

Knowledge, Attitude and Practices of Livestock (KAP) Farmers Regarding Zoonotic Diseases in Muridke, District Sheikhupura, Punjab, Pakistan: A Cross-Sectional KAP Study

Maham Muneer

mahammuneer940@gmail.com

DVM Student, Mirpur University of Science and Technology Azad & Jammu Kashmir

Muhammad Ijaz

ijaz@ajkuob.edu.pk

Lecturer, Department of Veterinary Sciences, Faculty of Veterinary and Animal Sciences, AJ&K University of Bhimber

Khizra Qaiser

khizraqaiser06@gmail.com

DVM Student, Mirpur University of Science and Technology Azad & Jammu Kashmir

Hadia Khalid

khalidhadia10@gmail.com

DVM Student, Mirpur University of Science and Technology Azad & Jammu Kashmir

Corresponding Author: Maham Muneer mahammuneer940@gmail.com

Received: 16-02-2026

Revised: 28-02-2026

Accepted: 20-03-2026

Published: 30-03-2026

ABSTRACT

In Pakistan, zoonotic diseases are a pressing public health and livestock economy problem, as there is constant, close interaction between humans and animals by smallholder farmers, providing a continuous transmission interface. No KAP (Knowledge, Attitude and Practices) study has ever been conducted with the livestock farmers of Muridke Tehsil, District Sheikhupura, Punjab, Pakistan.

Objective: *To evaluate the knowledge, attitude, and practices of livestock farmers of Muridke Tehsil and to determine the socio-demographic farm variables associated with positive attitude.*

Methods: *34 farmers were selected randomly from 10 villages of Muridke tehsil, and a cross-sectional survey was conducted. The socio-demographic profile was included along with 20 knowledge, 10 attitude, and 13 practice items in a structured, pretested, interviewer-administered questionnaire. All farmers (n = 340) were approached, and complete data were obtained from 270 (79.4% response rate). Each Knowledge, Attitude, and Practice score was converted into a percentage of the highest possible score and was divided into Good (80–<89%), Moderate (60–79%), and Poor (<60%). Chi-square, t-tests/ANOVA, Pearson correlation, and multivariable logistic regression were used to calculate the associations.*

Results: *Mean (Maximum) Knowledge, Attitude, and Practice scores were 74.9%, 75.6%, and 67.2%, respectively. The practice was found to be poor, with only 12.2% of the farmers, while the attitude and knowledge were satisfactory with 48.9% and 48.1%, respectively. There was a moderate correlation between knowledge and attitude ($r = 0.562$, $p < 0.001$), but weak correlations between both of these and practice ($r = 0.164$ and $r = 0.212$, respectively). Only 77.0% of the farmers could correctly identify raw milk as a path of transmission for brucellosis, but 94.1% believed that consuming raw milk was safe. Education independently predicted excellent knowledge (adjusted odds ratio [AOR] = 1.45, 95% CI 1.20–1.75) and positive attitude (AOR = 1.31, 95% CI 1.09–1.57); landlessness was independently associated with poorer knowledge (AOR = 0.33, 95% CI 0.13–0.83). None of the factors were found to significantly predict satisfactory practice.*

Conclusion: *Farmers in Muridke tehsil have moderate knowledge and generally positive attitudes towards zoonosis prevention, but they do not consistently engage in protective practices, particularly regarding raw milk consumption, the use of protective materials, and the testing and reporting of animal diseases. Enhanced access to the veterinary testing and reporting system and targeted One Health education (with less emphasis placed on better-educated people and land holdings) are recommended.*

Keywords: Zoonotic diseases, knowledge, attitude and practice, livestock farmers, one health, brucellosis, muridke, Pakistan.

INTRODUCTION

Zoonotic diseases (zoonoses) are infections or diseases that can be transmitted naturally from vertebrate animals to humans and were formally adopted by the World Health Organization and reaffirmed by the World Organisation for Animal Health and the Food and Agriculture Organization of the United Nations (FAO, WOA) [1, 2]. Zoonoses can be bacterial, viral, parasitic, or fungal and can be transmitted directly from animals, by eating contaminated animal products (unpasteurized milk or undercooked meat), or indirectly, via the environment or vectors [1]. The importance of zoonoses as public-health threats is large, with more than 60% of known human infectious diseases being of animal origin and about 75% of newly emerging infectious diseases originating in animal populations worldwide [2, 3].

Pakistan is an agricultural nation, and animal husbandry is an integral part of farming practices in the rural areas. For this district, in particular, livestock breeding has always been a significant economic activity, and the latest published district-level data are approximately 210,000 cattle, 297,000 buffaloes, 248,000 sheep, and 82,000 goats [4] as economic units in the district. Despite the rapid growth in the peri-urban population of Muridke, which has a census population of more than 250,000 at the time of writing in 2023 [5], this tehsil in Sheikhpura District, on the Lahore–Sheikhpura route, remains largely agricultural, with dairy and small ruminant husbandry carried out widely at the household level. This constant human–animal–environment interface facilitates the transmission of zoonotic pathogens, especially when farmers are unaware of transmission methods or do not implement protective measures.

The Knowledge, Attitude, and Practice (KAP) survey model is a commonly used approach to characterizing this risk, with the assumption that individual knowledge of a disease determines their attitude towards the risk and severity of the disease and thus their practices for preventing it. Formally, Pakistan has recognized the importance of a One Health approach by establishing a One Health Hub at the National Institute of Health, Islamabad, where coordination of the prevention, detection, and response for zoonotic diseases of national concern occurs [6].

A growing body of literature on KAP has published the knowledge and practice gaps among livestock-owning communities in other parts of Pakistan. A study of the awareness of brucellosis among smallholder dairy farmers in five districts of Punjab and two districts of Sindh showed that almost all farmers (97%) had no idea how brucellosis was spread, and the majority of all farmers reported drinking raw milk and sharing housing with livestock [7]; a later survey of 600 livestock owners in Punjab also noted that there was a lack of knowledge about brucellosis [8]. Similar knowledge has been reported for rabies in rural Lahore [9], in a broader multi-site study in Punjab and Khyber Pakhtunkhwa [10], and for a milk-borne zoonosis in Azad Jammu and Kashmir [11]. To complement the aforementioned KAP survey, another survey, with a similar design, of farmers and veterinary practitioners on foot-and-mouth disease in the border area between Pakistan and Afghanistan was conducted in 2025 and readily demonstrates that this type of surveying is an active line of inquiry in Pakistani livestock research [12]. The same trends of moderate to poor knowledge, along with more positive attitudes and relatively low levels of preventive practice, have been observed in nearby India [13] and Bangladesh [14].

However, a literature search of the published KAP studies could not identify any specific study conducted with livestock farmers of Muridke Tehsil or District Sheikhupura. Therefore, the aim of this study was to evaluate the knowledge, attitude, and practices of livestock farmers in Muridke Tehsil related to zoonotic diseases and their socio-demographic and farm-level factors linked to positive KAP, which could be used to design locally specific evidence for targeted One Health education efforts.

MATERIALS AND METHODS

Study Design, Area, and Duration

This was a descriptive and cross-sectional study carried out in Muridke Tehsil, Sheikhupura District, in Punjab, Pakistan, with the help of descriptive questionnaires. Muridke Tehsil is a transition zone of an emerging urban hub and significant land masses of farming in its rural union councils, which include rearing dairy and small ruminants as household-based activities. Data collection was done in 10 villages in the tehsil.

Study Population and Eligibility

The study population included adult livestock farmers (household heads/key decision makers) who owned and managed cattle, buffalo, goats, and sheep. Respondents eligible for the study were ≥ 18 years of age with ownership or management of at least one head of qualifying livestock and a residence in the village designated for selection for ≥ 1 year and who gave informed consent. Occupational-knowledge bias motivated the exclusion of qualified veterinarians and livestock-extension staff, as well as farmers who did not keep any livestock other than chickens or fish.

Sample Size and Sampling Technique

This study employed a random sampling technique. The minimum sample size was determined by the formula for prevalence-type cross-sectional studies [15, 16] as $n = Z^2p(1-p)/d^2$. The minimum sample size using a 95% confidence level ($Z = 1.96$), assumed proportion of $p = 0.5$ (the maximum possible variation in the case that no local KAP estimate was available for this population group), and precision of $d = 0.05$ was 385, but accounting for the non-response anticipated, the sample size was set at 425. A multi-stage random sampling technique was employed, and 10 villages in Muridke Tehsil were selected, from which 34 farming households were selected randomly, with systematic random sampling, utilizing the available farmers' lists, and one eligible respondent was interviewed from each household (340 farming households). The response rate was 79.4%, with 270 farmers (27/34 farmers per village) returning complete and valid responses. This lower than pre-specified sample is still sufficient for the descriptive and comparative analyses presented here (approximate margin of error is $\pm 5.7\%$ around the 50% proportion at the 95% confidence level) and is analyzed in its entirety below.

Data Collection Instrument

A structured, pre-tested interviewer-administered questionnaire, translated into Urdu/Punjabi for field administration, was used for data collection, based on validated questionnaires used in similar published KAP studies of livestock farmers of Pakistan and the region [7, 8, 9, 10, 13]. The instrument included four sections: (A) socio-demographic and farm profile (14 items); (B) knowledge of zoonotic diseases (20 items, one of which was a deliberate non-zoonotic item used to assess acquiescence bias); (C) attitude towards zoonotic disease risk, severity, and prevention (10 five-point Likert-scale items, with a reverse-scored item included); and (D) current husbandry, hygiene, and food-safety practices (13 scored items, plus a screening item on animal-bite exposure). A pilot test of the instrument was conducted before collecting data for full scale to test the face and content validity as well as clarity.

Scoring and Categorization

A total score for Knowledge (max of 20), Attitude (max of 50), and Practice (max of 13) was determined using 0 for each incorrect or undesirable response, or for “don't know,” and 1 for each correct or desirable response (one of the attitude items was reverse-scored and recoded before summing). In the Practice domain (items D1-D10), items D12 and D13 were scored separately, and items D11/D11a (family member ever bitten and, if bitten, if the person got treatment) were scored together, giving full marks if a person never had any contact with a tick or, if they did, if they got treatment. The domain scores were calculated as a percentage of the maximum possible score and categorized as Good (at least 80), Moderate (60–79), or Poor (<60), which were set based on similar published KAP literature.

Statistical Analysis

Data was analyzed using Python (pandas, SciPy, and statsmodels). The data of continuous variables are presented as mean $\pm$ SD, and those of categorical variables as n. Categorical sociodemographic variables and ‘Good’ KAP were compared using the chi-square test of independence, while analysis of means was performed with independent-samples t-tests (for two groups) or 1-way ANOVA (for three or more groups). The relationship between knowledge, attitude, and practice scores was quantified using the Pearson correlation coefficient. Each domain was stratified by multivariable logistic regression for independent predictors of ‘Good’ status, excluding livestock-farming experience because of very high collinearity with age ($r = 0.90$; variance inflation factor > 5 when both were included in the model), and all the other predictors had variance inflation factors < 1.2 . The results are presented as adjusted odds ratios (AOR) with 95% confidence intervals. Two-tailed $P < 0.05$ was taken as the level of significance throughout.

Ethical Considerations

This study protocol passed through the ethical review committee of Department of DVM of Azad Jammu and Kashmir University of Bhimber prior to data collection. No animals were sampled, and no invasive sampling of humans was involved aside from the voluntary interview, which was based on a questionnaire. Each participant provided verbal informed consent for the study after explaining the purpose and voluntary nature of the study and the assurance of confidentiality, and participants were allowed to withdraw at any point without any consequences. Before analysis, all data were anonymized.

RESULTS

Response Rate and Socio-Demographic Profile

Of the 340 farmers approached in 10 villages of Muridke Tehsil, 270 gave full details (79.4%) and were equally distributed across all villages (27 each). The study population was largely male (90.4%) and married (89.3%) with a mean age of 42.8 ± 10.7 years and 23.3 ± 11.3 years of livestock-farming experience. The majority were backyard/smallholder system (70.7%) producers, 31.9% were illiterate, and only 30.4% had ever taken part in any type of zoonoses-related training (Table 1).

Table 1. Socio-demographic and farm characteristics of respondents (n = 270).

Characteristic	n / Mean $\pm$ SD	%
Age (years), mean $\pm$ SD	42.8 $\pm$ 10.7	
Family size, mean $\pm$ SD	7.1 $\pm$ 2.5	
Livestock farming experience (years), mean $\pm$ SD	23.3 $\pm$ 11.3	
Gender		

Male	244	90.4%
Female	26	9.6%
Marital status		
Single	19	7.0%
Married	241	89.3%
Widowed/Other	10	3.7%
Education		
Illiterate	86	31.9%
Primary	51	18.9%
Middle	49	18.1%
Matric	58	21.5%
Intermediate	19	7.0%
Graduate+	7	2.6%
Herd size		
1–5	81	30.0%
6–10	87	32.2%
11–20	80	29.6%
>20	22	8.1%
Farming system		
Backyard/smallholder	191	70.7%
Semi-intensive	65	24.1%
Intensive/commercial	14	5.2%
Shelter distance from house		
Attached/within house	37	13.7%
<10 m	75	27.8%
10–50 m	109	40.4%
>50 m	49	18.1%
Primary occupation		
Livestock farming only	124	45.9%
Farming + other occupation	146	54.1%
Land ownership		
Owner	153	56.7%
Tenant/rented	87	32.2%
Landless	30	11.1%
Monthly household income (PKR)		
<30,000	75	27.8%
30,000–60,000	92	34.1%
60,001–100,000	78	28.9%
>100,000	25	9.3%
Prior zoonoses-related training		
Yes	82	30.4%
No	188	69.6%

Knowledge of Zoonotic Diseases

Specific knowledge on zoonoses was generally of a moderate to satisfactory level; 82.2% of the farmers correctly identified that rabies may be acquired from a dog/cat bite, while more than three-quarters correctly identified brucellosis, TB, and anthrax as zoonotic. However, 79.3% of respondents answered “yes” to the economically important but not significantly zoonotic foot-and-mouth disease (FMD), and 68.9% had heard the term “zoonotic disease”; more respondents (82.9%) had heard the specific term “FMD” (Table 2).

Table 2. Item-wise knowledge responses (n = 270). Item B3f is a distractor (Foot-and-Mouth Disease is not significantly zoonotic); a “Yes” response was scored as incorrect.

Statement	% Yes	% No	% Don't know	% Correct
Heard the term "zoonotic disease"	68.9%	21.1%	10%	68.9%
Believes disease can spread animal->human	74.1%	18.9%	7%	74.1%
Identifies Brucellosis as zoonotic	73.3%	20%	6.7%	73.3%
Identifies TB as zoonotic	76.7%	18.9%	4.4%	76.7%
Identifies Rabies as zoonotic	78.5%	15.6%	5.9%	78.5%
Identifies Anthrax as zoonotic	78.5%	16.3%	5.2%	78.5%
Identifies Ringworm as zoonotic	81.1%	12.6%	6.3%	81.1%
Incorrectly identifies FMD as zoonotic (distractor)	79.3%	14.4%	6.3%	14.4%
Brucellosis causes abortion in animals	78.5%	15.9%	5.6%	78.5%
Raw milk can transmit brucellosis	77%	16.3%	6.7%	77%
Raw milk/contact can transmit bovine TB	76.7%	15.2%	8.1%	76.7%
Dog/cat bite can transmit rabies	82.2%	11.9%	5.9%	82.2%
Rabies is fatal if untreated	78.1%	14.8%	7%	78.1%
Immediate treatment needed after animal bite	82.6%	11.9%	5.6%	82.6%
Anthrax transmissible via sick/dead animal contact	79.6%	15.2%	5.2%	79.6%
Handling aborted material without gloves is risky	78.1%	15.6%	6.3%	78.1%
Boiling/pasteurising milk reduces risk	78.9%	14.4%	6.7%	78.9%
Undercooked/raw meat can transmit disease	80.4%	13%	6.7%	80.4%
Vaccination of animals helps prevent zoonoses	80.7%	11.9%	7.4%	80.7%
Knows where to seek help for suspected zoonosis	79.3%	12.2%	8.5%	79.3%

Attitude towards Zoonotic Disease Risk and Prevention

Attitudes were generally good: the majority of farmers (73.3%) agreed that zoonoses represent a serious threat to their family, and 74.1% would contact the livestock department or a veterinarian if they had a sick or dead animal. There was only one exception: despite favorable attitudes on items C1–C6, a majority of farmers (94.1%) disagreed with item C7, which was, "Does the farmer think it is safe to drink raw milk?" (Table 3).

Table 3. Item-wise attitude responses (n = 270). For C7 (reverse-scored), % Favourable reflects disagreement with the statement that raw milk is safe.

Statement	Mean (1–5)	% Favourable
Zoonotic diseases are a serious risk to my family	4.05	73.3%
My occupation puts me at risk	4	71.5%
Necessary to get animals tested/vaccinated	3.96	69.3%
Veterinary services are important	3.93	70.7%
Would report sick/dead animal to vet/livestock dept.	4.04	74.1%
Willing to use PPE when handling sick animals/births	4	70%

Drinking raw milk is safe (reverse-scored)	4.04	5.9%
Trusts govt/veterinary health services	3.97	69.3%
Willing to attend awareness/training session	3.96	69.6%
Good hygiene around animals prevents disease	3.93	70.4%

Husbandry, Hygiene, and Food-Safety Practices

Practices were significantly lower than knowledge and attitude. While most farmers reported not eating undercooked meat (91.9%) and disposing of aborted material by burying or burning it (73.0%), only 41.9% used gloves or protective clothing when assisting births or handling aborted material, only 33.7% had ever had their animals tested for brucellosis or tuberculosis, and fewer than half (48.1%) reported sick or dead animals to a veterinarian or the livestock department. More than a fourth (27.9%) of the 43 respondents whose family members had been bitten or scratched by an animal sought no medical treatment or anti-rabies vaccination (15.9%) (Table 4).

Table 4. Item-wise practice responses (n = 270).

Desirable practice	% Practising / Reporting
Does NOT drink raw/unboiled milk	78.5%
Does NOT consume undercooked/raw meat	91.9%
Washes hands with soap after animal contact	63.7%
Uses gloves/PPE for births/aborted material	41.9%
Buries or burns aborted material/waste (vs. open dumping)	73%
Vaccinates animals on a regular schedule	61.9%
Has animals tested for brucellosis/TB	33.7%
Isolates sick animals from the herd	63.3%
Shelter NOT attached/very close to house	75.9%
Reports sick/dead animals to vet/livestock dept.	48.1%
Regularly cleans the animal shed	73.3%
Does NOT allow children near the shelter	72.6%
Family member ever bitten/scratched by an animal (n=43)	15.9%
Of those exposed, sought medical treatment/ARV	72.1%

Overall KAP scores and categorization

The percentages of the maximum possible scores for mean knowledge, attitude, and practice were 74.9%, 75.6%, and 67.2%, respectively. Knowledge and attitude had similar moderately favorable distributions (48.1% 'Satisfactory' and 48.9% 'Good,' respectively), while practices lagged far behind, with two-thirds (67.0%) classified as 'Moderate' and a further 20.7% 'Poor' (Table 5, Figure 1).

Table 5. Summary of Knowledge, Attitude and Practice scores and categorisation (n = 270).

Domain	Max score	Mean $\pm$ SD	Mean %	Median	Range	Good ($\geq 80\%$)	Moderate (60–79%)	Poor ($<60\%$)
Knowledge	20	14.98 $\pm$ 3.24	74.9%	15	3–20	130 (48.1%)	97 (35.9%)	43 (15.9%)
Attitude	50	37.80 $\pm$ 6.02	75.6%	39	22–48	132 (48.9%)	104 (38.5%)	34 (12.6%)
Practice	13	8.73 $\pm$ 1.50	67.2%	9	5–13	33 (12.2%)	181 (67.0%)	56 (20.7%)

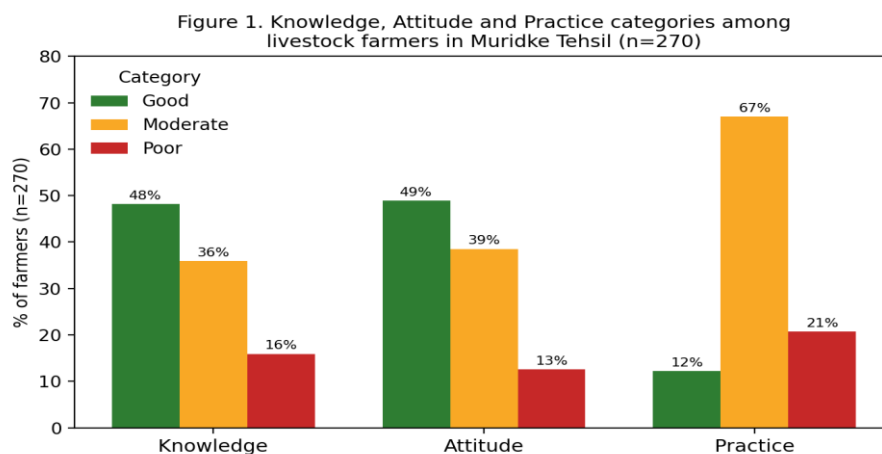


Figure 1. Distribution of Knowledge, Attitude and Practice categories among respondents (n = 270).

Relationship Between Knowledge, Attitude and Practice

The level of knowledge did not correlate well with the practice score ($r = 0.164$, $p = 0.007$), and the attitude score was also weakly correlated with the practice score ($r = 0.212$, $p < 0.001$), suggesting that knowledge and attitude alone were not enough to stimulate protective practice among this population (Table 6, Figure 2).

Table 6. Pearson correlation coefficients between Knowledge, Attitude and Practice scores (n = 270).

Score pair	Pearson r	p-value
Knowledge – Attitude	0.562	<0.001
Knowledge – Practice	0.164	0.007
Attitude – Practice	0.212	<0.001

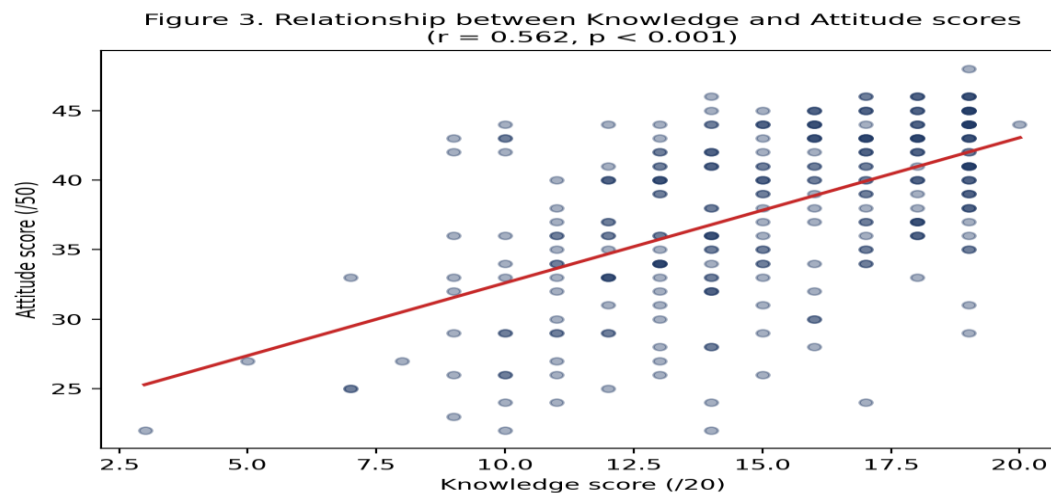


Figure 2. Scatter plot of Knowledge versus Attitude scores with fitted linear trend ($r = 0.562$, $p < 0.001$).

FACTORS ASSOCIATED WITH KNOWLEDGE, ATTITUDE AND PRACTICE

In bivariate analysis, the level of education and previous zoonoses training were significant factors associated with 'excellent knowledge and attitude' (both $p < 0.01$) in opposite directions to those expected (Table 7). Education gradient mean score comparisons showed a significant increase in mean scores from 13.9/20 for illiterate to 16.1/20 for graduates in the case of the knowledge component (Table 8, Figure 3). None of the socio-demographic factors tested were significantly associated with practice scores or with 'Good' practice status.

Table 7. Chi-square test p-values for association between socio-demographic factors and 'Good' KAP category (vs. Moderate/Poor combined). $p < 0.05$.

Factor	Knowledge (p)	Attitude (p)	Practice (p)
Gender	0.994	1.000	0.669
Education level	0.007*	0.006*	0.310
Herd size category	0.352	0.660	0.348
Farming system	0.387	0.630	0.778
Shelter distance from house	0.707	0.967	0.370
Primary occupation	0.846	0.030*	0.898
Land ownership	0.108	0.688	0.586
Monthly income category	0.072	0.411	0.434
Prior zoonoses training	0.008*	0.045*	0.317

Table 8. t-test/ANOVA p-values for mean Knowledge, Attitude and Practice score comparisons across socio-demographic groups. * $p < 0.05$.

Factor	Knowledge score (p)	Attitude score (p)	Practice score (p)
Gender (M vs F)	0.597	0.664	0.419
Prior training (Yes vs No)	0.021*	0.003*	0.552
Occupation (Livestock-only vs +other)	0.578	0.018*	0.681
Education level	<0.001*	0.001*	0.470

Herd size category	0.476	0.795	0.589
Farming system	0.515	0.798	0.996
Land ownership	0.094	0.795	0.727
Monthly income category	0.378	0.018*	0.181
Shelter distance	0.603	0.875	0.567

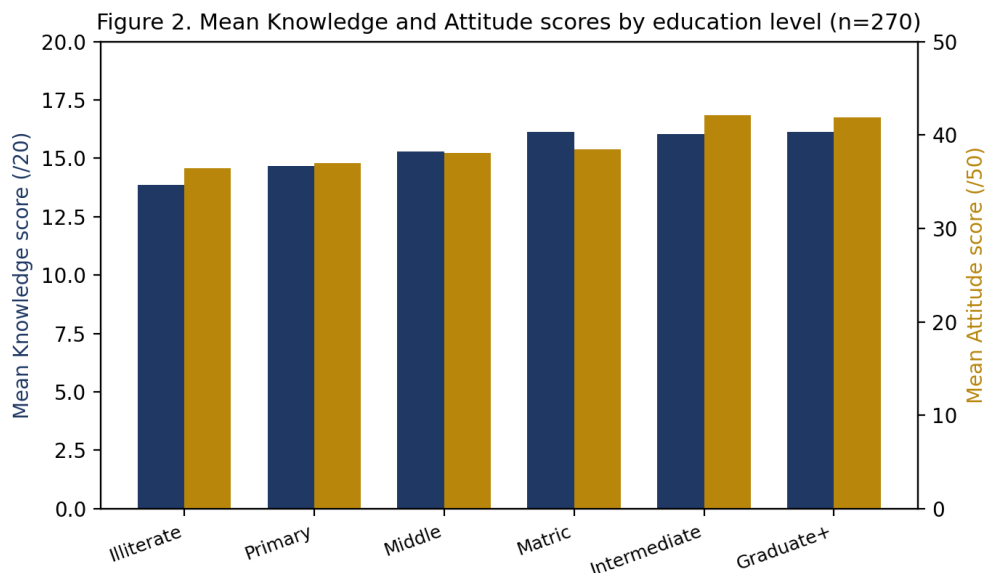


Figure 3. Mean Knowledge and Attitude scores by education level (n = 270).

Multivariable Predictors of Good Knowledge, Attitude, and Practice

Three multivariable logistic regression models were built to determine independent factors associated with ‘Good’ status in each domain while adjusting for farming system, land ownership, age, education, family size, herd size, and monthly income in addition to farm training and farm occupation type (Table 9). Education remained an independent predictor of satisfactory knowledge (AOR = 1.45, 95% CI 1.20–1.75, $p < 0.001$) and positive attitude (AOR = 1.31, 95% CI 1.09–1.57, $p = 0.003$). Landless farmers were less likely to have good knowledge compared to land-owning farmers (AOR = 0.33, 95% CI 0.13–0.83, $p = 0.018$), and farmers who were only engaged in livestock farming were more likely to have a positive attitude than those who worked on farming other than livestock farming (AOR = 1.78, 95% CI 1.07–2.96, $p = 0.027$). Notably, individuals who had previously received zoonoses-related training were not only not more likely to have good knowledge (AOR = 0.47, 95% CI 0.26–0.82, $p = 0.009$) but they were also not more likely to have a good attitude (AOR = 0.55, 95% CI 0.32–0.96, $p = 0.034$) after adjustment. None of the individual predictors were statistically significant, and the practice model did not reach overall statistical significance (likelihood-ratio $p = 0.785$; pseudo- $R^2 = 0.036$).

Table 9. Multivariable logistic regression: predictors of ‘Good’ Knowledge, Attitude and Practice (n = 270 in each model). AOR = adjusted odds ratio. * $p < 0.05$.

Predictor	Knowledge AOR (95% CI), p	Attitude AOR (95% CI), p	Practice AOR (95% CI), p
Farming system: Semi-intensive (vs. Backyard)	1.52 (0.82–2.82) 0.184	1.18 (0.65–2.15) 0.587	1.31 (0.55–3.12) 0.538
Farming system:	1.08 (0.34–3.50)	1.45 (0.45–4.63)	0.53 (0.06–4.39)

Intensive/commercial (vs. Backyard)	0.894	0.533	0.557
Land ownership: Tenant/rented (vs. Owner)	0.94 (0.53–1.66) 0.827	0.81 (0.46–1.43) 0.475	0.94 (0.42–2.10) 0.875
Land ownership: Landless (vs. Owner)	0.33 (0.13–0.83) 0.018*	0.59 (0.25–1.38) 0.224	0.42 (0.09–1.98) 0.273
Age (years)	1.01 (0.99–1.04) 0.405	0.99 (0.97–1.01) 0.431	1.01 (0.98–1.05) 0.466
Education (ordinal, 0=Illiterate–5=Graduate+)	1.45 (1.20–1.75) <0.001*	1.31 (1.09–1.57) 0.003*	1.19 (0.92–1.54) 0.179
Family size	1.04 (0.94–1.16) 0.437	0.97 (0.87–1.07) 0.508	0.99 (0.85–1.15) 0.880
Herd size category (ordinal)	0.83 (0.63–1.10) 0.189	0.87 (0.66–1.14) 0.311	0.96 (0.64–1.44) 0.852
Monthly income category (ordinal)	1.10 (0.83–1.45) 0.500	0.96 (0.73–1.25) 0.750	1.26 (0.85–1.87) 0.244
Received prior zoonoses training (vs. none)	0.47 (0.26–0.82) 0.009*	0.55 (0.32–0.96) 0.034*	1.67 (0.77–3.64) 0.194
Livestock farming as sole occupation (vs. + other)	1.00 (0.60–1.69) 0.994	1.78 (1.07–2.96) 0.027*	1.02 (0.48–2.16) 0.959

DISCUSSION

This study presents the first local-specific KAP evidence for livestock farmers in Muridke Tehsil, District Sheikhupura, and the key findings of this study are that there is a clear disconnect between farmers' knowledge and beliefs and what they do. Knowledge and attitude scores were moderate to satisfactory at 74.9% and 75.6% of the maximum, respectively; approximately half of the respondents fell into the 'Excellent' category for both knowledge and attitude, but only 12.2% were classified as 'Satisfactory' for practice. Additionally, the correlation between knowledge and attitude scores and practice scores was weak, with values of $r = 0.164$ and 0.212 , respectively. This knowledge/attitude-practice gap is similar to that reported in the comparable literature from Pakistan and the region; surveyed smallholder dairy farmers in Punjab and Sindh were virtually unanimously unaware of how bruises are spread but overall had high rates of risky practices like milking raw and living in shared housing with animals [7], and a subsequent survey across all of Punjab revealed inadequate knowledge of bruises despite reasonable overall awareness of bruises [8].

Similarly, reports indicate that a divergence exists among livestock farmers in Punjab, India, where 47.2% practice satisfactory husbandry while 55% maintain a positive attitude [13]. Additionally, a large-scale survey conducted in Bangladesh found that only 11.55% of livestock farmers had excellent knowledge of zoonoses, whereas 86.32% had a positive attitude towards them [14]. The pattern of this difference is consistent across a range of smallholder livestock systems in South Asia, suggesting that the disparity may be attributed to structural and economic limitations on protective behavior, rather than simply a lack of awareness, as demonstrated by the low knowledge results from this survey in Muridke Tehsil, which indicate that education may help overcome these issues.

The most important finding of this survey is the contradiction between the responses of farmers B5 and C7: 77.0% of farmers answered correctly on item B5, while 94.1% answered "safe" on item C7. Regarding 77.0% of farmers, they answered correctly on item B5, yet 94.1% answered "safe" on item C7 with regard to raw milk. This contradiction is not an opposition of two independent constructs; rather, it's a direct opposition in the same person's knowledge and attitude regarding the same specific behavior, and it is in line with the finding of Arif et al., who observed that, out of the surveyed dairy-farming households, 66% used to consume raw milk despite very limited knowledge about the transmission of brucellosis [7]. One possible suggestion is that raw milk is a familiar component of

rural Punjabi culture and that, despite knowing about the risk of a theoretical disease, this information is not enough to prevent this well-established custom from being followed. The findings suggest a need for health message content that directly and explicitly target raw milk consumption and not general zoonotic disease messages, which aim to shift the behavior of raw milk consumption.

The level of education was the strongest independent predictive factor of satisfactory knowledge (AOR = 1.45, $p < 0.001$) and positive attitude (AOR = 1.31, $p = 0.003$) after adjusting for other socio-demographic and farm-level variables, which is consistent with the negative relationship between low education and poor zoonoses knowledge found among livestock farmers in Punjab, India [13]. Landless farmers also had significantly reduced odds of possessing adequate knowledge (AOR = 0.33, $p = 0.018$) compared to land-owning farmers, which can be reasonably attributed to a pattern of socio-economic marginalization; specifically, many landless farmers were less literate, less likely to engage in extension services, and less likely to utilize knowledge compared to their land-owning counterparts. Farmers who were only engaged in livestock farming had a more favorable attitude than farmers who were engaged in both livestock farming and other occupations (AOR = 1.78, $p = 0.027$); this difference could be as a result of full-time farmers having a greater sense of risk and investment in farming.

Significant but counterintuitive results were also the independent association of prior zoonoses-related training with lower (not higher) knowledge and attitude scores (AOR = 0.47 and 0.55, respectively; both $p < 0.05$). Since the study is a cross-sectional survey, it cannot determine whether training or current KAP status came first. A cross-sectional survey cannot determine which came first training or current KAP status and at least three explanations are possible.

First, there is the possibility of reverse causality or targeting bias: extension workers and NGOs may choose to train farmers or villages that initially have less awareness, meaning that the farmers who were most likely trained were those who were weakest at the start. Second, self-selection, i.e., farmers who have less confidence in the knowledge they already have and possess might be more motivated to try to find or access training opportunities. Third, training quality or recency effects: the survey failed to provide information on the nature of the training or how long ago it took place; as such, a one-time, short training session or training that is outdated will not have lasting impact. This finding reflects that training per se is not a cause for concern, and more longitudinal or qualitative follow-ups that monitor farmers' KAP before and after a specified, standardized training experience should be conducted in this field for purposes of distinguishing these explanations.

The lack of any significant predictors in the adjusted model (likelihood-ratio $p = 0.785$) and the failure to see any significant difference in poor practice across all socio-demographic components measured are in themselves important negative findings. It proposes that the cost of diagnostic testing, the cost of personal protective equipment, accessibility and distance from veterinary services, and possibly a lack of awareness or trust in the livestock-department reporting chain are more likely structural barriers to protective behaviour than attitudinal ones; i.e., that these factors limit behaviour regardless of what a farmer knows or believes. This finding aligns with the call for a coordinated, cross-sectoral One Health approach to zoonotic disease control in Pakistan, as the country has very limited capacity for surveillance and veterinary services relative to the size of the livestock-based rural economy [6]. Enhanced accessibility and reduced cost for veterinary testing and improved reporting through farmer pathways may therefore be more effective at addressing practice gaps than education that is based on knowledge building alone.

The second, clinically important observation is that of those who had responded that a family member had been bitten or scratched by an animal (15.9%), over a quarter did not receive anti-rabies vaccination or seek medical attention. This gap is a real and ongoing threat to life in this population and corresponds to gaps in post-exposure treatment-seeking reported in rural Lahore [9] and the broader Punjab/Khyber Pakhtunkhwa canine rabies KAP survey [10], where a consistent

understanding of rabies as a concept (82.2% knew a dog bite could transmit rabies) did not translate into post-exposure action.

The totality of these findings points to several practical recommendations. First, education should be specifically directed towards less educated and landless farmers, as the survey from Muridke Tehsil demonstrated that low knowledge levels persist. The survey from Muridke Tehsil revealed low knowledge levels among participants regarding One Health education activities. Second, health officials need to deliver direct and specific messaging about the practices of consuming raw milk and general zoonosis awareness; however, such messaging is unlikely to change the deeply normalized behavior of raw milk consumption. Third, there is a gap between knowledge/attitude and practice, so interventions should focus on reducing the structural barriers to practicing protection (e.g., subsidized or mobile bruising/TB testing services, greater access to inexpensive protection equipment, and better, more credible ways to report sick or dead animals without displacing education messages). Fourth, post-exposure rabies care pathways should be specifically reinforced, as the treatment-seeking gap highlighted here is immediate in nature and presents life-saving implications.

STRENGTHS AND LIMITATIONS

This study is characterized by having a reasonably large sample size ($n = 270$) and uniform size across all 10 villages sampled; the data-collection instrument was adapted from the previously validated Pakistani and regional KAP tools; there was a fully transparent and independently verified scoring algorithm; and there were an explicit verification and resolution of collinearity between candidate predictors in the multivariable analysis. It is important, however, to note several caveats to the interpretation of these results. The study is a cross-sectional design and is therefore susceptible to association rather than causal and temporal relationships, which is directly germane to the above counterintuitive training finding. Data were all self-reported, which may have introduced recall and social desirability bias and, specifically for practice-related items (raw milk consumption and wearing protective equipment), may have identified a lower prevalence of risky practice than the true figure. The realized sample of 270 was less than the pre-specified target of 425 due to a low response rate from farmers (79.4%), which increased the margin of error around the estimated proportions from the originally targeted $\pm 5.0\%$ to approximately $\pm 5.7\%$. Although this discrepancy does not invalidate the reported associations, it deviates from the study's original protocol. Lastly, it should be stressed that the results obtained in Muridke Tehsil are confined to this particular tehsil and may not be applicable to other tehsils or districts of Punjab, involving differences in farming systems, educational level, and availability of veterinary infrastructure.

CONCLUSION

Livestock farmers in Muridke Tehsil District, Sheikhpura, have moderate knowledge and generally positive attitudes towards zoonotic disease risk and prevention, but only 12.2% of farmers demonstrated good practice, and practice scores were only modestly correlated with either knowledge or attitude. The most transparent and operable gap noted is regarding raw milk consumption, with a majority of farmers correctly aware of the disease risk but believing that raw milk consumption is safe. Education and land ownership were the most constant independent predictors of satisfactory knowledge and attitude, and no factor measured predicted excellent practice, suggesting structural, as well as purely educational, barriers to behaviour change. The results indicate the need for a coordinated One Health response, including targeted and practice-specific education needs for less educated, landless farmers and improved access to veterinary testing facilities, protective personal equipment (PPE) and disease reporting systems in Muridke Tehsil.

REFERENCES

- Food and Agriculture Organization of the United Nations (FAO). Zoonoses. One Health – Areas of Work [Internet]. Rome: FAO. Available from: <https://www.fao.org/one-health/areas-of-work/zoonoses/en>
- World Health Organization Regional Office for the Eastern Mediterranean (WHO-EMRO). Zoonotic disease: emerging public health threats in the Region [Internet]. Cairo: WHO-EMRO. Available from: <https://www.emro.who.int/about-who/rc61/zoonotic-diseases.html>
- Rahman MT, Sobur MA, Islam MS, Ievy S, Hossain MJ, El Zowalaty ME, Rahman AT, Ashour HM. Zoonotic diseases: etiology, impact, and control. *Microorganisms*. 2020;8(9):1405.
- Government of Punjab, Bureau of Statistics. Punjab Development Statistics 2018–19: Sheikhpura District livestock statistics (Pakistan Livestock Census 2010 data). Lahore: Government of Punjab.
- Pakistan Bureau of Statistics. Population and Housing Census 2023: Sheikhpura District and Muridke Tehsil detailed results. Islamabad: PBS.
- Yasmeen N, Jabbar A, Shah T, Fang L-x, Aslam B, Naseeb I, Shakeel F, Ahmad HI, Baloch Z, Liu Y. One Health paradigm to confront zoonotic health threats: a Pakistan prospective. *Front Microbiol*. 2022;12:719334.
- Arif S, Thomson PC, Hernandez-Jover M, McGill DM, Warriach HM, Heller J. Knowledge, attitudes and practices (KAP) relating to brucellosis in smallholder dairy farmers in two provinces in Pakistan. *PLoS ONE*. 2017;12(3):e0173365.
- Hussain S, Hussain A, Zia UuR, Naqvi SMR, Zahoor MY, Bilal M, Ho J, Sparagano OAE. Knowledge, attitude, and practices associated with brucellosis among livestock owners and its public health impact in Punjab, Pakistan. *Biologia*. 2021;76(10):2921–2929.
- Noureen R, Afzal M, Majeed I, Gilani SA. Knowledge, attitude and practice regarding rabies in rural area of Lahore. *Int J Sci Eng Res*. 2018;9(7):868–873.
- Ahmed T, Hussain S, Zia UuR, Rinchen S, Yasir A, Ahmed S, Khan WA, Tahir MF, Ricketson R. Knowledge, attitude and practice (KAP) survey of canine rabies in Khyber Pakhtunkhwa and Punjab Province of Pakistan. *BMC Public Health*. 2020;20. doi:10.1186/s12889-020-09388-9
- Alam J, Alam J, Nadeem ur Rehman S, Chaudhry A, Athar Abbas M, Fatima Z, Wasif Malik M, Abbas Ranjha M, Iqbal Baig Z, Ashraf N, Ali Khan M, Ansari JA, Ikram A. Assessment of farmers' knowledge, attitude, and practices related to milk-borne zoonosis in District Muzaffarabad, Azad Jammu and Kashmir. *iProc*. 2022;8(1):e36644.
- Kabir A, Kamboh AA, Abubakar M, Kumar K, Mohammed Matar A. Knowledge, attitude and practices towards foot-and-mouth disease among farmers and veterinary practitioners in selected border regions of Pakistan adjoining to Afghanistan. *Vet Med Sci*. 2025;11(4):e70215.
- Singh BB, Kaur R, Gill GS, Gill JPS, Soni RK, Aulakh RS. Knowledge, attitude and practices relating to zoonotic diseases among livestock farmers in Punjab, India. *Acta Trop*. 2019;189:15–21.

Ahmed MJ, Bhuiyan MIH, Chalise R, Mamun M, Bhandari P, Islam K, Jami SS, Ali M, Sabrin MS. One health assessment of farmers' knowledge, attitudes, and practices (KAPs) on zoonoses in Bangladesh. *Sci Rep.* 2025;15:1258.

Cochran WG. *Sampling Techniques*. 3rd ed. New York: John Wiley & Sons; 1977.

Charan J, Biswas T. How to calculate sample size for different study designs in medical research? *Indian J Psychol Med.* 2013;35(2):121–126.