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RESEARCH ARTICLE

# Knowledge, attitudes, and practices of veterinary students toward brucellosis control in Indonesia: A One Health perspective

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## ABSTRACT

**Background and Aim:** Brucellosis remains an important zoonotic disease affecting animal health, public health, food safety, and livestock productivity. Veterinary students are future frontline professionals in disease surveillance, biosafety, risk communication, and zoonotic disease control. However, evidence regarding their preparedness for brucellosis control within a One Health framework remains limited in Indonesia. This study assessed the knowledge, attitudes, and practices (KAP) of undergraduate veterinary students regarding brucellosis control and examined relationships among these domains.

**Materials and Methods:** A cross-sectional survey was conducted from January to April 2026 among 216 undergraduate veterinary students at Universitas Brawijaya, Malang, Indonesia. Of 300 eligible students invited, 216 completed a validated structured questionnaire, yielding a 72.0% response rate. The questionnaire assessed demographic characteristics, knowledge of brucellosis, attitudes toward control, and self-reported preventive practices. Content validity was high (S-CVI/Ave = 0.94). Descriptive statistics, Spearman's rank correlation, Chi-square test, and odds ratio (OR) analysis were performed.

**Results:** Good knowledge was observed in 95.4% of respondents, although a pronounced ceiling effect limited score discrimination. The overall weighted mean attitude and practice scores were 4.164 and 4.182, respectively. Handwashing after livestock contact (4.55) and use of personal protective equipment (4.49) received the highest practice scores, whereas field- and community-oriented activities received lower scores. Knowledge was not significantly correlated with attitude ($\rho = -0.040$, $p = 0.559$) or practice ($\rho = 0.008$, $p = 0.905$). In contrast, attitude was moderately and positively correlated with practice ($\rho = 0.444$, $p < 0.001$). Students with high attitude scores had significantly greater odds of reporting high practice scores ($\chi^2 = 42.6$, $p < 0.001$; OR = 6.76; 95% confidence interval = 3.72–12.3).

**Conclusion:** Veterinary students demonstrated strong foundational knowledge and generally favorable attitudes and preventive practices regarding brucellosis control. However, gaps in field response and community engagement indicate that knowledge alone may not translate into preventive behavior. Strengthening One Health-based veterinary education through experiential field training, case-based exercises, practical competency assessment, and intersectoral learning may improve preparedness for zoonotic disease control.

**Keywords:** brucellosis control, Indonesia, knowledge attitudes practices, One Health, preventive practices, veterinary education, veterinary students, zoonotic disease.

## INTRODUCTION

Brucellosis is an important zoonotic disease that affects animal and human health worldwide. In livestock, particularly cattle, goats, and sheep, the disease causes substantial economic losses through abortion, infertility, reproductive failure, and reduced milk production. In humans, brucellosis may cause prolonged fever, fatigue, and chronic complications, making it a significant public health concern [1]. Transmission commonly occurs through direct contact with infected animals, exposure to contaminated reproductive materials, consumption of contaminated animal products, or occupational exposure among farmers, veterinarians, and animal health workers [2].

In Indonesia, bovine brucellosis remains a persistent concern in dairy farming areas, including East Java

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Province. Previous studies have documented serological evidence of brucellosis in dairy cattle in Malang and Batu Regencies, indicating the persistence of the disease in local livestock populations [3–5]. In Batu City, bovine brucellosis was detected in 0.7% of dairy cattle tested using the Rose Bengal test (RBT) and complement fixation test (CFT) [6], whereas a study conducted in Turen, Malang Regency, detected no seropositive dairy cattle [4]. In addition, *Brucella suis* was identified in an aborting sow in Kediri, East Java [3]. High animal density, diverse farm management systems, and variable biosecurity levels may contribute to the maintenance and spread of brucellosis within farming communities. Reports of human exposure to *Brucella* spp. in Indonesia and the occupational risk of brucellosis further underscore the need to strengthen surveillance, prevention, and control measures at the animal–human interface [7, 8].

Current brucellosis control strategies increasingly emphasize a One Health approach that integrates veterinary, medical, and environmental sectors to reduce zoonotic transmission and improve disease management [9]. Within this framework, veterinary professionals play essential roles in disease surveillance, diagnosis, implementation of biosafety measures, vaccination programs, farmer education, and risk communication. Veterinary students, as future animal health professionals, therefore require adequate knowledge, favorable attitudes, and practical preparedness to contribute effectively to brucellosis prevention and control. Veterinary curricula should not only develop clinical competence but also strengthen public health awareness, intersectoral collaboration, and community-oriented disease prevention skills.

Despite the continued epidemiological relevance of brucellosis in livestock-producing regions of Indonesia, evidence regarding the preparedness of veterinary students to contribute to its prevention and control remains limited. Existing knowledge, attitudes, and practices (KAP) studies have primarily focused on farmers, livestock workers, and animal health personnel. Student-focused KAP studies on zoonotic diseases in Indonesia have examined avian influenza, toxoplasmosis, and other emerging infections and have indicated that veterinary and medical education can influence students' knowledge, attitudes, and preventive behaviors [10–12]. However, limited evidence is available specifically on veterinary students' preparedness for brucellosis control. In particular, it remains unclear whether strong theoretical knowledge is associated with favorable attitudes and appropriate preventive practices and whether favorable attitudes translate into better preventive behaviors. Therefore, the relationships among these KAP domains in the context of brucellosis control and OH-oriented veterinary education remain insufficiently characterized.

Evaluating undergraduate veterinary students at a formative stage of professional training may help identify gaps between theoretical knowledge and its translation into field-oriented attitudes and preventive practices. During this stage, students develop fundamental competencies in zoonoses, microbiology, and veterinary public health, while their opportunities for practical application may still be developing. Assessing their preparedness may identify areas requiring greater emphasis in field response, risk communication, community engagement, and intersectoral collaboration. Adequate preparedness may support improved biosafety practices, disease recognition, and communication with livestock owners and communities [13]. Strengthening veterinary education on brucellosis and One Health principles may consequently enhance the capacity of Indonesia's future animal health workforce [2, 14]. This educational focus is also relevant to the Sustainable Development Goals (SDGs), particularly SDG 3 (Good Health and Well-being), SDG 2 (Zero Hunger), SDG 4 (Quality Education), and SDG 17 (Partnerships for the Goals), through improved zoonotic disease preparedness, safer livestock production, competency-based veterinary education, and intersectoral collaboration, respectively.

Therefore, this study aimed to assess undergraduate veterinary students' KAP regarding brucellosis control in Malang, Indonesia, and to examine relationships among the KAP domains. Specifically, the study investigated whether students' knowledge was associated with their attitudes and self-reported preventive practices and whether more favorable attitudes were associated with better reported practices. We hypothesized that greater knowledge would be associated with more favorable attitudes and better preventive practices and that favorable attitudes would be associated with better practices, consistent with previous KAP research involving veterinary students [15]. The findings are expected to provide evidence for strengthening competency-based, OH-oriented veterinary education and improving the preparedness of future veterinarians to contribute effectively to zoonotic disease prevention and control.

## MATERIALS AND METHODS

### Ethical approval

The study protocol, questionnaire, participant information, and informed consent procedures were reviewed

and approved by the Research Ethics Committee of the Faculty of Veterinary Medicine, Universitas Brawijaya, Malang, Indonesia (approval No. 65-KEP-FKHUB-2025, dated 22/12/2025). The study was conducted in accordance with the approved protocol, applicable institutional and national research regulations, and the ethical principles of the Declaration of Helsinki. Before participation, all respondents were informed of the study objectives, procedures, voluntary nature of participation, and intended use of the collected data. Written informed consent was obtained from each participant before questionnaire completion. Participation was voluntary, and respondents' privacy and anonymity were maintained. Survey data were used exclusively for academic and research purposes.

**Study period and location**

The study was conducted from January 26 to April 10, 2026, at the Faculty of Veterinary Medicine, Universitas Brawijaya, Malang, East Java, Indonesia. East Java was selected because it is one of Indonesia's major cattle-producing provinces and remains epidemiologically relevant for bovine brucellosis, with ongoing surveillance and control activities by animal health authorities.

**Study design**

A cross-sectional questionnaire-based study was conducted to assess the KAP of undergraduate veterinary students regarding animal brucellosis and brucellosis control in Indonesia. In 2026, 810 undergraduate veterinary students were enrolled at the Faculty of Veterinary Medicine, Universitas Brawijaya. A questionnaire was specifically developed for this study in Bahasa Indonesia and administered online using Google Forms. The self-administered format enabled respondents to complete the questionnaire voluntarily and anonymously. Eligible students were invited to participate through an initial survey invitation, and no follow-up reminders were sent to nonrespondents.

**Sample size determination**

The minimum required sample size ($n_o$) was calculated using Cochran's formula for estimating a population proportion in a cross-sectional survey:

$$n_0 = Z^2 p(1-p)/e^2$$

An anticipated population proportion (p) of 15% was used for sample size estimation based on a previous brucellosis KAP study [16]. The margin of error (e) was set at 5%, and the Z value was 1.96 for a 95% confidence interval (CI). The calculated minimum sample size was 196 respondents. An additional 10% was included to account for potential nonresponse or incomplete questionnaires, resulting in a final required sample size of 216 respondents.

A total of 300 eligible students in the second year or above were invited to participate. Students in the second year or above were eligible because the core lecture materials relevant to brucellosis, including microbiology, veterinary public health, and zoonoses, are introduced by the fourth semester. Therefore, these students were expected to have had prior academic exposure to the concepts assessed in the questionnaire. First-year students were excluded because they had not yet completed these relevant courses. Students who did not provide consent or submitted incomplete questionnaires were also excluded. A nonprobability voluntary sampling approach was used, and data collection continued until 216 complete responses were obtained. The survey was then closed. Thus, the response rate among invited students was 72.0% (216/300).

**Questionnaire preparation**

The questionnaire was reviewed by five senior faculty members and revised based on their feedback. Content validation yielded a scale-level Content Validity Index based on the average method (S-CVI/Ave) of 0.94, indicating high content validity. A separate pilot test was not conducted. Construct validity was evaluated using responses from the main study population. Cronbach's alpha was 0.96 for both the attitude and practice scales. Test–retest reliability was not assessed.

The questionnaire comprised four sections: demographic characteristics (9 questions), knowledge regarding brucellosis (17 questions), attitudes toward the brucellosis control program (10 questions), and self-reported practices related to brucellosis prevention and control (10 questions). The complete questionnaire is provided as Supplementary Material.

**Scoring method**

Knowledge items were scored as 1 for a correct response and 0 for an incorrect response, resulting in a

maximum knowledge score of 17. Knowledge levels were categorized *a priori* using the modified Bloom's cut-off points as poor (0-10 points; <60%), moderate (11–13 points; 60%-80%), and good (14–17 points; >80%). Attitudes were assessed using a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), whereas practices were assessed using a 5-point Likert scale ranging from 1 (never) to 5 (always). Respondents with domain scores equal to or greater than the weighted mean (≥ cut-off) were classified as having a high/positive attitude or good practice, whereas those with scores below the weighted mean (< cut-off) were classified as having a low attitude or poor practice.

Sensitivity analyses using alternative cut-offs or continuous scores were not performed. Previous KAP studies have used sample-derived mean or median scores as cut-offs when established external thresholds were unavailable [17, 18].

**Statistical analysis**

Data were entered into Microsoft Excel 365 (Microsoft Corporation, Redmond, WA, USA) and checked for completeness and consistency before statistical analysis. Statistical analyses were performed using jamovi version 2.4.11 [19]. Descriptive statistics were used to summarize respondents' demographic characteristics and KAP scores. Categorical variables were expressed as frequencies and percentages, whereas numerical and ordinal variables were summarized as means and standard deviations (SD).

Spearman's rank correlation analysis was used to examine relationships among knowledge, attitude, and practice scores. This nonparametric approach was selected because the attitude and practice variables were derived from Likert scale responses and the KAP scores might not satisfy the assumption of normality. Spearman's correlation coefficient (ρ) was used to describe the direction and strength of the associations. The ceiling effect observed for knowledge scores was not statistically adjusted in the correlation analyses; therefore, correlations involving knowledge were considered potentially attenuated because of restricted score variability.

The Chi-square test was used to assess the association between categorized attitude and practice levels. Odds ratio (OR) analysis was performed to estimate the magnitude of the association between high attitude and high practice levels. Statistical significance was interpreted at $p < 0.05$.

**RESULTS**

A total of 216 undergraduate veterinary students participated in the study, with no missing data for any demographic variables. Most respondents were female (80.09%), aged 18-20 years (85.65%), and in their second year of study (89.81%). Most respondents did not live with their families at the time of the survey (72.22%), had current or previous pet ownership (77.78%), and had no livestock ownership experience (76.85%). Lecture materials were the primary source of information on brucellosis (95.83%), whereas only 21.76% of respondents had attended zoonotic disease training outside the formal curriculum (Table 1).

**Table 1:** Demographic characteristics of respondents (N = 216).

| Variable | Category | n | % |
|---|---|---|---|
| Age group (years) | 18–20 | 185 | 85.65 |
| | 21–23 | 30 | 13.89 |
| | >23 | 1 | 0.46 |
| Gender | Male | 43 | 19.91 |
| | Female | 173 | 80.09 |
| Current living condition | Not with family | 156 | 72.22 |
| | With family | 60 | 27.78 |
| Pet ownership | No | 48 | 22.22 |
| | Yes | 168 | 77.78 |
| Livestock ownership | No | 166 | 76.85 |
| | Yes | 50 | 23.15 |
| Source of brucellosis information | Practicing veterinarian | 1 | 0.46 |
| | Lecture materials | 207 | 95.83 |
| | Social media | 8 | 3.70 |
| Zoonotic disease training outside coursework | No | 169 | 78.24 |
| | Yes | 47 | 21.76 |
| Year of study | Second year | 194 | 89.81 |
| | Third year | 10 | 4.63 |
| | Fourth year | 12 | 5.56 |

The geographic origins of the respondents are presented in Figure 1. The 216 respondents represented 20 provinces across Indonesia, with more than half originating from East Java (53.2%). The next largest proportions came from Central Java (14.4%) and West Java (10.2%), while students from the remaining provinces made up much smaller proportions.

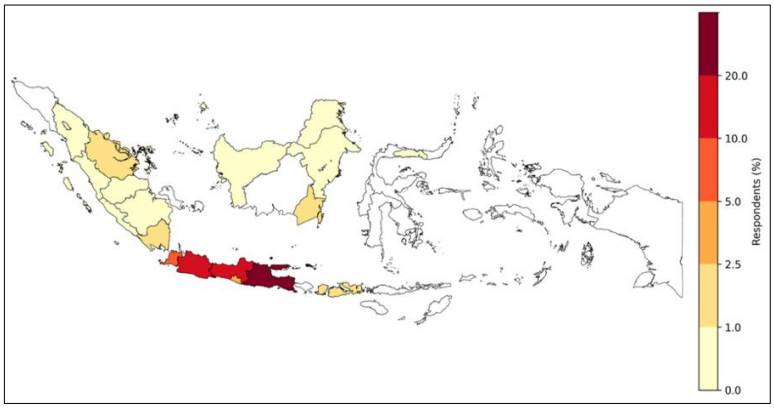



**Figure 1:** Distribution of respondents by province of origin in Indonesia. Provinces are shaded according to the percentage of respondents. The majority of respondents (53.2%) were from East Java.

### Knowledge regarding brucellosis

Respondents demonstrated a high level of knowledge regarding brucellosis. As shown in Table 2, the proportions of correct responses exceeded 94% for most knowledge items. The lowest proportions of correct responses were recorded for the item concerning *Brucella* vaccines used in livestock in Indonesia (60.6%) and the item concerning the gestational period during which abortion occurs due to brucellosis (71.8%).

**Table 2:** Correct responses to knowledge items among respondents (N = 216).

| Item | Correct answers, n | % |
|---|---|---|
| Is the causative agent of brucellosis an intracellular bacterium? | 213 | 98.6 |
| Does brucellosis infect domestic ruminants? | 216 | 100.0 |
| Can brucellosis be transmitted from livestock to humans? | 212 | 98.1 |
| Can brucellosis be contracted by drinking raw or unpasteurized milk? | 212 | 98.1 |
| Can brucellosis be contracted through contact with an aborted fetus or placenta? | 205 | 94.9 |
| Can brucellosis be contracted by consuming undercooked meat or organs? | 213 | 98.6 |
| Can brucellosis be transmitted through laboratory aerosols? | 207 | 95.8 |
| Can brucellosis be contracted through breaks in the skin or mucous membranes? | 211 | 97.7 |
| Can brucellosis be transmitted through a blood transfusion from a person infected with *Brucella* spp.? | 203 | 94.0 |
| Does the control of brucellosis in humans depend on the control of brucellosis in animals? | 216 | 100.0 |
| Can aborted materials from infected animals contaminate the environment? | 211 | 97.7 |
| Can vaccination programs prevent brucellosis? | 212 | 98.1 |
| Is a test-and-slaughter policy for *Brucella*-reactor animals implemented in Indonesia? | 207 | 95.8 |
| What are the clinical signs of brucellosis in farm animals? | 216 | 100.0 |
| *Brucella abortus* strains S19 and RB51 are vaccines used for bovine brucellosis control in Indonesia | 131 | 60.6 |
| In bovine brucellosis, abortion most commonly occurs during the third trimester of gestation | 155 | 71.8 |
| What laboratory methods are used to diagnose brucellosis? | 216 | 100.0 |

The distribution of overall knowledge levels is presented in Figure 2. Most respondents had good knowledge (95.4%), while 4.6% had moderate knowledge. Of the 216 respondents, 129 (59.7%) obtained a knowledge score of 16; 88.9% scored 15-16, and 95.4% scored ≥14 (Figure 3).

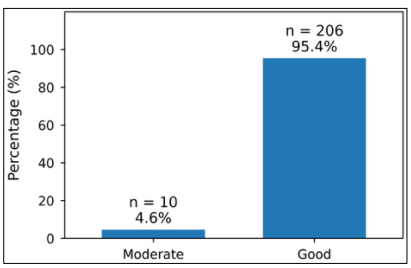



**Figure 2:** Distribution of respondents according to knowledge level. Most respondents had good knowledge (95.4%), while 4.6% had moderate knowledge.

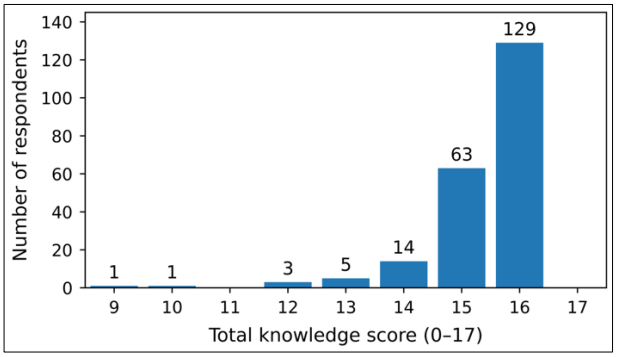



**Figure 3:** Distribution of total brucellosis knowledge scores among undergraduate veterinary students (n = 216). Scores ranged from 9 to 16 on a 0–17 scale, with most respondents clustered at the upper end of the distribution.

### Attitudes toward the brucellosis control program in Indonesia

Respondents generally demonstrated favorable attitudes toward brucellosis prevention and control. The overall weighted mean attitude score was 4.164 (Table 3). The highest mean score was recorded for the statement that milk and meat should be cooked before consumption (mean = 4.39, SD = 0.89), followed by routine testing of ruminants in endemic areas (mean = 4.32, SD = 0.89), the use of standard operating procedures (SOPs) or guidelines to improve diagnosis and case management (mean = 4.31, SD = 0.87), and the role of public health officers in event-based surveillance and case reporting (mean = 4.31, SD = 0.90).

Some attitude items received comparatively lower scores. The lowest mean score was recorded for the statement that a combined test-and-slaughter and vaccination program would be successful in Indonesia (mean = 3.57, SD = 1.47). A relatively lower score was also recorded for the statement that brucellosis can be cured with treatment (mean = 3.88, SD = 0.99). Based on the predefined attitude level classification, six items were categorized as high and four as low.

**Table 3:** Attitudes of respondents toward brucellosis prevention and control (N = 216).

| Item | SD, n (%) | D, n (%) | N, n (%) | A, n (%) | SA, n (%) | Mean | Standard deviation | A + SA (%) | Attitude level |
|---|---|---|---|---|---|---|---|---|---|
| *Brucella* vaccination prevents abortion in livestock | 6 (2.8) | 1 (0.5) | 21 (9.7) | 85 (39.4) | 103 (47.7) | 4.29 | 0.87 | 87.0 | High |
| Routine brucellosis testing should be conducted in all ruminants in endemic areas | 7 (3.2) | 0 (0.0) | 20 (9.3) | 79 (36.6) | 110 (50.9) | 4.32 | 0.89 | 87.5 | High |
| Brucellosis can be cured with treatment | 8 (3.7) | 9 (4.2) | 46 (21.3) | 90 (41.7) | 63 (29.2) | 3.88 | 0.99 | 70.8 | Low |
| Limited knowledge about brucellosis among veterinarians contributes to misdiagnosis | 7 (3.2) | 1 (0.5) | 31 (14.4) | 90 (41.7) | 87 (40.3) | 4.15 | 0.92 | 81.9 | Low |
| Brucellosis can be prevented and controlled through collaborative strategies between the animal and human sectors | 7 (3.2) | 1 (0.5) | 23 (10.6) | 78 (36.1) | 107 (49.5) | 4.28 | 0.91 | 85.6 | High |
| The use of SOPs/guidelines improves the diagnosis and case management of brucellosis | 6 (2.8) | 0 (0.0) | 22 (10.2) | 80 (37.0) | 108 (50.0) | 4.31 | 0.87 | 87.0 | High |
| Involvement of public health officers in event-based surveillance can improve early detection and reporting of suspected brucellosis | 7 (3.2) | 0 (0.0) | 22 (10.2) | 77 (35.6) | 110 (50.9) | 4.31 | 0.90 | 86.6 | High |
| Brucellosis is an important disease that causes significant economic losses | 6 (2.8) | 0 (0.0) | 35 (16.2) | 91 (42.1) | 84 (38.9) | 4.14 | 0.89 | 81.0 | Low |
| A combination of test-and-slaughter and brucellosis vaccination programs will be successful in Indonesia | 6 (2.8) | 80 (37.0) | 22 (10.2) | 0 (0.0) | 108 (50.0) | 3.57 | 1.47 | 50.0 | Low |
| Milk and meat should be cooked before consumption | 7 (3.2) | 0 (0.0) | 19 (8.8) | 65 (30.1) | 125 (57.9) | 4.39 | 0.89 | 88.0 | High |

Attitude items were assessed using a 5-point Likert scale. SD = Strongly disagree; D = Disagree; N = Neutral; A = Agree; SA = Strongly agree; SOPs = Standard operating procedures. The overall weighted mean attitude score was 4.164. Items with mean scores ≥4.164 were classified as high, whereas those with mean scores <4.164 were classified as low.

### Practices related to brucellosis prevention and control

Respondents generally reported favorable preventive practices related to brucellosis control. The overall weighted mean practice score was 4.182 (Table 4). The highest mean score was for washing hands with soap after contact with livestock (mean = 4.55, SD = 0.69), followed by using personal protective equipment during practical

activities involving livestock or in farm environments (mean = 4.49, SD = 0.75).

Comparatively lower scores were observed for field- and community-oriented activities. The lowest mean score was recorded for collecting abortion material for laboratory testing during farm visits (mean = 3.75, SD = 1.33), followed by participation in community service activities involving zoonotic disease education, including brucellosis (mean = 3.77, SD = 1.26). Based on the predefined practice level classification, five items were categorized as high and five as low.

**Table 4:** Practices of respondents related to brucellosis prevention and control (N = 216).

| Item | N, n (%) | R, n (%) | S, n (%) | O, n (%) | A, n (%) | Mean | Standard deviation | O + A (%) | Practice level |
|---|---|---|---|---|---|---|---|---|---|
| Advise farmers to consult a veterinarian if their animals show clinical signs of brucellosis | 16 (7.4) | 14 (6.5) | 23 (10.6) | 66 (30.6) | 97 (44.9) | 3.99 | 1.22 | 75.5 | Low |
| Use personal protective equipment during practical work with livestock or in farm environments | 1 (0.5) | 4 (1.9) | 15 (6.9) | 65 (30.1) | 131 (60.6) | 4.49 | 0.75 | 90.7 | High |
| Wash hands with soap after contact with livestock | 1 (0.5) | 3 (1.4) | 10 (4.6) | 64 (29.6) | 138 (63.9) | 4.55 | 0.69 | 93.5 | High |
| Keep vaccines under cold-chain conditions during transport or storage | 11 (5.1) | 5 (2.3) | 17 (7.9) | 74 (34.3) | 109 (50.5) | 4.23 | 1.04 | 84.7 | High |
| Advise relatives and friends not to consume meat or milk from sick livestock | 1 (0.5) | 4 (1.9) | 18 (8.3) | 66 (30.6) | 127 (58.8) | 4.45 | 0.76 | 89.4 | High |
| Advise farmers to isolate an animal if it aborts | 14 (6.5) | 10 (4.6) | 18 (8.3) | 66 (30.6) | 108 (50.0) | 4.13 | 1.16 | 80.6 | Low |
| Collect abortion material samples for laboratory testing if livestock experience abortion during a farm visit | 24 (11.1) | 15 (6.9) | 36 (16.7) | 57 (26.4) | 84 (38.9) | 3.75 | 1.33 | 65.3 | Low |
| Advise farmers to bury fetuses and remaining abortion materials | 17 (7.9) | 11 (5.1) | 20 (9.3) | 69 (31.9) | 99 (45.8) | 4.03 | 1.21 | 77.8 | Low |
| Advise family and friends not to consume unpasteurized milk | 3 (1.4) | 7 (3.2) | 13 (6.0) | 64 (29.6) | 129 (59.7) | 4.43 | 0.85 | 89.4 | High |
| Participate in community service activities for zoonotic disease education, including brucellosis | 21 (9.7) | 12 (5.6) | 40 (18.5) | 66 (30.6) | 77 (35.6) | 3.77 | 1.26 | 66.2 | Low |

Practice items were assessed using a 5-point frequency scale. N = Never; R = Rarely; S = Sometimes; O = Often; A = Always. The overall weighted mean practice score was 4.182. Items with mean scores ≥4.182 were classified as high, whereas those with mean scores <4.182 were classified as low.
All respondents were expected to answer the field-specific practice items because students in the eligible study years had participated in at least one farm visit as part of their field-practice training.

### Correlation between demographic characteristics and KAP domains

Spearman's rank correlation analysis identified several significant relationships among the demographic variables (Table 5). Age was moderately and positively correlated with year of study ($\rho = 0.521$, $p < 0.001$). Weak positive correlations were observed between age and livestock ownership ($\rho = 0.134$, $p = 0.049$), current living condition and livestock ownership ($\rho = 0.150$, $p = 0.028$), and pet ownership and livestock ownership ($\rho = 0.135$, $p = 0.048$).

**Table 5:** Statistically significant Spearman's rank correlations among demographic variables.

| Variable pair | Spearman's rho (ρ) | p-value |
|---|---|---|
| Age vs. year of study | 0.521 | <0.001 |
| Age vs. livestock ownership | 0.134 | 0.049 |
| Living condition vs. livestock ownership | 0.150 | 0.028 |
| Pet ownership vs. livestock ownership | 0.135 | 0.048 |

$p < 0.05$ was considered statistically significant. Living condition was coded as living without family = 0 and living with family = 1. Pet ownership and livestock ownership were each coded as never owned = 0 and owned = 1.

Knowledge score was not significantly correlated with attitude score ($\rho = -0.040$, $p = 0.559$) or practice score ($\rho = 0.008$, $p = 0.905$) (Table 6). In contrast, attitude score was moderately and positively correlated with practice score ($\rho = 0.444$, $p < 0.001$), indicating that respondents with more favorable attitudes toward brucellosis control tended to report better preventive practices.

The contingency analysis further demonstrated a significant association between attitude and practice categories (Table 7; $\chi^2 = 42.6$, $p < 0.001$). Respondents with high attitude scores had 6.76-fold higher odds of having high practice scores than those with low attitude scores (OR = 6.76; 95% CI = 3.72–12.3).

**Table 6:** Spearman's rank correlations among knowledge, attitude, and practice scores of veterinary students regarding brucellosis control.

| Variable pair | Spearman's rho (ρ) | p-value |
|---|---|---|
| Knowledge score vs. attitude score | −0.040 | 0.559 |
| Knowledge score vs. practice score | 0.008 | 0.905 |
| Attitude score vs. practice score | 0.444 | <0.001 |

$p < 0.05$ was considered statistically significant.

**Table 7:** Association between attitude and practice score categories among students regarding brucellosis control.

| Attitude score | Practice score, low | Practice score, high | Total | $\chi^2$ | p-value | OR | 95% CI |
|---|---|---|---|---|---|---|---|
| Low | 75 | 31 | 106 | 42.6 | <0.001 | 6.76 | 3.72–12.3 |
| High | 29 | 81 | 110 | | | | |
| Total | 104 | 112 | 216 | | | | |

Attitude and practice scores were categorized as high or low based on the overall weighted mean scores. OR = Odds ratio; CI = Confidence interval. $p < 0.05$ was considered statistically significant.

## DISCUSSION

This study assessed the KAP of undergraduate veterinary students at the Faculty of Veterinary Medicine, Universitas Brawijaya, Malang, East Java, Indonesia, regarding brucellosis control within a One Health context. Most respondents were female, in the early years of their veterinary education, and relied primarily on lecture materials for brucellosis information, whereas only a minority had attended zoonotic disease training outside the formal curriculum. The predominance of second year students may partly explain the comparatively lower scores for field-oriented practices. At this stage, students had received relevant theoretical instruction through veterinary public health and microbiology courses, but their opportunities for repeated clinical and field-based application were likely more limited than those of students in later years.

Only a small proportion of respondents were third- and fourth year students, limiting meaningful comparisons across academic years and reducing the statistical power to identify year-specific differences. Recent studies involving undergraduate veterinary students have similarly reported a predominance of female participants [20, 21], consistent with the broader trend toward increased female enrollment in veterinary medicine and other health professions [22]. The predominance of second year students in the present study may also have contributed to lower endorsement of some practical and applied activities compared with theoretical or general preventive measures.

The geographic distribution of respondents is also relevant to the interpretation of the findings. More than half originated from East Java, one of Indonesia's major livestock-producing regions and an important setting for animal and zoonotic disease control. Brucellosis has been documented in dairy cattle in Malang Regency [5], supporting the local relevance of the disease. Thus, students in this setting receive veterinary education in a region where livestock production and zoonotic disease risks closely intersect.

### Knowledge regarding brucellosis

The findings demonstrated a high level of knowledge regarding brucellosis, with 95.4% of respondents classified as having good knowledge (Table 2 and Figures 2 and 3). However, the pronounced concentration of scores at the upper end of the scale indicates a ceiling effect. This restricted variability may have reduced the ability of the correlation analysis to detect associations between knowledge and the other KAP domains.

High proportions of correct responses regarding zoonotic transmission, exposure through raw milk and reproductive materials, and the importance of controlling infection in animals to prevent human brucellosis indicate a strong understanding of fundamental disease concepts. These findings suggest that formal veterinary education provided an adequate foundation in brucellosis epidemiology and prevention. Nevertheless, comparatively lower proportions of correct responses regarding *Brucella* vaccines used in Indonesia and the gestational period associated with brucellosis-related abortion indicate specific areas in which applied and field-relevant knowledge could be strengthened. Previous evidence indicates that exposure to animal health information, including instruction on brucellosis, dairy herd health, and One Health topics, may improve recognition of brucellosis transmission and its implications for human health [13].

The high knowledge scores may also reflect the content of the questionnaire, which primarily assessed fundamental concepts that students in the second year and above had encountered during their veterinary

education. These concepts included the causative agent, transmission, zoonotic potential, clinical manifestations, and basic prevention and control principles introduced through courses such as microbiology and veterinary public health. Therefore, the concentration of scores at the upper end of the scale may indicate that most respondents had acquired the core knowledge expected at their stage of training, although this limited discrimination among respondents with high knowledge levels. The findings are consistent with an Indonesian KAP study on avian influenza, in which 76.9% of knowledge responses were correct, 72.9% reflected positive attitudes, and 56.9% represented proactive practices; veterinary students also demonstrated significantly greater knowledge than students from other faculties [10].

**Attitudes toward brucellosis prevention and control**

Respondents generally demonstrated favorable attitudes toward brucellosis prevention and control (Table 3). High scores for routine testing, vaccination, adherence to SOP, public health involvement, and safe consumption of milk and meat indicate recognition of the importance of coordinated prevention and control strategies.

In contrast, the comparatively lower score for the feasibility of a combined test-and-slaughter and vaccination program may reflect uncertainty about implementing brucellosis control programs in Indonesia. Effective brucellosis control requires not only scientific knowledge but also consideration of policy, field constraints, farmer compliance, and intersectoral coordination. Previous studies indicate that, in settings with a substantial brucellosis burden, test-and-slaughter strategies without vaccination may be insufficient for eradication, whereas vaccination without removing infected animals may allow reservoirs to persist. Accordingly, combined approaches have been advocated where epidemiologically and operationally appropriate [5, 23].

The comparatively lower score for the statement that animal brucellosis can be cured with treatment may also indicate uncertainty regarding the distinction between individual clinical management and population-level disease control. From a public health perspective, prevention of human brucellosis depends substantially on controlling infection in animal reservoirs and reducing exposure to contaminated animal products and materials [24].

**Preventive practices and field preparedness**

Respondents reported generally favorable personal hygiene, food safety, and biosafety practices (Table 4). The highest scores were recorded for handwashing after livestock contact, use of personal protective equipment, advising against consumption of products from sick animals, and discouraging consumption of unpasteurized milk. These behaviors are particularly relevant because brucellosis can be transmitted through direct contact with infected animals and consumption of contaminated animal products [25].

In contrast, comparatively lower scores were observed for field-oriented activities, including collection of abortion materials for laboratory testing, participation in community education, isolation of aborting animals, and appropriate disposal of fetuses and abortion materials. Personal hygiene behaviors are relatively routine, individually controlled, and commonly reinforced during laboratory and practical training. Field-oriented activities, however, may require exposure to actual farm cases, interaction with livestock owners, appropriate facilities, supervision, and greater practical experience. Therefore, the lower scores for these activities may reflect fewer opportunities to apply theoretical knowledge in field settings rather than inadequate understanding of brucellosis prevention.

This pattern suggests a potential gap between knowledge of preventive principles and preparedness to implement more complex professional actions requiring decision-making, communication, and direct field responsibility. Previous studies show that knowledge does not always translate into appropriate practices when enabling factors, including experiential learning, policy awareness, and opportunities for practical application, are limited. Similar knowledge–practice gaps have been reported among livestock owners and undergraduate populations, emphasizing the importance of training that links theoretical knowledge with risk assessment, policy interpretation, and practical implementation [13, 26].

**Relationships among KAP**

Knowledge was not significantly correlated with attitude ($\rho = -0.040$, $p = 0.559$) or practice ($\rho = 0.008$, $p = 0.905$). These findings should be interpreted cautiously because the pronounced ceiling effect in knowledge scores restricted score variability and may have attenuated correlations involving this domain. Therefore, the absence of significant associations does not necessarily indicate that knowledge is unimportant for the development of attitudes or preventive practices.

In contrast, attitude was moderately and positively correlated with practice ($\rho = 0.444$, $p < 0.001$). Students with more favorable attitudes toward brucellosis prevention and control therefore tended to report better preventive practices. Previous studies have reported associations among KAP domains, although the strength and direction of relationships between knowledge and practice have varied across populations and settings [27, 28].

The categorical analysis further supported the attitude–practice relationship. Students with high attitude scores had significantly greater odds of reporting high practice scores than those with low attitude scores ($\chi^2 = 42.6$, $p < 0.001$; OR = 6.76; 95% CI = 3.72–12.3). Together, these findings indicate a strong association between favorable attitudes and reported preventive practices. However, because this is a cross-sectional study, the results should not be interpreted as evidence that favorable attitudes caused better practices or that attitude mediates the relationship between knowledge and practice.

**Implications for veterinary education**

Previous KAP studies among Indonesian students have predominantly addressed avian influenza, toxoplasmosis, and COVID-19 in medical, veterinary, or mixed student populations [11, 12, 29]. In contrast, this study specifically examined brucellosis among veterinary undergraduates, for whom knowledge of reproductive signs, occupational exposure, biosecurity, diagnostic testing, and zoonotic risks directly relates to future professional responsibilities. The observed differences in knowledge, attitudes, and reported practices emphasize the importance of extending veterinary education beyond theory to include opportunities for practical application.

The Faculty of Veterinary Medicine at Universitas Brawijaya provides instruction relevant to global and public health through courses addressing veterinary public health, One Health, and zoonoses. Students also undertake field practical activities that include pre-slaughter cattle health assessments at livestock facilities. However, comparatively lower scores in several field-oriented practices indicate areas where additional experiential learning may be beneficial. Structured training could include appropriate use of personal protective equipment, biosecurity procedures, safe collection and handling of diagnostic specimens, brucellosis case reporting simulations, supervised farm visits, scenario-based case investigations, and participation in zoonotic disease surveillance activities.

Interprofessional learning involving veterinary students and human health disciplines may further strengthen risk communication and One Health coordination. An Objective Structured Clinical Examination, skills checklists, or supervised field assessments could also assess practical competency, evaluating students' ability to apply brucellosis prevention and control principles rather than relying exclusively on theoretical knowledge.

**Study limitations and future research**

The findings should be interpreted within several methodological limitations. First, the cross-sectional design does not establish temporal or causal relationships among KAP. Professional identity, educational experience, prior field exposure, and access to information may influence multiple KAP domains simultaneously. Reverse or reciprocal relationships are also possible; for example, greater practical exposure may strengthen attitudes and practices while simultaneously encouraging further knowledge acquisition.

Second, all KAP domains were assessed using the same self-administered questionnaire, creating the possibility of recall, social desirability, and common-method biases. In particular, self-reported practices may overestimate actual adherence to recommended preventive behaviors. Third, the pronounced ceiling effect in knowledge scores restricted variability and may have reduced the ability to identify associations involving knowledge. Fourth, the predominance of second-year students and small numbers of students from later academic years limited comparisons according to stage of veterinary training. Finally, because the study was conducted at a single veterinary faculty in East Java, the findings may not be generalizable to veterinary students at other institutions or regions of Indonesia.

Future studies should therefore include multiple veterinary schools across different regions of Indonesia and ensure greater representation across academic years. Longitudinal and intervention-based designs could assess how KAP changes as students progress through the veterinary curriculum and gain more clinical and field exposure. Future research should also incorporate objective knowledge assessments, direct observation of practical competencies, and qualitative approaches to examine professional attitudes, risk perception, and barriers to applying brucellosis control measures. Such studies could further evaluate the effects of specific One Health educational interventions, field training, and interprofessional learning on students' preparedness for zoonotic disease control.

### One Health and sustainable development implications

Strengthening preparedness for brucellosis prevention and control has implications beyond veterinary education. Brucellosis remains an important zoonosis in many low- and middle-income countries, affecting human health and livestock productivity. Improving KAP among farmers, veterinarians, health workers, and communities may contribute to SDG 3 through improved zoonotic disease preparedness and SDG 2 through safer and healthier livestock production [28, 30]. The comparatively lower performance on several field-oriented practice items also highlights the relevance of SDG 4 and the need to strengthen applied veterinary education in zoonotic disease control [20].

Effective brucellosis control additionally depends on collaboration across animal, human, and environmental health sectors, consistent with SDG 17 and the One Health framework [31]. Therefore, preparing veterinary students to participate effectively in surveillance, diagnosis, biosafety, and risk communication requires integrating classroom instruction with experiential learning, simulated case exercises, community engagement, and interdisciplinary exposure. Participatory and community-based experiences, including immersive field activities and One Health initiatives, may strengthen competencies in communication, teamwork, and cross-sector collaboration that are important for surveillance and risk communication [32].

## CONCLUSION

Undergraduate veterinary students demonstrated high knowledge and generally favorable attitudes and self-reported practices regarding brucellosis prevention and control. However, specific gaps were identified in knowledge of livestock vaccination and the gestational period associated with brucellosis-related abortion, as well as in field- and community-oriented practices. Knowledge was not significantly associated with attitude or practice, although the pronounced ceiling effect in knowledge scores may have attenuated these relationships. In contrast, attitude was moderately and positively associated with practice, and students with high attitude scores had substantially greater odds of reporting high practice scores.

The findings indicate a need to complement theoretical instruction with greater emphasis on applied competencies. Veterinary education should strengthen supervised field exposure, safe specimen collection and handling, biosecurity procedures, case reporting, community engagement, risk communication, and interdisciplinary One Health activities. Such training may better prepare students to translate classroom knowledge into effective brucellosis prevention and control practices.

A key strength of this study was its simultaneous assessment of the three KAP domains specifically in relation to brucellosis among veterinary students. The study also examined relationships among these domains and identified areas where theoretical knowledge and positive attitudes may not fully translate into field-oriented practices.

Overall, the findings highlight the importance of moving beyond knowledge acquisition toward competency-based veterinary education that integrates theoretical learning with practical experience. Strengthening applied training, professional attitudes, and One Health competencies may improve the preparedness of future veterinarians to participate effectively in brucellosis surveillance, prevention, risk communication, and integrated zoonotic disease control in Indonesia.

## DATA AVAILABILITY

The anonymized dataset generated and/or analyzed during the current study is not publicly available but is available from the corresponding author upon reasonable request.

## GENERATIVE AI DECLARATION

The authors declare that generative artificial intelligence (AI) tools were used exclusively for language editing to improve the readability and grammar of the manuscript. All scientific content, interpretations, and conclusions were independently developed and verified by the authors. The authors take full responsibility for the accuracy, integrity, and originality of the manuscript. No AI tool was listed or acknowledged as an author.

## AUTHORS' CONTRIBUTIONS

HH and AS: Conceptualization. AS and IAA: Methodology. IAA: Validation. AS: Formal analysis and investigation. AS and IAA: Data curation. HH, AS, and IAA: Writing – original draft preparation and writing – review

and editing. AS: Visualization. HH: Supervision and funding acquisition. IAA: Project administration. All authors have read and approved the final manuscript.

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**COMPETING INTERESTS**

The authors declare that they have no competing interests.

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