

# Estimation of the prevalence of the main reproductive pathologies that affected dairy farming in Colombia reported between 2019 and 2022 through a meta-analysis

## Estimación de la prevalencia de las principales patologías reproductivas que afectaron a la ganadería lechera en Colombia reportadas entre 2019 y 2022 por medio de un metaanálisis

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### ABSTRACT

Reproductive pathologies in dairy cattle significantly impact animal welfare, profitability, and productivity. The objective of this study was to estimate the prevalence of the main reproductive pathologies that have affected livestock farming in Colombia during the period between 2019 and 2022 through a systematic review and meta-analysis. A meta-analysis was carried out where the prevalence of diseases was identified, where initially a systematic review was accomplished with the PRISMA methodology, using the databases PubMed, Science Direct, Dialnet, Google Scholar. Inclusion and exclusion criteria were defined, the quality of the studies was evaluated and data was extracted from the selected articles to analyze the information using the OpenMeta [Analyst]<sup>®</sup> software, in order to standardize the findings obtained. From an initial 3,883 bibliographic references, 28 studies met the inclusion criteria. Infectious Bovine Rhinotracheitis (IBR) exhibited the highest prevalence, ranging from 0.00% to 77.30%, followed by Bovine Neosporosis (17.55% - 61.34%) and Bovine Viral Diarrhea (BVD) (16.14% - 44.13%). Brucellosis (0.01% - 1.65%) and Leptospirosis (1.48% - 24.33%) displayed the lowest overall prevalence. Data for other reproductive diseases was either absent or excluded based on the defined criteria. The identified prevalence of reproductive diseases in Colombian dairy cattle highlights the need for improved farm health protocols and management practices. Furthermore, a scarcity of studies across different regions suggests a gap in knowledge regarding the true national prevalence of these diseases. This knowledge is crucial for establishing effective health and animal welfare plans.

**Key words:** Colombia; dairy cows; reproductive pathologies; prevalence

### RESUMEN

Las patologías reproductivas en el ganado lechero impactan significativamente el bienestar, la rentabilidad y la productividad animal. El objetivo de este estudio fue estimar la prevalencia de las principales patologías reproductivas que han afectado a la ganadería en Colombia durante el periodo comprendido entre los años 2019 y 2022 mediante revisión sistemática y metaanálisis. Se realizó un metaanálisis donde se identificó la prevalencia de enfermedades, para esto inicialmente se efectuó una revisión sistemática con la metodología PRISMA, utilizando las bases de datos PubMed, Science Direct, Dialnet, Google Scholar. Se definieron criterios de inclusión y exclusión, se evaluó la calidad de los estudios y se extrajeron los datos de los artículos seleccionados para poder realizar el análisis de la información mediante el software OpenMeta [Analyst]<sup>®</sup> software, con el fin estandarizar los hallazgos obtenidos. De 3.883 referencias bibliográficas iniciales, 28 estudios cumplieron los criterios de inclusión. La Rinotraqueitis Infecciosa Bovina (IBR) exhibió la prevalencia más alta, oscilando entre 0,00% y 77,30%, seguida de la Neosporosis bovina (17,55% - 61,34%) y la Diarrea Viral Bovina (DVB) (16,14% - 44,13%). La Brucelosis (0,01% - 1,65%) y la Leptospirosis (1,48% - 24,33%) mostraron la prevalencia global más baja. Los datos sobre otras enfermedades reproductivas estuvieron ausentes o excluidos según los criterios definidos. La prevalencia identificada de enfermedades reproductivas en el ganado lechero colombiano resalta la necesidad de mejorar los protocolos de salud y las prácticas de manejo de las granjas. Además, la escasez de estudios en diferentes regiones sugiere una brecha en el conocimiento sobre la verdadera prevalencia nacional de estas enfermedades. Este conocimiento es crucial para establecer planes eficaces de salud y bienestar animal.

**Palabras clave:** Colombia; vacas lecheras; patologías reproductivas; prevalencia

## INTRODUCTION

Dairy farming is a major productive activity in Colombia, encompassing two primary production systems: specialized (40% of national production) and dual-purpose (60%) [1]. In these systems, reproduction plays a critical role in herd profitability and milk yield. Dairy cattle are susceptible to various health problems with reproductive consequences, caused by diverse etiological agents, including viruses, bacteria, and parasites [2, 3, 4].

Some of the key reproductive pathologies include:

1. Infectious Bovine Rhinotracheitis (IBR): This highly contagious and infectious disease, caused by Bovine Herpesvirus Type 1 (BHV-1), manifests with respiratory and conjunctival signs, as well as infertility, embryonic mortality, abortion, and neonatal mortality [5, 6].
2. Bovine Viral Diarrhea (BVD): Caused by a Pestivirus, BVD exhibits a range of clinical presentations, including enteric, respiratory, or reproductive symptoms, abortions, fetal mummification, congenital malformations, and the birth of persistently infected animals [7, 8].
3. Brucellosis: A contagious zoonotic disease with mandatory reporting, brucellosis is caused in cattle (*Bos taurus*) by *Brucella abortus*. It leads to abortions, retained placenta, infertility, low milk production, and human infection [9].
4. Leptospirosis: Another zoonotic and infectious disease, caused by bacteria of the genus *Leptospira*, leptospirosis manifests as reproductive disorders in cattle, including abortions, birth of weak calves, stillbirths, infertility, and decreased milk production [7, 10].
5. Neosporosis: This parasitic disease is caused by *Neospora caninum*, a protozoan with dogs as the definitive host. It affects other animal species, causing abortions, subfertility, early pregnancy losses, mummification, extended calving intervals, reduced milk production, and the birth of weak calves with neurological signs [5, 7].

Currently, in Latin America, particularly in Colombia, the implementation of reproductive disease control measures has been difficult [11]. Therefore, it is necessary to perform a compilation of recent cross-sectional survey to assess the importance of the main reproductive pathologies that affect dairy farming in Colombia in recent years, for which we performed a systematic review and a meta-analysis (in order to discard the studies with low quality).

## MATERIALS AND METHODS

### Materials

In the present study, descriptive observational cross-sectional studies were included, such as reproductive pathology studies, conference proceedings, epidemiological bulletins, degree theses and prevalence reports of reproductive diseases that have affected dairy cattle in Colombia (Brucellosis, Leptospirosis, IBR, BVD, Neosporosis, Campylobacteriosis, Trichomoniasis, Metritis and Endometritis) that were published within the time period between 2019 and 2022 and performed in Colombia.

### Methods

A meta-analysis was performed where the prevalence of diseases was identified, where initially a systematic review was conducted following

the PRISMA methodology (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) [12]. The search strategy utilized four databases: PubMed, ScienceDirect, Dialnet, and Google Scholar.

For the search process, Boolean operators were employed in a specific order (Colombia AND cattle AND reproductive prevalence). This search string was designed to identify relevant studies for the research question, focusing on the study population (dairy cattle), intervention/comparison (diagnostic tests), or outcome (percentage of reported prevalence of reproductive diseases in Colombia).

### Inclusion criteria

Only articles published in peer-reviewed journals were included in the systematic review. Additionally, relevant studies on the prevalence of the main reproductive diseases in Colombian dairy cattle were considered from the grey literature, including epidemiological reports, dissertations, and theses.

### Definition of inclusion and exclusion criteria

The study included descriptive studies, descriptive observational studies, case-control studies, reproductive pathology studies, conference proceedings, epidemiological bulletins, degree projects, and reports of the prevalence of reproductive diseases affecting dairy cattle in Colombia (Brucellosis, Leptospirosis, IBR, BVD, Neosporosis, Campylobacteriosis, Trichomoniasis, Metritis, and Endometritis) published between 2019 and 2022.

### Exclusion criteria

Studies not published between 2019 and 2022, those reported for countries other than Colombia, and those not addressing reproductive diseases, or their prevalence were excluded. Initial selection was performed based on titles and abstracts.

### Study quality assessment

Four reviewers independently assessed the internal validity of the studies.

### Data extraction

Following the preliminary selection by title and abstract, a detailed review of each article was conducted. Data were extracted and organized in Microsoft Excel, including the year of publication, the region in Colombia where the study was conducted, the reported reproductive disease, the type of sample collected, the diagnostic technique used, sample size, prevalence percentage, and the last names of the author(s).

### Analysis of data

Data obtained from the systematic review were analyzed by using the OpenMeta [Analyst]<sup>®</sup> software (<http://www.cebm.brown.edu/openmeta/>). The analysis considered the diagnostic tests performed, individual prevalence data, reported prevalence in infected farms, and the confidence interval for each disease. The 95% confidence interval for the estimated prevalence values was calculated by using an arcsine transformation. Study heterogeneity was quantified using the I<sup>2</sup> statistic, based on Cochran's Q test of homogeneity [13]. The I<sup>2</sup> value was interpreted with a significance level of P<0.05, indicating heterogeneity when the value was close to 100%, and homogeneity when close to 0%.

### Meta-Analysis

For the meta-analysis, only studies addressing reproductive diseases and utilizing the following diagnostic techniques were included: ELISA for BVD and IBR, RBT/ELISA (Rose Bengal Test/ELISA) for bovine Brucellosis, MAT (Microagglutination Test) for *Leptospira*, and ELISA for bovine Neosporosis. A *P*-value of less than 0.05 was considered statistically significant, indicating a significant difference in the analyzed studies and leading to the rejection of the null hypothesis.

### RESULTS AND DISCUSSION

The search strategy identified a total of 3,883 articles. Of these, 2,619 were deemed ineligible by automated tools, and 131 were eliminated due to duplication. We examined 1,133 records in the databases: 17 from PubMed, 1,000 from Google Scholar, 11 from Dialnet, and 105 from ScienceDirect. After removing duplicates, we screened 1,064 articles by title and abstract. Ultimately, 69 studies were included, with only 41 meeting our inclusion criteria. Finally, 28 articles were included in the meta-analysis. Systematic or literature review studies whose diagnostic methods could not be compared for quantitative synthesis were excluded from the meta-analysis. The results of the included studies are illustrated in FIG. 1 [12].

The distribution of studies found at different departments of Colombia reported from the 41 articles selected in the systematic review, was represented by a choroplethic map in order to determine the distribution of studies and the departments that had the greatest number of studies. It is important to keep in mind that, in the map,

more than one disease could be represented in different departments of Colombia in the same study (FIG. 2).

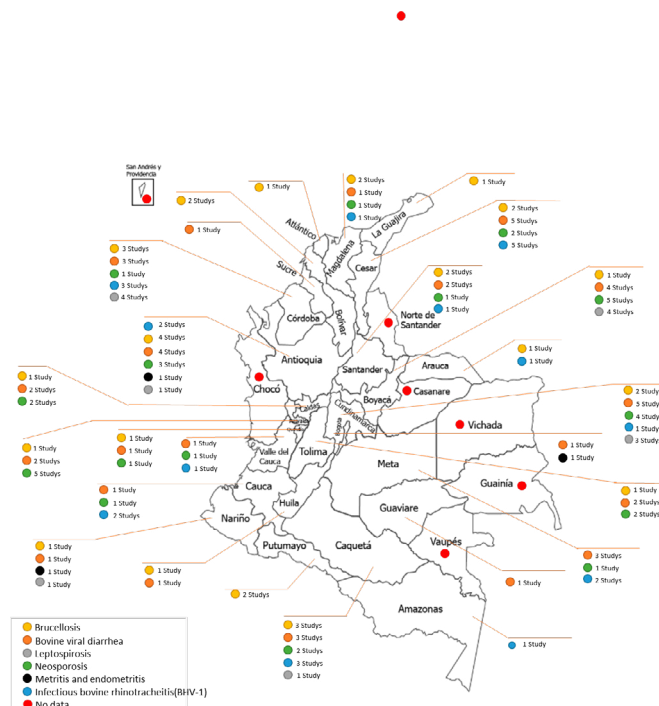


FIGURE 2. Number of publications by the location at different departments of Colombia 2019-2022

Taking into account the FIG. 2, it can be seen that the disease with the greatest number of studies published was BVD, followed by Brucellosis and Neosporosis, then IBR, Leptospirosis and Metritis and Endometritis.

Likewise, according to the systematic review obtained, it was observed that the departments that had the greatest number of studies carried out and published were Antioquia and Cundinamarca with 15 studies each department; Boyacá, Cesar and Córdoba with 14 studies each one; Caquetá with 12 studies; Risaralda 8 studies carried out; Meta and Santander with 6 studies each one; Caldas, Magdalena and Tolima with 5 studies each one; Cauca and Nariño 4 studies each one; Quindío and Valle del Cauca 3 studies each one; Arauca, Bogotá, Bolívar, Huila and Putumayo with 2 studies each one and 7 Departments where no studies were reported such as Casanare, Chocó, Guainía, Norte de Santander, San Andrés and Providencia, Vaupés.

From the systematic review, a total of 28 articles were included in the meta-analysis.

According to the entire rigorous process of systematic review, it can be determined that there are few fully published research studies on reproductive diseases in dairy cattle in Colombia. This coincides with Pérez [11], who reported that, in Latin America, there is a lack

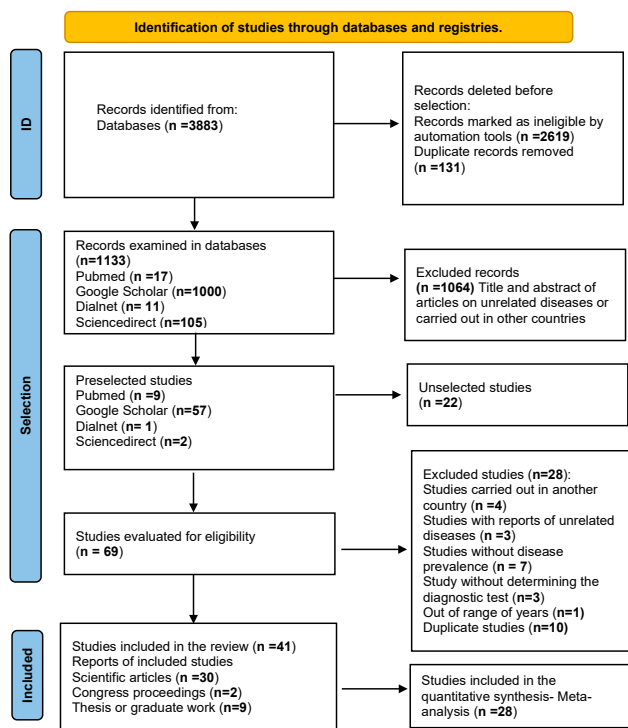


FIGURE 1. Results of the bibliographic search according to PRISMA 2022 statement (<http://www.prisma-statement.org>)

of analysis on the degree of incidence and impact of reproductive pathologies in cattle, which makes it difficult to adopt sanitary measures to control these diseases.

Additionally, it was possible to observe that the disease BVD is the disease with the highest number of studies published, followed by bovine Brucellosis, bovine Neosporosis, IBR, and leptospirosis. For diseases such as metritis and/or endometritis, some studies were included in the systematic review but could not be included in the meta-analysis because there were very few reports and because the diagnostic techniques used in them were different from immunological techniques. This fact does not allow an adequate comparison in terms of the method used, which in some studies turned out to be bacteriological or biochemical tests, making it impossible to make prevalence comparisons. In regard to other reproductive diseases, it was found that there are no complete studies reported in recent years according to the Boolean search engines established in the systematic review and therefore included in the meta-analysis. This could be due to the interest that different researchers have to the study of more common reproductive diseases, such as those that were considered in the meta-analysis of the present study.

It is important to highlight that livestock farming in Colombia is distributed in different departments, where 9 of them are identified by their high milk production, however, other departments have small productions. By 2022, the number of farms (properties) dedicated to dairy and dual-purpose livestock farming was 1,378,104 and the number of milk-producing and dual-purpose animals was 13,888,956. However, of this sample universe, not all departments have conducted studies on reproductive diseases, likewise some studies found did not meet the inclusion criteria. For this reason, only 28 relevant studies that fit the established parameters could be included in this meta-analysis.

These results from the 28 studies included in the meta-analysis shown below by TABLES and FIGURES indicating frequency of infected farms and individual prevalence for each reproductive disease which were reported and fulfilled the inclusion criteria of study: BVD, Brucellosis, IBR and Neosporosis (TABLE 1; FIG. 3, FIG. 4).

For BVD, regarding the individual prevalence by ELISA in infected farms, 12 studies that reported the disease in the departments of Antioquia, Boyacá, Caldas, Cesar, Córdoba, Cundinamarca, Magdalena, Meta, Nariño, Quindío, Risaralda, Santander, Tolima and Valle del Cauca, were found. The mean frequency of individual prevalence for the pathology was 40.4%; 95%CI (33.7% – 47.1%) with a significant

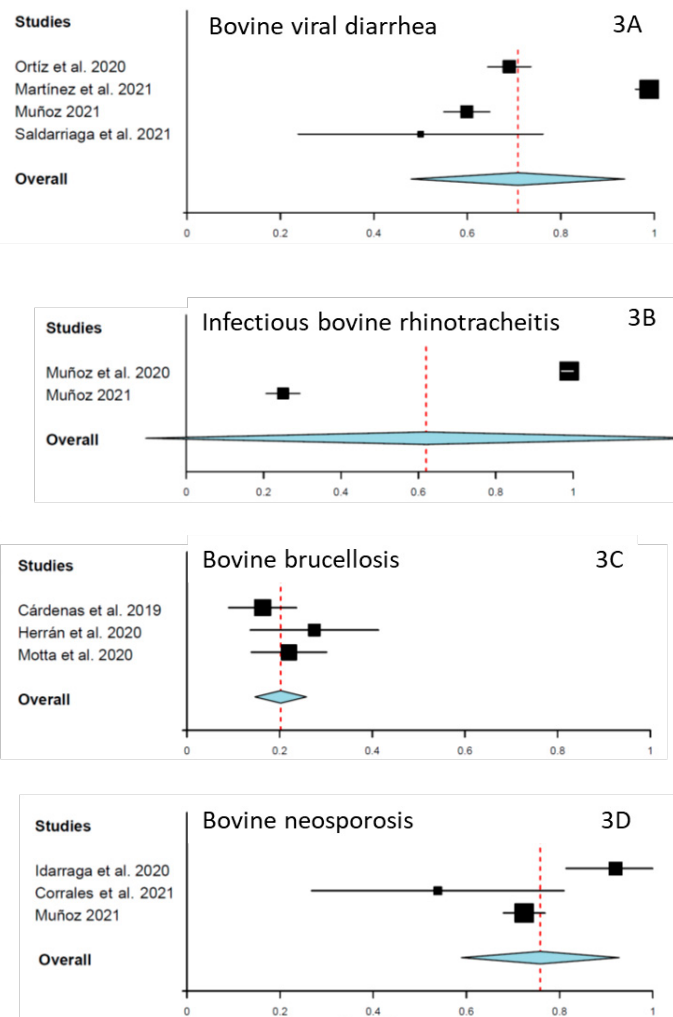
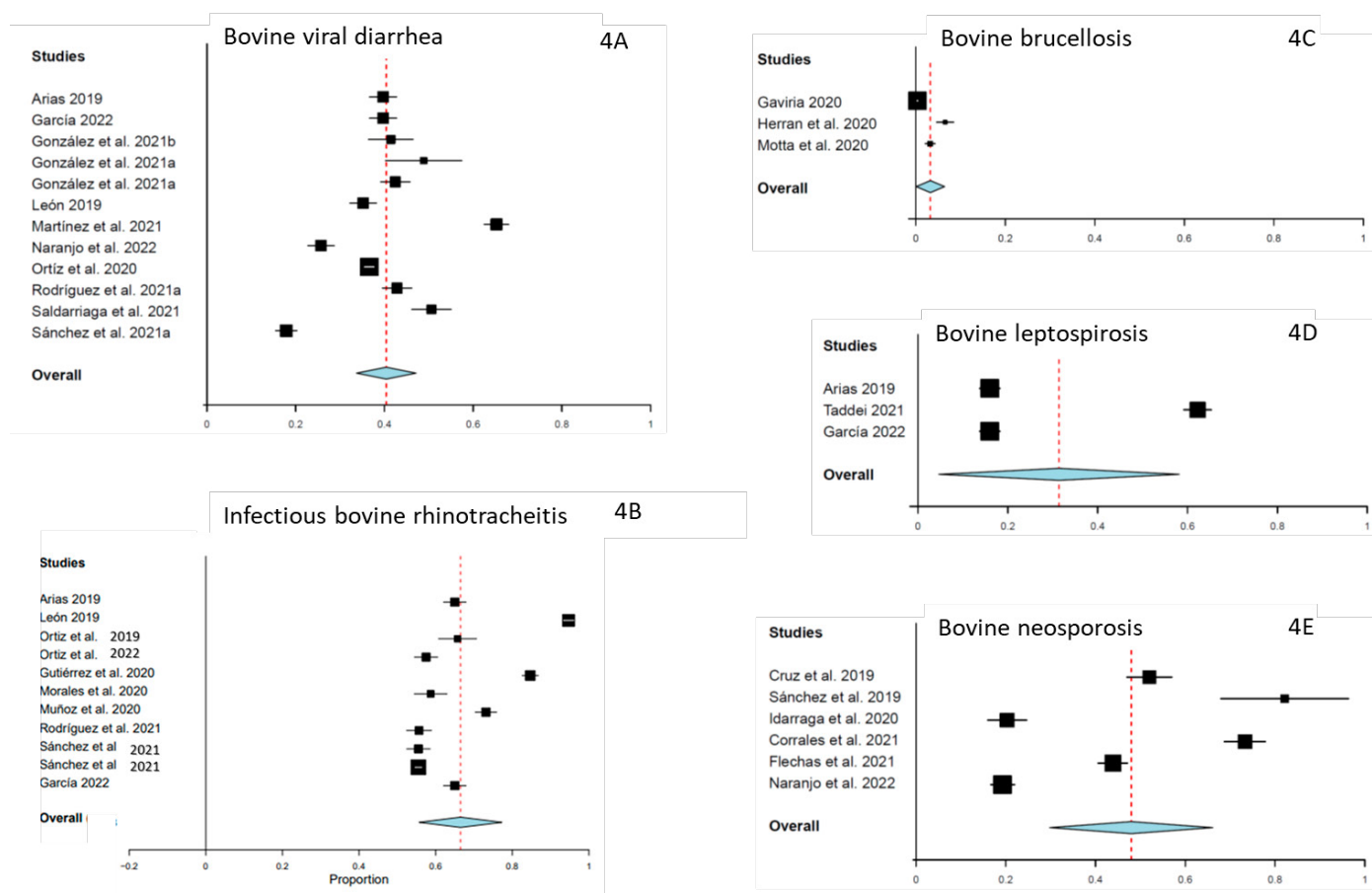


FIGURE 3. Result of the meta-analysis on the frequency of infected farms with reproductive diseases reported (3A. Bovine viral diarrhoea; 3B. Infectious bovine rhinotracheitis; 3C. Bovine brucellosis; 3D. Bovine neosporosis)

high heterogeneity ( $I^2 = 98.60\%$ ;  $P < 0.001$ ), (TABLE 1; FIG. 4A) [9, 14, 15, 17, 23, 24, 25, 26, 27, 28, 29]. On the other hand, for the prevalence in herds, only four studies were found where the average frequency was

TABLE 1  
Frequency of infected farms and individual prevalence in infected farms

Disease	Frequency of infected farms				Individual prevalence at infected farms			
	Studies	Farms	Frequency (95%CI)	$I^2$ (P-value)	Studies	Animals	Prevalence (95%CI)	$I^2$ (P-value)
Bovine viral diarrhoea	4	831	70.8% (47.9% – 93.7%)	98.75% (<0.001)	12	16,861	40.4% (33.7% – 47.1%)	98.60% (<0.001)
Infectious Bovine Rhinotracheitis	2	484	62.0% (-10.5% – 134.5%)	99.89% (<0.001)	11	20,143	66.5% (55.7% – 77.3%)	99.61% (<0.001)
Bovine brucellosis	3	238	20.2% (14.6% – 25.8%)	14.15% (0.312)	3	28,396	3.3% (0.1% – 6.4%)	96.99% (<0.001)
Bovine leptospirosis	1	384	37.0% (32.2% – 41.8%)	-	3	2,959	31.4% (4.6% – 58.2%)	99.71% (<0.001)
Bovine neosporosis	3	422	75.9% (58.9% – 92.8%)	85.14% (0.001)	6	2,813	48.0% (29.8% – 66.1%)	99.11% (<0.001)



**Figure 4. Result of the meta-analysis on the individual prevalence of reproductive diseases reported in infected farms (4A. Bovine viral diarrhea; 4B. Infectious bovine rhinotracheitis; 4C. Bovine brucellosis; 4D. Bovine leptospirosis; 4E. Bovine neosporosis)**

70.8%, 95%CI (47.9% – 93.7%) and also high heterogeneity ( $I^2 = 98.75\%$ ;  $P < 0.001$ ) (TABLE I; FIG. 3A) [14, 15, 16, 17].

Regarding IBR, the individual prevalence by ELISA in infected farms, eleven studies that included the departments of Boyacá, Caquetá, Córdoba, Cesar, Cundinamarca and Meta were found, where the average frequency was 66.5%, 95%CI (55.7% – 77.3%) and high heterogeneity ( $I^2 = 99.61\%$ ;  $P < 0.001$ ), so IBR was the most prevalent disease at individual level (TABLE I; FIG. 4B) [9, 23, 24, 28, 29, 31, 32, 33, 34, 35, 36]. Likewise, concerning the prevalence in herds, only 2 studies were found where the average frequency was 62.0%, 95%CI (-10.5% – 134.5%) and high heterogeneity ( $I^2 = 99.89\%$ ;  $P < 0.001$ ). The confident interval with negative values is due to the meta-analysis only includes 2 studies (TABLE I; FIG. 3B) [6, 16].

With reference to bovine brucellosis, the individual prevalence in infected farms by Rose Bengal, three studies were found in the departments of Putumayo, Caquetá, and Antioquia, where the average frequency was 3.3%, 95%CI (0.1% – 6.4%) and high heterogeneity ( $I^2 = 96.99\%$ ;  $P < 0.001$ ), that corresponds with the lower individual prevalence observed in our study (TABLE I; FIG. 4C) [19, 20, 37]. In terms of prevalence in herds, three studies were found where the average frequency was 20.2%, 95%CI (14.6% – 25.8%) and shows a good homogeneity, but not significant ( $I^2 = 14.15\%$ ;  $P < 0.312$ ). In this case the frequency of infected farms was also the lowest observed (TABLE I; FIG. 3C) [18, 19, 20].

For the individual prevalence of bovine leptospirosis pathology in infected farms by MAT (microagglutination), three studies were found in the departments of Boyacá and Córdoba, where the average frequency was 31.4%, 95%CI (4.6% – 58.2%) and high heterogeneity ( $I^2 = 97.19\%$ ;  $P < 0.001$ ) (TABLE I; FIG. 4D) [23, 24, 38]. Likewise, the prevalence in herds, only one study was found with a frequency of 37.0%, 95%CI (32.2% – 41.8%).

Finally, regarding bovine neosporosis, the individual prevalence in infected farms by ELISA, six studies were found in the departments of Antioquia, Boyacá, Cundinamarca, Caldas, Quindío, Risaralda, Valle del Cauca, Caquetá, Cesar, Magdalena, Meta, Santander and Tolima, where the average frequency was 48.0%; 95%CI (29.8% – 66.1%) and high heterogeneity ( $I^2 = 99.11\%$ ;  $P < 0.001$ ) (TABLE I; FIG. 4E) [21, 22, 27, 39, 40, 41]. Likewise, three studies were found about prevalence in herds, where the average frequency was 75.9%, 95%CI (58.9% – 92.8%) and moderate-heterogeneity ( $I^2 = 85.14\%$ ;  $P = 0.001$ ), and according this data bovine neosporosis would be the disease present in more dairy farms in Colombia (TABLE I; FIG. 3D) [16, 21, 22].

Furthermore, an analysis was performed in order to determine the global prevalence by disease as product of frequency of infected farms and individual prevalence, where the lower limit of the frequency of infected farms was multiplied by the lower limit of the individual prevalence in infected farms, and the upper limits were multiplied to obtain the upper limit (TABLE II).

**TABLE II**  
**Summary of the global prevalence of reproductive diseases reported in the last 3 years in dairy farms in Colombia according to the results of the meta-analysis**

Disease	Average	min	max
Bovine viral diarrhea	28.60%	16.14%	44.13%
Infectious bovine rhinotracheitis	41.23%	0.00%	77.30%
Bovine brucellosis	0.67%	0.01%	1.65%
Bovine leptospirosis	11.62%	1.48%	24.33%
Bovine neosporosis	36.43%	17.55%	61.34%

Since we do not have an accurate estimate of the individual and overall prevalence in infected herds, there is considerable variability that generates a high degree of uncertainty. This lack of accurate data makes it difficult to make effective decisions for monitoring and controlling these pathologies. In contrast, the situation is different with brucellosis, since more specific data are available. This greater precision is probably due to the vaccination and control programs implemented in Colombia.

According to this global analysis, the disease with the largest number of infected bovine populations was IBR 41.23% (0.00% – 77.30%) but with a vast confident interval, followed by Neosporosis with a prevalence of 36.43% (17.5% – 61.34%), and BVD with a 28.60% (16.14% – 44.13%). Finally, the two pathologies that reported lower overall results were Brucellosis with 0.67% (0.01% – 1.65%), followed by leptospirosis with 11.62% (1.48% – 24.33%).

Regarding the global prevalence of reproductive diseases in the present study, it was observed that the disease that presented the most significant number of infected bovine population was IBR (41.23%), followed by bovine Neosporosis (36.43%), and BVD (28.6%). Finally, the two pathologies that reported global results of lower presence of infected bovine population were bovine Brucellosis (0.83%), followed by Leptospirosis (11.62%). In most of the cases, a large variability of results was observed both at farm and individual level. These overall results contrast with what was published by FEDEGAN (42) which reports that 102,296 samples were processed, with 47% (48,542 samples) being positive. It is evident that the disease with highest number of reports was IBR (69%), followed by bovine Leptospirosis (46%), BVD (41%), bovine Neosporosis (37%), bovine Trichomoniasis (6%) and Campylobacteriosis (6%) [3]. This allows us to analyze that there is a variation in these figures if we compare these reports of reproductive diseases with the number found in the studies published in this systematic review and meta-analysis. Still, in general, they are very similar except for bovine leptospirosis, which in this study reports a lower prevalence and bovine Neosporosis that reports a higher prevalence. Some of these differences observed in studies by different authors, such as those included in this study, may also be due to differences in prevalence between departments and regions of the country in those who have developed these studies.

On the other hand, the results of an investigation accomplished by Vecol, Minagricultura and Corpoica [43], show that the prevalence of the most relevant diseases for the farmer was studied, in some municipalities of the Departments of Antioquia, Boyacá and Cundinamarca. In this study, it was found that the pathology with the highest prevalence was BVD (54%), followed by bovine Neosporosis (39%), then IBR (34%) and finally bovine Leptospirosis (17%). This

allows us to identify consistency with the study carried out since a relationship is observed with the number of studies obtained by disease in the systematic review, except by brucellosis; Although, it is noteworthy that Vecol, Minagricultura and Corpoica [43], did not take bovine brucellosis into account in their study, is possible that this disease has an important prevalence, because it has a national control program established by the ICA. However, the need to apply sanitary plans is evident to reduce the presence of these pathologies in the different regions of Colombia and thus avoid the impact that this generates in livestock farms.

On the other hand, a study published by Ordóñez *et al.* [44], in Ecuador mentions that, according to the results obtained, the main reproductive diseases presented in dairy farming were: IBR (48%), followed by BVD (36%), then bovine Neosporosis (24%) and later bovine Leptospirosis (10 to 12%), but there was no presence of bovine Brucellosis. A similar case was presented in Uruguay in an investigation obtained by Silveira [45], where he published that he analyzed information obtained between 2016 and 2019, on the main reproductive pathologies, and observed that the disease with the highest prevalence was bovine Neosporosis (36.1%), followed by bovine Leptospirosis (19.4%), then bovine Trichomoniasis (2.25%) and then BVD (0.35%). In the case of bovine Campylobacteriosis, in the present study, no findings compatible with the disease and diagnosis by immunological methods were found, which causes a contradiction with Barros and Silva [46], since they mention that the bovine campylobacteriosis disease is within the leading infectious diseases that affect reproduction in Uruguay. It should be noted that these variations in percentages are possibly due to the application of sanitary protocols, vaccination, and animal management in the different countries.

## CONCLUSION

There is a high degree of uncertainty due to the great variability of data on BVD, IBR, neosporosis and leptospirosis, which prevents knowing the real health status with precision. This highlights the need to improve protocols to take effective actions and decisions that help mitigate the presence of these pathologies.

There is low variability in the reported data on brucellosis, this is because in Colombia there is a prevention, control and eradication program established throughout the national territory for this disease.

It reflects that there are reproductive pathologies that have few prevalence studies such as Trichomoniasis, Toxoplasmosis, Campylobacteriosis, Histophilosis, Ureaplasmosis and Mycosis, which makes it difficult to identify their impact and establish strategies that contribute to improving the health status of dairy cattle, productivity and animal welfare.

## Conflicts of interest

The authors declare they have no conflicts of interest with regard to the work presented in this report.

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