González et al. BMC Veterinary Research (2025) 21:24
https://doi.org/10.1186/s12917-024-04461-6

BMC Veterinary Research

RESEARCH

Open Access

Cross-sectional seroprevalence study of bovine herpesvirus 1, bovine respiratory syncytial virus, and parainfluenza virus 3 in cattle from Villavicencio, Colombia

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Abstract

Background Bovine respiratory disease complex (BRDC) is a widely distributed and multifactorial syndrome, leading to significant economic losses to the cattle industry. Many viruses are considered causative agents of BRDC, including bovine herpesvirus 1 (BoHV-1), bovine respiratory syncytial virus (BRSV), and parainfluenza virus 3 (PI-3). This study aimed to determine the seroprevalence of BoHV-1, BRSV, and PI-3 in serum samples collected from cattle in Villavicencio, Colombia. A total of 725 animals from 29 herds were sampled and tested for BoHV-1 and BRSV using ELISA. For PI-3, 440 animals were selected from 24 herds and tested using ELISA. An epidemiological survey collected information on animal characteristics, management practices, health, and environmental factors. Seroprevalence rates for each disease were determined, and a bivariate analysis was performed using a contingency table with odds ratios and Pearson's Chi-square test.

Results The seroprevalence rates were 44.9% for BoHV-1, 94.3% for BRSV, and 85.9% for PI-3. At the herd level, the seroprevalence was above 95% for all tested viruses. Two simultaneous risk factors for all three diseases were identified: female sex and age over 3 years. The risk factors for BoHV-1 were the sale of animals, purchase of animals, history of abortions, and Brahman breed. Conversely, artificial insemination was a protective factor. For BRSV, the purchase of animals was a risk factor, and the history of abortions correlated to PI-3 seropositivity. No significant correlation between the three diseases was identified.

Conclusions This study confirms the high prevalence of BoHV-1, BRSV, and PI-3, underscoring the need for preventive measures against these non-officially notified diseases in Colombia.

Keywords Bovine respiratory disease complex, ELISA, Seroprevalence, Risk factor, Virus

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Background

Bovine respiratory disease complex (BRDC) is a significant cause of mortality in calves [1], accounting for 26.9% of calves' deaths in the USA [2]. The BRDC involves several pathogens and is widely distributed worldwide. BRDC also causes significant economic losses to the livestock industry due to decreased productivity and treatment costs [3, 4]. The BRDC is multifactorial and associated with a combination of environmental conditions, stressful events, and the presence of pathogens [5].

The pathogens of the BRDC are mainly transmitted by contact with the respiratory mucosa, secretions of infected cattle, and aerosol [5]. The severity of the clinical presentation depends on multiple factors, including age, genetics, management, and immune status [6]. However, it usually presents with depression, anorexia, fever, cough, nasal discharge, and dyspnea, and frequently may evolve into pneumonia [7–9]. Calves have an increased risk of displaying severe clinical signs, especially in their first weeks of life, especially in the absence of passive immune transfer [6]. Reinfections are possible throughout life. However, subsequent reinfections are typically milder or inapparent [8].

Outbreaks of bovine herpesvirus type 1 (BoHV-1), bovine respiratory syncytial virus (BRSV), and parainfluenza virus 3 (PI-3) have been frequently reported around the world. In Ontario, Canada, and the USA, the presence of BoHV-1, BRSV, and PI-3 has been observed in feedlot animals after commercialization [12, 13]. Outbreaks of pneumonia in dairy calves in Iran have reported the presence of BoHV-1, BRSV, and PI-3 [14]. These viruses frequently facilitate colonization or translocation of bacteria to the lower respiratory tract, causing pneumonia [6, 7, 15]. In Latin America, the presence of respiratory diseases in cattle is significant [16, 17]. However, there is a lack of epidemiological data about these diseases in Colombia to support the design of more efficient control strategies tailored to the geoeconomic traits of the region.

The agriculture in the country represents 6.8% of the gross domestic product (GDP), and the livestock sector 1,4% of the national GDP [10]. Livestock farming occurs mainly through small producers located in central Colombia. Villavicencio is one of Colombia's most important livestock regions between the Andean region and the plains of Los Llanos and is favored by its large grassland areas [11]. Therefore, the present study estimated the seroprevalence of BoHV-1, BRSV, and PI-3 in Villavicencio, Colombia.

Methods

Study population

A cross-sectional epidemiological study was conducted to estimate the seroprevalence of BoHV-1, BRSV, and PI-3 in the municipality of Villavicencio, located in the Department of Meta in the central-eastern region of Colombia. The area, has an average elevation of 380 m, presents an average temperature of 27 °C, with humidity around 80%, and with annual precipitation between 3,500 and 4,000 mm [18].

Farmers involved in dual-purpose livestock production in the municipality of Villavicencio, who were also participants in the Ministry of Agriculture's Sanitary Excellence Project, were invited to join the study. A total of 29 farmers from five villages agreed to participate, providing written consent before inclusion. Animals were randomly selected between March and August 2017. The study included cattle of all age groups that had not been vaccinated against respiratory diseases, specifically BoHV-1, BRSV, and PI-3. A total of 725 samples were collected from a bovine population estimate of 108,109 animals [20].

Using the 725 banked serum samples, we calculated the margin of error to be 3.2% at a 95% confidence level, as previously described [19]. The seroprevalence value used in this calculation was informed by a previous study in Colombia that reported a seroprevalence of 74.7% for BoHV-1 [21]. Due to sample availability, the PI-3 evaluation was conducted using 440 samples from 24 farms. The calculations were performed using the Statistical Package for the Social Sciences (SPSS) software version 20 (SPSS Inc., Chicago, IL, USA).

Sampling and testing

About 5 ml of blood was obtained from the coccygeal vein of each animal in sterile Vacutainer® (Becton, Dickinson and Company, New Jersey, USA) tubes without anticoagulant. Tubes were placed in isothermal boxes and transported to the laboratory of the veterinary school of the University of Los Llanos, Colombia, for analysis. The samples were then centrifuged at 5,000 g for 10 min, and the sera were recovered and stored at -20° C until testing. The antibody evaluation for BoHV-1, BRSV, and PI-3 was conducted using ELISA kits. For BoHV-1, the INGEZIM IBR Compac 2.0 (Ingenasa, Madrid, Spain), was used. The BRSV testing was evaluated with INGEZIM BRSV (Bio-X Diagnostics, Rochefort, Belgium), while the PI-3 was tested using the Svanovir PI-3-Ab kit (Bio-X Diagnostics, Rochefort, Belgium).

Risk analyses evaluation

An in-person survey was carried out on each property for the risk analysis. Among the information collected were sex, age, race, presence of other animal species, productive activities, technical assistance, sanitation, infrastructure, and health events. The complete questionnaire is detailed in Table 1. The questionnaire used in the survey was developed by Empresa Colombiana de Productos

Table 1 Epidemiological questionnaire conducted on the farms selected for the study

Questions	Categorical (Dichotomous)
Sex	Female and male
Age	<1 year old, 1 to 2 years, 2 to 3 years, over 3 years
Animal breed	Jersey, Swiss Brown x Holstein crosses, Holstein, Swiss Brown, Gir, Simmental, Creole (native breed), Brahman, Angus
The animal has reproductive problems	Abortions, weak calves
Use of bull	Yes or no
Artificial insemination	Yes or no
Damaged fences	Yes or no
Share needles	Yes or no
Sale of animals	Yes or no
Purchase of animals	Yes or no
Carcass disposal method	Buried, cremated, none
Rodent control	Yes or no
Proper food storage (silage or concentrate in barns)	Yes or no

Veterinarios (supplementary material). The survey was carried out in collaboration with the animal health authorities Instituto Agropecuario Colombiano (ICA).

Statistical analysis

The seroprevalence and confidence interval (CI) was calculated for each disease. Association analysis was carried out using bivariate analysis with a 2 by 2 table, odds ratio (OR), and Pearson's Chi-square test to evaluate the relationship between seroprevalence results and selected variables. Also, association analysis was conducted among the three studied pathogens. The variables with $p \leq 0.05$ in the univariable analysis were included in the multivariable logistic regression model. The statistical analyses were performed using SPSS. The evaluation was conducted between the BoHV-1, BRSV, and PI-3 through a correlation matrix using software R (R Foundation for Statistical Computing, Vienna, Austria) and the graphical user interface R studio (RStudio PBC, Boston, USA) [22, 23]. For cluster analysis, we considered the seroprevalence of each disease, positive farms, and risk factors identified in each one. In addition, the principal component analysis (PCA) was conducted, evaluating the significance of risk factors identified as significant variables using the Biplot R package.

Results

The seroprevalence for BoHV-1 was 44.9%, and 96.5% of tested herds had at least one positive animal. The seroprevalence of BRSV was 94.3%, and positive animals were found in all tested herds. The PI-3 prevalence was 85.9% at the animal level and 96.5% at the herd level. Detailed results by category as presented in Table 2. Prevalence for each village is show in Fig. 1.

The risk factor analysis revealed that two variables were simultaneously statistically significant in the three diseases (sex and age). The probability of seropositivity for the three respiratory diseases was significant in females, and the likelihood of seropositivity occurring in animals under one year of age was lower and higher in animals older than three years (Table 3).

Swiss Brown breed demonstrated a protective effect against three diseases. The Brahman breed was a risk factor for BoHV-1. Conversely, the Holstein, Pardo x Holstein crosses, Swiss Brow, Gir, and Simmental demonstrated a protective effect against BoHV-1. For BRSV, the Jersey breed and Swiss Brown were a protective factor. Meanwhile, for PI-3, the Jersey, Pardo x Holstein crosses, Swiss Brown, and Brahman breeds were protective factors. The analysis of management and reproductive variables identified abortion, sale of the animals, cremated,

Table 2 Antibody prevalence for BoHV-1, BRSV, and PI-3 according to demographic characteristics with a 95% confidence interval (CI)

Variables	BoHV-1		BRSV		PI-3	
	Total	Positive (%)	Total	Positive (%)	Total	Positive (%)
Females	600	46.7	600	96.2	426	98.1
Male	125	36.8	125	85.6	14	11.3
<1 years old	176	32.4	176	85.8	64	75.0
1 to 2 years old	83	20.5	83	95.2	50	80.0
2 a 3 year old	61	39.3	61	95.1	36	94.4
> 3 year old	405	56.3	405	97.8	290	88.3
Amor	150	30.0	150	90.7	97	83.5
Apiay	121	44.6	121	94.2	48	93.8
Barcelona	149	56.4	149	93.3	94	80.9
Bella Suiza	227	47.6	227	96.4	144	91.7
Cocuy	78	44.9	78	97.4	57	77.2
Positive herds	28	96.5	29	100	23	96.5
Total	725	44.9	725	94.3	440	85.9

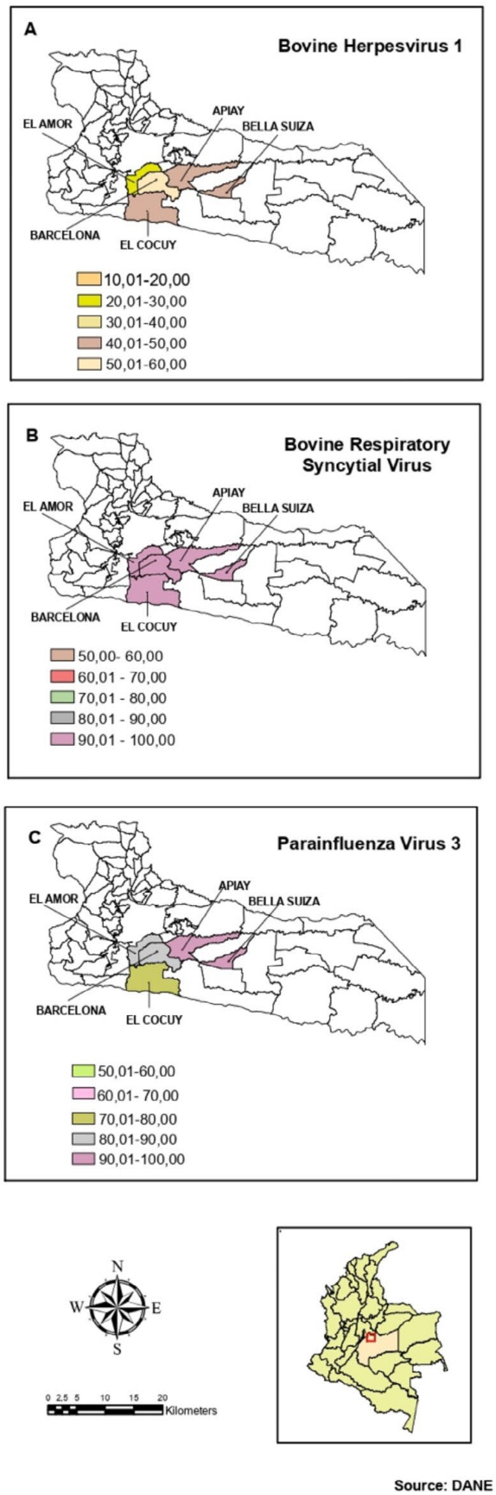

Fig. 1 Seroprevalence for BoHV-1, BRSV, and PI-3 in cattle from Villavicencio, Colombia

The colored areas represent villages from which samples were collected (Apiay, Amor, Barcelona, Bella Suiza, and Cocuy). Figure 1**A** shows the seroprevalence of antibodies to BoHV-1. Figure 1**B** shows the seroprevalence for BRSV. Figure 1**C** shows the level of seropositivity for PI-3

and purchasing of animals as risk factors associated with the seroprevalence of BoHV-1, while artificial insemination was a protective factor. Also, the sale of the animals was a risk factor for BRSV, and abortion was identified for PI-3. Considering diseases as risk factors, no disease was found to be associated with the occurrence of any other study disease. The results of the multivariate logistic regression with significant $p \leq 0.05$ variables are presented below (Table 4).

The correlation analysis showed no significant correlations between the diseases, BoHV-1 vs. PI-3 (*R*: -0.001), BRSV vs. PI-3 (*R: -0.032*), BoHV-1 vs. BRSV (*R*: 0.053). Three main clusters were generated-cluster one was associated with a bull use, not Simmental, and sale of animals-cluster two was associated with the use of bulls, presence of Creole, and sale of animals-and cluster three with artificial insemination, not abortion, not Brahman.

Discussion

The results demonstrated high prevalence rates (over 85%) of animals presenting antibodies against BRSV and PI-3 in cattle raised in Villavicencio. However, the seroprevalence of BoHV-1 was lower, at 44.9%. The seroprevalence at the herd level was nearly 90% for all tested viruses.

Respiratory disease seroprevalence levels show significant differences between countries. Regarding BoHV-1, for instance, a study in Mexico showed a seroprevalence of 64.4% in unvaccinated animals [24]. Meanwhile, the seroprevalence of BoHV-1 in unvaccinated cattle in South America was 43.2% in Ecuador [25] and 92.1% in Brazil [26]. Regarding BRSV, the seroprevalence in Yucatan, Mexico, was 90.8% [27]. In South America, a study conducted in Argentina reported a seroprevalence of 78.6% in unvaccinated animals [28] and another study from Brazil reported a seroprevalence of 77.1% [26].

The seroprevalence of PI-3 is less studied. Studies from Mexico demonstrated a seroprevalence of 60.8% and 85.6% [27, 29], whereas in Brazil, the seropositive rate was 86.6% in animals raised in grazing systems [26]. In Colombia, there is scarce information about the seroprevalence of these viruses and risk factors. In the country, a high prevalence was observed for BoHV-1 (61.1%) in high plains 30, while BRSV was reported at 35.2% and PI-3 at 47.1% seropositivity in the Caribbean [30, 31].

Respiratory diseases are multifactorial and associated with herd size, livestock density, distance to neighboring herds, and trade characteristics [32]. The analysis of risk factors revealed that older animals exhibited higher seropositivity for the three diseases, constituting a risk factor in our study. The BRSV infection triggers a robust response of neutralizing antibodies, especially IgG1 and IgG2, which can endure for two to four years [33]. In the case of BoHV-1, it was demonstrated that affected

Table 3 Analysis of risk factors associated with the BoHV-1, BRSV, PI-3 seroprevalence in cattle from Villavicencio, Colombia. The results include the significance (p), odds ratio (OR) with a 95% confidence interval

Variables	BoHV-1			BRSV			PI-3		
	p-value	OR	CI	*p*-value	OR	CI	*p*-value	OR	CI
Female	0.036*	1.527	1.027–2.270	< 0.001*	4.174	2.179–7.996	< 0.001*	6.745	2.279–19.96
Male	0.036*	0.655	0.441–0.974	< 0.001*	0.240	0.125–0.459	< 0.001*	0.148	0.050–0.439
Under 1 year old	< 0.001*	0.499	0.349–0.713	< 0.001*	0.181	0.094–0.348	0.007*	0.418	0.220–0.797
Between 1 to 2 years	< 0.001*	0.278	0.159–0.484	0.123	1.208	0.419–3.479	0.202	0.615	0.290–1.305
Between 2 to 3 years	0.356	0.778	0.455–1.329	0.795	1.174	0.351–3.919	0.125	2.965	0.694–12.66
Over 3 years old	< 0.001*	2.918	2.144–3.972	< 0.001*	4.889	2.298–10.401	0.047*	1.728	1.002–2.979
Jersey	0.577	0.838	0.451 1.558	0.018*	0.343	0.136–0.866	< 0.001*	0.188	0.087–0.408
Holstein	0.001*	0.479	0.311–0.739	0.103	0.543	0.258–1.142	0.171	0.634	0.329–1.223
Gir	< 0.001*	0.487	0.326–0.728	0.304	1.642	0.632–4.266	0.976	1.010	0.325–1.445
Angus	0.977	1.006	0.661–1.533	0.722	1.190	0.456–3.107	0.318	0.685	0.531–1.919
Pardo x Holstein	< 0.001*	0.319	0.156–0.653	0.086	1.064	1.044–1.085	0.039*	0.435	0.193–0.979
Swiss Brown	0.024*	0.682	0.489–0.952	0.038*	0.512	0.269–0.975	0.008*	0.485	0.281–0.837
Simmental	< 0.001*	0.239	0.142–0.404	0.427	1.529	0.533–4.384	0.711	0.875	0.431–1.775
Brahman	< 0.001*	1.880	1.377–2.568	0.683	0.872	0.453–1.680	0.004*	0.449	0.260–0.776
Creole (native breed)	0.929	0.981	0.643–1.497	0.550	0.774	0.333–1.796	0.077	2.076	0.910–4.736
Abortion	< 0.001*	2.117	1.391–3.220	0.982	1.011	0.414–2.464	< 0.005*	3.312	1.384–7.926
Weak calves	0.064	0.754	0.560–1.017	0.025*	0.488	0.257–0.925	0.071	0.610	0.356–1.046
Use of bull	0.073	1.395	0.969–2.008	0.150	0.503	0.194–1.304	0.984	1.007	0.538–1885
Artificial insemination	0.025*	0.713	0.530–0.959	0.056	0.540	0.285–1.024	0.368	0.781	0.455–1.339
Damaged fences	0.982	1.008	0.489–2.078	0.164	1.063	1.043–1.063	0.258	3.050	0.400-23.26
Share needles	0.126	0.719	0.470–1.099	0.977	0.987	0.405–2.408	0.105	2.047	0.848–4.945
Sale of animals	< 0.001*	1.685	1.254–2.263	0.007*	2.557	1.261–5.186	0.106	1.575	0.905–2.738
Purchase of animals	< 0.001*	2.304	1.627–3.263	0.476	1.332	0.604–2.941	0.051	2.140	0.982–4.664
Carcass disposal method - buried	0.367	0.840	0.575–1.227	0.573	0.803	0.374–1.724	0.406	0.740	0.362–1.511
Carcass disposal method - cremated	< 0.002*	2.255	2.077–2.447	0.486	1.061	1.042–1.080	NA	NA	NA
Carcass disposal method - none	0.128	0.727	0.481–1.098	0.299	1.734	0.606–4.966	0.257	0.650	0.307–1.375
Rodent control	0.014*	0.667	0.481–0.923	0.596	0.821	0.395–1.706	0.521	0.822	0.452–1.496
Proper food storage (silage or concentrate in barns)	0.028*	1.454	1.040–2.033	0.237	0.608	0.265–1.397	0.018*	2.386	1.138–5.005
BoHV-1	NA	NA	NA	1.61	0.075	0.83–3.13	1.047	0.434	0.61–1.79
BRSV	1.67	0.075	0.83–3.39	NA	NA	NA	0.666	0.295	0.15–2.94
PI-3	1.04	0.434	0.61–1.79	0.66	0.295	0.15–2.90	NA	NA	NA

* Statistically significant, NA (Not available)

animals may have antibodies persisting for years due to virus reactivation episodes [34]. The observation from our study aligns with findings from other studies in which older age was a risk factor [26, 35, 36].

The association between sex and the prevalence of antibodies against respiratory diseases has been extensively studied [32, 37–39]. Our research identified the female sex as a risk factor for the three diseases. However, in the case of BoHV-1, a study conducted on vaccinated and unvaccinated animals in Belgium highlighted males as a risk factor [40]. A study evaluating seroprevalence to BRSV in cattle with no vaccination history in Iran showed no significant differences between the sexes [38]. In a report from Colombia, females present a greater risk of seropositive for PI-3 [31]. The influence of sex in our study could be associated with the high number of females associated with dual-purpose production, which was previously identified as a risk factor [32, 39].

Numerous studies have consistently identified trade activities as a significant risk factor for respiratory diseases [39, 41]. In our research, the sale of animals was recognized as a risk factor for the seroprevalence of the BoHV-1 and BRSV and the purchase of animals to BoHV-1. A comprehensive review of factors associated with the presence of BoHV-1 highlighted that the introduction of cattle into herds (purchase of replacement cattle, bulls purchased from dairies, and animal transportation) increased the probability of being seropositive for BoHV-1 [32, 35, 42]. Additionally, a study in the United States demonstrated that calves purchased after weaning are more susceptible to infections by BoHV-1, BVDV, PI-3, and BRSV 13. In Spain, animal transportation, frequency of animal introductions to herds, testing protocols, quarantine facilities, external rearing farms, participation in cattle fairs, pastures, vehicles, and the presence of visitors and staff have been identified as

Table 4 Multivariable logistic regression analysis of variables associated with the BoHV-1, BRSV, PI-3

General Variables	BoHV-1			BRSV			PI-3		
	OR (95% CI)	**β**	***p*-value**	**OR (95% CI)**	**β**	***p*-value**	**OR (95% CI)**	**β**	***p*-value**
Female	1.526 (1.043–2.234)	0.423	0.001*	4.175 (1.154–15.10)	1.429	0.036*	6.746 (1.213–7.604)	1.909	0.001*
Male	0.655 (0.448–0.959)	-0.423	0.001*	0.24 (0.066–0.867)	-1.43	0.036*	0.148 (0.026–0.826)	-1.911	0.001*
Under 1 year old	0.499 (0.267–0.933)	-0.695	0.007*	0.181 (0.039–0.843)	-1.71	0.001*	0.418 (0.191–0.916)	-0.872	0.001*
Between 1 to 2 years	0.278 (0.088–0.88)	-1.28	0.002*	-	-	-	-	-	-
Between 2 to 3 years	-	-	-	-	-	-	-	-	-
Over 3 years old	2.918 (1.113–7.651)	1.071	0.047*	4.889 (1.172–20.39)	1.587	0.001*	1.728 (1.056–2.827)	0.547	0.001*
Jersey	-	-	-	0.343 (0.131–0.899)	-1.07	0.006*	0.188 (0.042–0.846)	-1.671	0.018*
Holstein	0.479 (0.247–0.929)	-0.736	0.017*	-	-	-	-	-	-
Gir	0.487 (0.255–0.931)	-0.719	0.031*	-	-	-	-	-	-
Angus	-	-	-	-	-	-	-	-	-
Swiss Brown x Holstein	0.318 (0.114–0.892)	-1.143	0.039*	-	-	-	0.435 (0.206–0.92)	-0.832	0.008*
Swiss Brown	0.681 (0.483–0.962)	-0.383	0.008*	0.497 (0.265–0.932)	-0.699	0.024*	0.485 (0.253–0.93)	-0.724	0.038*
Simmental	0.239 (0.066–0.867)	-1.431	0.007*	-	-	-	-	-	-
Brahman	1.879 (1.065–3.316)	0.631	0.004*	-	-	-	0.449 (0.218–0.923)	-0.801	0.006*
Creole (native breed)	-	-	-	-	-	-	-	-	-
Abortion	2.117 (1.078–4.158)	0.75	0.005*	-	-	-	3.313 (1.127–9.74)	1.198	0.009*
Weak calves	-	-	-	-	-	-	-	-	-
Use of bull	-	-	-	-	-	-	-	-	-
Artificial insemination	0.713 (0.526–0.967)	-0.338	0.036*	-	-	-	-	-	-
Damaged fences	-	-	-	-	-	-	-	-	-
Share needles	-	-	-	-	-	-	-	-	-
Sale of animals	1.685 (1.054–2.696)	0.522	0.011*	2.557 (1.098–5.954)	0.939	0.001*	-	-	-
Purchase of animals	2.304 (1.087–4.887)	0.835	0.05*	-	-	-	-	-	-
Carcass disposal method - buried	-	-	-	-	-	-	-	-	-
Carcass disposal method - cremated	2.254 (1.085–4.687)	0.813	0.002*	-	-	-	-	-	-
Carcass disposal method - none	-	-	-	-	-	-	-	-	-
Rodent control	-	-	-	-	-	-	-	-	-
Proper food storage	-		-	-	-	-	-		-

* Statistically significant

contributing to increasing the probability of reintroducing BoHV-1 [43].

The observed relationship between animals with a history of abortions and BoHV-1 and PI-3 is consistent with findings in Estonia, where a higher risk of abortions was reported with the moderate presence of BoHV-1 antibodies [44]. Shewie et al. also associated BoHV-1 with cows that had a history of abortion, retained placenta, and repeated breeding [45]. However, some studies have not identified relationships between reproductive failures and BoHV-1, suggesting that reproductive impairments were associated with BVDV and *Neospora* spp [46, 47]. Conversely, artificial insemination was found to be a protective factor associated with the BoHV-1 seroprevalence in our study. In Ethiopia, herds that used bulls for reproduction were more likely to be seropositive for BoHV-1 than those that used artificial insemination [45]. The BoHV-1 can be transmitted through semen, and bulls can intermittently eliminate BoHV-1 in semen throughout their lives during reactivation episodes and often may be asymptomatic [48, 49]. However, infection after artificial insemination typically requires a viral dose higher than 200 median tissue culture infectious doses. Therefore, the transmission rate during artificial insemination is limited [48].

A previous study suggests that the heritability of BRDC susceptibility appears to be low [5]. However, susceptibility differences among different cattle breeds have been detected [5]. An increased risk of respiratory disease was identified in *Bos taurus* cattle breeds than in *Bos Indicus* breeds in Australia [50]. Despite an outbreak of BRSV in Brown Swiss cattle in Brazil [51], our study identified Brown Swiss as a protective factor for all three diseases studied. Breeds such as Brown Swiss, Brown Swiss x Holstein cross, Simmental, Gir, and Holstein were found to be protective factors against BoHV-1. Additionally, Jersey cattle were found to be protected against BRSV, and both Jersey and Pardo x Holstein breeds were protected against PI-3. However, the Colombian native Creole breed was not statistically significant in our study. Conversely, a study in Spain reported that crossbreeding local breeds and Limousine or Charolais presented a greater risk [52]. In this regard, it is possible that the higher-value breeds may have improved management practices, which can influence the protection effect. Susceptibility to respiratory diseases may vary depending on geographic location, environmental factors, and other variables, making universal generalizations challenging 5 and demonstrating the need for regional identification of risk factors associated with each pathogen.

The correlation analyses conducted with the three studied pathogens identified no association. Contrastingly, several studies have demonstrated the association between respiratory diseases [13, 26, 53]. In Kenya, an association was observed between BoHV-1, PI-3, and BVDV 53. Another study revealed interactions of BVDV with *Pasteurella spp*, PI-3, and BRSV 13. In Brazil, a study identified positive correlation between BoHV-1 and PI-3 and between BRSV and BPIV-3 [26]. The differences in the results may be attributed to contrasting herd characteristics, management, study design, and the evaluated pathogens. One of the drawbacks of the present study is the lack of testing for bovine viral diarrhea virus due to sample availability. However, future studies are planned to address the role of this important pathogen in respiratory disease in cattle herds in central Colombia.

The cluster evaluation identified 3 clusters grouping the main variables studied, which were mainly associated with the practices of reproduction, trade, abortion, and some specific breeds. In clusters 1 and two, two variables that presented as factor risk stand out: the use of bulls and the sale of animals. In the third group, which is broader, the grouped variables include variables that were not risk factors, such as artificial insemination, not abortions, and not Brahman. The cluster identification allows the development of integrated management of respiratory diseases considered the risk variables.

In Europe, several countries have implemented critical strategies for controlling respiratory diseases, such as mass vaccinations, vaccinations with markers for the differentiation of seropositive, mandatory quarantines, routine testing, elimination of positive animals, restrictions on imports, and restrictions on trade in semen and embryos. However, despite these efforts, many countries struggle to achieve free status [44, 54].

Although the samples were collected in 2017, these results provide a crucial baseline for understanding the epidemiology of respiratory diseases in cattle within the region. These results remain highly relevant, as they offer a valuable historical reference for tracking changes in disease prevalence over time. This is particularly significant given that vaccination against respiratory diseases has yet to be implemented in Colombia.

Strategies for controlling respiratory diseases are complex and costly, requiring careful consideration for implementation in Colombia. Many countries in Latin America, including Colombia, do not officially report respiratory diseases in cattle, and producers face challenges due to their small-scale production, limited resources, and scarcity of vaccine development. The results in the present study suggest frequent circulation of BoHV-1, PI-3, and BRSV in a significant cattle producer area in Colombia. These findings indicate that local producers would benefit from systematic vaccination efforts, reinforcement of biosecurity measures, increased technification, and further control over animal movements.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12917-024-04461-6.

Supplementary Material 1

Author contributions

C.B.G.: data curation; formal analysis; investigation; methodology; software. K.B.: data curation; formal analysis; investigation; methodology; software. J.C.T.: conceptualization; investigation, methodology; data curation; funding acquisition; project administration; resources. D.W.S.C.: formal analysis, investigation; methodology; software; validation. F.V.B.: visualization; resources; writing - original draft; and writing - review & editing. B.L.G.B.: conceptualization; formal analysis, data curation; project administration, methodology, software, visualization; data curation; writing - original draft; and writing - review & editing.All authors reviewed the manuscript.

Funding

FVB and BLGB were partially supported by the Sitlington Endowment in Veterinary Medicine Food and Fiber (FVB) during portions of this project.

Data availability

The datasets used and/or analyzed during the current study are available from the corresponding authors upon reasonable request.

Declarations

Ethics approval and consent to participate
The study adhered to the guidelines for animal experimentation outlined in the International Guiding Principles for Veterinary Research and received approval from the Ethics Committee of the Faculty of Agricultural Sciences at the University of Applied and Environmental Sciences (UDCA), No. 001–2017. The authors received written informed consent from owners to collect samples and epidemiological data from each studied farm.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Received: 21 March 2024 / Accepted: 25 December 2024
Published online: 16 January 2025

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