services into a few key factors. Principal component analysis was employed to analyze the linear relationship of KAPP by assessing data variability in pesticide use in Eastern Uganda across three orthogonal components[22]. However, unlike the previous studies[22,23], the present study identified the critical indicators associated with each KAPP domain.

3.1. Binary logistic regression

The Cox and Snell square test scores were 0.71 for knowledge, 0.74 for attitudes and practices, and 0.75 for perceptions. These scores indicated the proportion of variance in the dependent variable that the developed model could predict. Additionally, the Nagelkerke R-squared value estimated how well the model explained variation in the outcome. The Nagelkerke R-squared values in the present study, including 0.96 for knowledge and 1.00 for attitudes, practices, and perceptions, indicated high explanatory power. Since the Nagelkerke value was close to 1, the model explained a significant portion of the variability in the outcome[29]. For attitudes, practices, and perceptions scores, no predictive models were generated from the different independent variables used. However, for the knowledge score, a prediction model was developed using the indicated independent variables (Table 11). The knowledge score was predicted as −36.5, plus 7.2 for knowing rabies is notifiable, 6.8 for knowing rabies can be transmitted by other animals, 6.6 for knowing dog bite is not the only route, 6.8 for knowing broken-skin contact with saliva can transmit rabies, 6.5 for knowing rabies is fatal, 6.3 for having seen a suspected case, 6.7 for knowing rabies cannot be treated after clinical signs appear, 7.7 for having heard of World Rabies Day, 5.6 for knowing of community vaccination campaigns, and 7.1 for having been bitten by an animal before. The predictive model identified independent variables, as shown in the Knowledge score model, that could be used to enhance understanding and actions related to rabies prevention and control.

The present study was limited exclusively to pet owners and therefore constituted a selective sample that did not represent the entire population of pet owners in Accra or Ghana as a whole. Because perceptions were subjective, this raised a reliability concern, as reported elsewhere[14]. Some questionnaire items were suspected to be multidimensional and heterogeneous. Removing some questions could have improved reliability, but in the present study, all questions were kept, consistent with the questionnaire developed by Turkson and Wi-Afedzi[17], in Sekondi-Takoradi cities in the Western Region of Ghana.

Table 11. Binary logistic regression values of respondents' knowledge scores about rabies in Accra, Ghana, from August 2024 to August 2025

Variables in the equation						
Questions/category	**B**	**SE**	**Wald**	**df**	**Sig**	**Exp(B)**
Gender category	-0.44	1.05	0.18	1	0.674	0.64
Age category	0.54	1.08	0.25	1	0.615	1.72
Years pet kept category	-0.82	1.11	0.55	1	0.458	0.44
Have heard of rabies category	-0.72	1.92	0.14	1	0.709	0.49
Is rabies a notifiable disease	7.16	1.74	16.95	1	0.000	1288.04
Can vaccinating dogs prevent rabies?	6.71	3.57	3.53	1	0.060	821.04
Can rabies be transmitted by other animals?	6.79	1.47	21.45	1	0.000	890.31
Is a dog bite the only way to get rabies?	6.65	1.81	13.42	1	0.000	768.69
Can one get rabies through contact (broken skin) with the saliva of a rabid dog?	6.81	1.61	17.82	1	0.000	904.91
Is rabies fatal?	6.54	1.75	13.99	1	0.000	690.08
Have you ever seen a suspected case of rabies in a dog or any animal?	6.30	1.37	21.2	1	0.000	542.22
Can rabies be treated after onset of clinical signs in a human victim?	6.71	1.53	19.16	1	0.000	821.23
Have you ever heard of World Rabies Day?	7.74	1.72	20.17	1	0.000	2293.63
Has your community ever organized dog vaccination against rabies?	5.62	1.33	17.98	1	0.000	275.25
Have you ever been bitten by an animal?	7.15	1.86	14.75	1	0.000	1272.46
Constant	-36.53	7.74	22.26	1	0.000	.000

SE: Standard error, Wald: Wald Test Statistic, df : Degrees of freedom, Sig: Significance logistic equations, Exp: Exponential logistic equations. B: Beta

4. Conclusion

The present study demonstrated that PCA is an effective approach for reducing the extensive rabies dataset to fewer components, simplifying interpretation of pet keepers' KAPP about rabies in Accra, Ghana. The current findings can help enhance clients' understanding and actions regarding rabies prevention and control. The present study revealed key KAPP attributes of pet owners relating to rabies in humans and animals in Accra, Ghana. The PCA extracted six knowledge components, four attitude components, four practice components, and seven perception components, collectively explaining 54%, 63%, 60%, and 60% of the variance in each domain, respectively. The current findings could assist in creating educational materials to raise public awareness about rabies prevention and control. Future research should refine the questionnaire items and expand sampling to community-based pet-owner populations to improve reliability and representativeness.

Declarations

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Authors' contributions

Paa Kobina Turkson was involved in conceptualization, data collection, collation and curation, formal analysis, supervision, writing the original draft, and review, editing, and approval of the paper. David Gyau Sarpong was involved in data collection and collation, and in reviewing, editing, and approving the manuscript. All authors read and approved the final edition of the manuscript.

Availability of data and materials

The data generated and analyzed in the current study are available from the corresponding authors upon reasonable request.

Competing interests

The authors declared no competing interests.

Ethical considerations

All procedures followed ethical principles, and the authors confirmed that they followed the journal's guidelines for ethical publication. The authors stated that this article is original and has not been submitted elsewhere. The authors confirmed that the present manuscript has been checked for plagiarism, misconduct, and fabrication. The authors declared that no AI tools or applications were used in conducting and writing or preparing any part of the study. The authors declare and accept full responsibility for the originality of this study before submission and after acceptance.

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Appendix 1. Communalities of respondents' knowledge scores in Accra, Ghana, from August 2024 to August 2025

Questions/category	Initial	Extraction
Gender category	1.00	0.66
Age category	1.00	0.63
Years pet kept category	1.00	0.44
Have heard of rabies category	1.00	0.38
Is rabies a notifiable disease?	1.00	0.56
Can dog vaccination prevent rabies?	1.00	0.44
Can rabies be transmitted by other animals?	1.00	0.61
Is a dog bite the only way to get rabies?	1.00	0.58
Can one get rabies through contact (broken skin) with the saliva of a rabid dog?	1.00	0.41
Is rabies fatal?	1.00	0.44
Have you ever seen a suspected case of rabies in a dog or any animal?	1.00	0.43
Can rabies be treated after onset of clinical signs in a human victim?	1.00	0.63
Have you ever heard of the World Rabies Day?	1.00	0.48
Has your community ever organized dog vaccination against rabies?	1.00	0.62
Have you ever been bitten by an animal?	1.00	0.72

Extraction method: Principal component analysis

Appendix 2. Communalities of respondents' attitude scores in Accra in a study from August 2024 to August 2025

Questions/category	Initial	Extraction
Gender category	1.00	0.40
Age category	1.00	0.60
Years pet kept category	1.00	0.59
Have heard of rabies category	1.00	0.68
Should stray dogs and cats be put to death?	1.00	0.66
Would you report a suspected case of rabies in your community?	1.00	0.73
Would you allow your dog to be put to death if suspected of having rabies?	1.00	0.68
Are you willing to support rabies control by volunteering to vaccinate your animals?	1.00	0.70

Extraction method: Principal component analysis

Appendix 3. Communalities of respondents' practice scores in Accra, Ghana, from August 2024 to August 2025

Questions/category	Initial	Extraction
Gender category	1.000	0.37
Age category	1.00	0.64
Years pet kept category	1.00	0.51
Have heard of rabies category	1.00	0.66
Should bite wounds be washed with soap and water?	1.00	0.59
Would you go to the hospital for treatment if a stray dog bit you?	1.00	0.60
Would you go to the hospital for treatment if your own dog bit you?	1.00	0.68
Would you go to the hospital for treatment if a vaccinated dog bit you?	1.00	0.65
Would you go to the hospital for treatment if bitten by a wild animal?	1.00	0.71

Extraction method: Principal component analysis

Appendix 4. Communalities of respondents' perceptions score in Accra, Ghana, from August 2024 to August 2025

Questions/category	Initial	Extraction
Gender category	1.00	0.68
Age category	1.00	0.48
Years pet kept category	1.00	0.65
Have heard of rabies category	1.00	0.45
Do you believe that rabies can be treated by traditional healing?	1.00	0.62
Are there any locally available treatments for dog bites and rabies?	1.00	0.73
Do you believe it is good to vaccinate dogs against rabies?	1.00	0.49
Is the cost of vaccinating a dog against rabies affordable?	1.00	0.69
Is the cost of vaccinating a dog against rabies reasonable?	1.00	0.72
Do you think pet owners are willing to pay a reasonable fee for rabies vaccination?	1.00	0.39
Should rabies vaccination for dogs and cats be free, with the government covering the cost?	1.00	0.76
Should dogs be allowed to roam freely around in the community?	1.00	0.63
Is it important to control the dog population in an area?	1.00	0.55
Do you think authorities in your area are doing a good job in controlling rabies in dogs?	1.00	0.53
Is information/education on rabies in Ghana adequate?	1.00	0.61
Do you think rabies in dogs is a problem in your community?	1.00	0.54
Do you believe it is good to vaccinate dogs against rabies?	1.00	0.62

Extraction method: Principal component analysis