



Temporal Analysis and Economic Implications of Reported Bovine Brucellosis Cases in Algeria



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Abstract

Bovine brucellosis is an important infectious and zoonotic disease affecting cattle production and public health. The disease may cause reproductive disorders, reduced productivity and economic losses at farm level, while also creating challenges for veterinary surveillance and disease control. This study investigated the temporal evolution of reported positive bovine brucellosis cases in Algeria and examined their relationship with calendar time and cattle population during the study period. A retrospective analysis of annual national secondary data was conducted using multiple linear regression. The analysis showed considerable year-to-year variation in reported cases, including a pronounced peak followed by a decline during the final years of the study period. The fitted model suggested positive associations between reported cases, calendar time and cattle population. However, the limited number of annual observations restricted the statistical strength of the model. The findings should therefore be interpreted as an analysis of reported surveillance data rather than as an estimate of true national prevalence or incidence. The study also highlights the economic relevance of bovine brucellosis through reproductive losses, possible reductions in milk production and expenditure related to veterinary care, diagnosis and disease control.

Keywords: Bovine brucellosis; Algeria; cattle population; temporal trend; reported cases; economic implications; zoonosis.

1. Introduction

Bovine brucellosis is a contagious bacterial disease of livestock and an important zoonosis with consequences for animal health, agricultural productivity and public health. In cattle, infection is commonly associated with abortion, stillbirth, infertility, prolonged calving intervals and other reproductive disorders. These effects may reduce herd productivity and generate economic losses for livestock producers [1].

The importance of bovine brucellosis extends beyond the direct biological effects of infection. Reproductive failure may result in the loss of calves, increased replacement requirements, reduced reproductive efficiency and lower herd productivity. In dairy production systems, reproductive disorders may also be associated with reductions in milk production. Additional costs may arise from veterinary services, diagnostic testing, vaccination, surveillance and other disease-control activities [2].

In Algeria, bovine brucellosis has been documented for several decades and remains an important veterinary and public-health concern. A retrospective national study covering 2009–2018 reported bovine and caprine brucellosis and provides the principal historical source for the annual bovine case figures used in the present analysis.

The interpretation of reported cases requires caution. The number of positive animals reported in a given year does not necessarily represent the true prevalence or incidence of infection in the national cattle population. Reported figures may be influenced by surveillance intensity, diagnostic testing, geographical coverage, reporting practices and the number of animals examined [3].

The cattle population is also relevant when interpreting annual reported cases. A larger cattle population may provide a larger population in which infected animals can potentially occur and be detected. However, the relationship between population size and reported cases is not necessarily proportional because detection depends on surveillance intensity and other epidemiological factors.

From an economic perspective, bovine brucellosis can affect livestock farms through reproductive losses, decreased milk production, veterinary expenditure, disease-control measures and losses associated with infected animals. Algerian research conducted in the Tiaret region has documented economic consequences associated with milk production, reproduction, veterinary care and vaccination among affected cattle farms.

The public-health importance of the disease further supports the need for effective animal surveillance. Because bovine brucellosis is zoonotic, control of infection in cattle can contribute to reducing opportunities for human exposure and improving food safety.

More recent Algerian research has continued to examine brucellosis beyond the historical period considered in this study and has emphasized the importance of integrating animal and human surveillance within a One Health framework [4]. Such later evidence is used here only to contextualize the historical findings and is not included in the statistical model.

The present study therefore aimed to examine the temporal pattern of reported positive bovine brucellosis cases in Algeria during 2010–2018 while considering cattle population as an additional explanatory variable. The study is intended as a retrospective analysis of reported surveillance data and not as an estimation of national prevalence, incidence or total economic cost.

1.2 Research Problem

The annual number of reported bovine brucellosis cases may vary because of changes in disease occurrence, cattle population size, surveillance intensity and diagnostic practices. Consequently, examining calendar time alone may not provide a sufficiently informative interpretation of the observed variation.

The central research question is:

To what extent are annual variations in reported positive bovine brucellosis cases in Algeria associated with year and cattle population during 2010–2018?

1.3 Research Gap

Previous Algerian studies have documented bovine brucellosis at national and regional levels. However, there is limited quantitative analysis combining temporal variation and cattle population within a single statistical model using annual national surveillance data.

The present study addresses this gap by applying a multiple linear regression model to national data.

1.4 Research Objective

The main objective was to assess the temporal evolution of reported positive bovine brucellosis cases in Algeria during 2010–2018 and to examine their statistical relationship with calendar time and cattle population.

The specific objectives were to:

1. describe the annual evolution of reported positive bovine brucellosis cases;
2. describe changes in cattle population during the study period;
3. examine the association between calendar time and reported cases while accounting for cattle population;
4. examine the association between cattle population and reported cases while accounting for calendar time; and
5. discuss the epidemiological, economic and public-health implications of the observed pattern.

1.5 Research Hypotheses

H1: Calendar time is associated with annual reported positive bovine brucellosis cases after accounting for cattle population.

H2: Cattle population is associated with annual reported positive bovine brucellosis cases after accounting for calendar time.

H3: Calendar time and cattle population jointly provide explanatory information about annual variation in reported positive bovine brucellosis cases.

2. Section 1: Materials and Methods

2.1 Study Design and Data Source

A retrospective quantitative ecological design was adopted.

The study covered the period from 2010 to 2018 and used annual national data on reported positive bovine brucellosis cases.

The analysis focused on the annual number of reported positive bovine brucellosis cases in Algeria during the study period.

The present study consisted of a statistical analysis of the available annual bovine brucellosis data for the period 2010–2018.

2.2 Variables

The dependent variable was:

Y = annual number of reported positive bovine brucellosis cases.

Two explanatory variables were included:

T = calendar-time index.

C = cattle population expressed in millions of animals.

The time index was coded as follows:

Table 01 : Calendar-Time Index Coding for the Study Period

Year	T
2010	0
2011	1
2012	2
2013	3
2014	4
2015	5
2016	6
2017	7
2018	8

2.3 Annual Reported Positive Cases

Table 02 .: Calendar-Time Index Coding and Annual Reported Positive Bovine Brucellosis Cases

Year	T	Reported positive cases(cases)
2010	0	948
2011	1	1,104
2012	2	1,161
2013	3	1,206
2014	4	1,485
2015	5	1,178
2016	6	2,473
2017	7	1,999
2018	8	1,303
Total		12,857

Source: Directorate of Veterinary Services, Ministry of Agriculture and Rural Development, Algeria.

2.4 Cattle Population

The cattle population was included as the second explanatory variable.

Table 03 : Annual Cattle Population in Algeria During the Study Period

Year	Cattle population(head)
2010	1,747,700
2011	1,790,140
2012	1,843,930
2013	1,909,455
2014	2,049,652
2015	2,149,549
2016	2,081,306
2017	1,895,126
2018	1,816,280

Source: National Office of Statistics (ONS), For the regression analysis, these values were expressed in millions of cattle.

2.5 Statistical Analysis

A multiple ordinary least squares regression model was used.

The model was expressed simply as:

$$Y = a + b_1T + b_2C$$

where:

- **Y** = reported positive bovine cases;
- **T** = time index;
- **C** = cattle population in millions;
- **a** = constant;
- **b₁** = coefficient for time;
- **b₂** = coefficient for cattle population.

The coefficient of determination (R^2), adjusted R^2 and overall F-test were considered when interpreting the model.

A statistical significance level of 5% was adopted.

Because only nine annual observations were available, all inferential results were interpreted cautiously.

3. Section 2: Results and Discussion

3.1 Descriptive Results

A total of **12,857 reported positive bovine brucellosis cases** were recorded during the study period.

The annual mean was **1,428.56 cases**.

The lowest annual number was recorded in 2010, while the highest was observed in 2016.

Following the peak in 2016, the number of reported cases declined in 2017 and again in 2018.

The annual series therefore demonstrated substantial fluctuations rather than a continuous increase.

3.2 Temporal Pattern

The reported cases showed a general increase during the first part of the study period, although the pattern was not continuous.

A decrease was observed in 2015, followed by a marked increase in 2016. The 2016 peak was subsequently followed by decreases in 2017 and 2018.

This pattern indicates that the annual evolution of reported cases cannot be fully described by a simple straight-line increase.

The pronounced variation may reflect changes in the epidemiological situation as well as changes in surveillance, diagnostic activity and reporting.

3.3 Multiple Regression Results

Table 04 : Multiple Linear Regression Coefficients for Reported Positive Bovine Brucellosis Cases

Predictor	B	Std. Error	Beta	t	Sig.
Constant	-685.162	2183.533	—	−0.314	0.764
Time	91.921	60.929	0.555	1.509	0.182
Cattle population (million)	909.227	1182.298	0.283	0.769	0.471

Source: Authors' calculations using IBM SPSS Statistics

The estimated regression equation was:

$$\text{Reported cases} = -685.16 + 91.92 \times \text{Time} + 909.23 \times \text{Cattle population}$$

where cattle population is expressed in millions.

In simple terms, the model estimates the number of reported cases from two variables: **the passage of time and the size of the cattle population**.

The time coefficient was positive. Within the fitted model, one additional year was associated with approximately 92 additional reported positive cases, after accounting for cattle population.

The cattle-population coefficient was also positive. Because cattle population was expressed in millions, an increase of one million cattle was associated with approximately 909 additional reported cases, after accounting for calendar time.

These coefficients represent statistical associations and should not be interpreted as causal effects.

3.4 Overall Model

Table 05 : Multiple Linear Regression Model for Reported Positive Bovine Brucellosis Cases

Indicator	Value
Observations	9
Intercept	-685.16
Time coefficient	91.92
Cattle-population coefficient	909.23
R ²	0.438
Adjusted R ²	0.251
F-statistic	2.339
Residual degrees of freedom	6

Source: Authors' calculations using IBM SPSS Statistics.

The model produced an **R² of 0.438**, indicating that approximately 43.8% of the observed annual variation in reported cases was accounted for by calendar time and cattle population in the fitted model.

The adjusted R² was lower, reflecting the small number of observations and the inclusion of two explanatory variables.

The overall model did not reach conventional statistical significance at the 5% level.

Therefore, the model should be considered **exploratory rather than confirmatory**.

Because calendar time and cattle population may change simultaneously over the study period, a multicollinearity diagnostic was performed to assess whether the explanatory variables were sufficiently independent for inclusion in the multiple regression model. The variance inflation factor (VIF) was 1.216 for both calendar time and cattle population. This value is well below the commonly used threshold of 5, indicating a low degree of multicollinearity and no substantial inflation of the variance of the regression coefficients. Therefore, multicollinearity was not considered a major concern in the interpretation of the fitted model.

Regarding the hypotheses, H1 showed the stronger association among the individual predictors, with a positive association between calendar time and reported bovine brucellosis cases ($\beta_1 = 91.92$, $p = 0.182$). However, this association was not statistically significant at the 5% significance level.

3.5 Epidemiological Interpretation

The positive coefficient for time indicates an upward fitted direction in reported cases after accounting for cattle population.

However, this does not demonstrate that the underlying prevalence of bovine brucellosis increased significantly.

Similarly, the positive cattle-population coefficient is epidemiologically plausible because a larger cattle population creates a larger population in which infection may occur and be detected.

Nevertheless, population size alone cannot explain the observed fluctuations.

The number of reported cases depends not only on the number of cattle but also on the number of animals tested, the geographical coverage of surveillance, diagnostic methods, reporting practices and disease-control activities.

Consequently, an increase in reported cases may sometimes indicate improved detection rather than an actual increase in disease prevalence.

3.6 Economic Implications

Bovine brucellosis has economic implications for cattle farms even when the available surveillance data do not permit a direct calculation of national monetary losses.

The main economic consequences include abortion, infertility, stillbirth, prolonged calving intervals, loss of calves and possible reductions in milk production

Additional costs may result from veterinary consultation, diagnostic testing, vaccination, surveillance, animal management and disease-control measures.

Evidence from Algeria, particularly research conducted in the Tiaret region, has documented economic consequences associated with bovine brucellosis and examined effects related to reproduction, milk production, veterinary care and vaccination.

The disease therefore represents an economic issue as well as an epidemiological and public-health issue.

However, the number of reported positive cases cannot be directly multiplied by an assumed cost to obtain a national economic loss.

A reliable cost-of-disease estimate would require additional information on herd size, number of animals tested, reproductive losses, milk production, animal replacement, culling, veterinary expenditure and control costs.

3.7 Public Health and One Health Perspective

Bovine brucellosis has an important zoonotic dimension.

Infected cattle and contaminated animal products may contribute to human exposure, making control of animal infection relevant to food safety and public health.

A One Health approach is therefore appropriate because effective control requires interaction between veterinary surveillance, human-health surveillance, food-safety measures and livestock management.

Algerian studies have highlighted the relationship between animal brucellosis and human health and the importance of surveillance and control [5].

3.8 Interpretation of the 2016 Peak

The pronounced increase in reported cases in 2016 deserves particular attention.

The peak may reflect an actual increase in disease occurrence, increased surveillance activity, expanded testing or changes in reporting.

Because the present dataset does not contain annual information on the number of animals tested or surveillance intensity, it is not possible to determine which explanation contributed most strongly to the peak.

Therefore, the 2016 observation should be regarded as an important feature of the reported surveillance series rather than automatically interpreted as an epidemiological outbreak.

Research conducted after 2018 indicates that brucellosis continued to be investigated in Algeria and that surveillance remained relevant to both animal health and public health [6].

4. Conclusion

This study provided a national retrospective assessment of the temporal evolution of reported positive bovine brucellosis cases in Algeria during 2010–2018, while examining their relationship with calendar time and cattle population using multiple linear regression. By combining national surveillance data with quantitative statistical analysis, the study provided a broader perspective on the evolution of reported bovine brucellosis and highlighted important patterns that may contribute to a better understanding of the disease in the Algerian cattle population.

The results revealed considerable year-to-year variation in reported positive cases, with a pronounced peak in 2016 followed by a decline during 2017 and 2018. This temporal pattern demonstrates that reported bovine brucellosis varied substantially throughout the study period and emphasizes the importance of continuous surveillance and longitudinal analysis when assessing the evolution of the disease. The regression analysis further indicated positive associations between reported cases, calendar time and cattle population, suggesting that both temporal changes and the size of the cattle population are relevant factors when interpreting variations in reported cases.

An important contribution of this study is the integration of calendar time and cattle population within a single statistical framework. Rather than considering annual case numbers independently, the analysis examined their variation in relation to two important explanatory factors. This approach provides a quantitative basis for interpreting national surveillance data and contributes to a more structured understanding of the epidemiological pattern of bovine brucellosis in Algeria.

The study also highlights the economic importance of bovine brucellosis for cattle production. The disease may affect farm productivity through abortion, infertility, stillbirth, reduced reproductive efficiency and possible decreases in milk production. Additional economic consequences may result from veterinary care, diagnostic testing, vaccination, surveillance and disease-control activities. Although the present study did not calculate the total monetary burden of bovine brucellosis, the temporal patterns identified provide an important basis for understanding the potential economic significance of variations in disease occurrence and detection.

From a public-health perspective, the zoonotic nature of bovine brucellosis reinforces the importance of controlling infection in cattle. Strengthening animal surveillance and disease-control measures can

contribute to reducing opportunities for human exposure and improving food safety. The findings therefore support an integrated One Health perspective in which animal health, public health and livestock productivity are considered as interconnected components of disease management.

Overall, this study contributes to the epidemiological understanding of bovine brucellosis in Algeria by documenting its temporal variation, identifying the marked peak observed in 2016, and examining the relationship of reported cases with calendar time and cattle population. It also demonstrates the value of national surveillance data as a foundation for epidemiological and economic assessment. The findings can serve as a useful reference for future research and for strengthening disease-monitoring strategies through more systematic collection of information on animals tested, geographical distribution, herd characteristics, surveillance intensity, reproductive outcomes and economic indicators.

In this context, integrating epidemiological surveillance with economic assessment and public-health monitoring would provide a more comprehensive understanding of the burden of bovine brucellosis and contribute to the development of more informed and sustainable disease-control strategies in Algeria.

5. Recommendations

Based on the findings of this study, the following recommendations are proposed:

- ✓ Strengthen epidemiological surveillance and improve the recording of reported cases and the number of animals tested annually.
- ✓ Conduct future studies using longer and more detailed time series, particularly including the number of animals tested and the geographical distribution of disease.
- ✓ Quantify the economic impact of brucellosis by linking reported cases with production and reproductive losses and the costs of diagnosis and disease control.
- ✓ Strengthen the One Health approach by integrating animal-health, human-health and food-safety data

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