DOI: 10.1590/1809-6891v24e-73611E

Ciência Animal Brasileira
Brazilian Animal Science

e-ISSN 1809-6891

Section: Veterinary medicine
Research article

# Impact on condemnations of bovine carcasses for tuberculosis and cysticercosis after changes in federal legislation in the state of Rio Grande do Sul (2014-2020)

## Impacto nas condenações de carcaças bovídeas por tuberculose e cisticercose após as modificações na legislação federal no estado do Rio Grande do Sul (2014-2020)

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**Abstract**
The inspection of products of animal origin, carried out by veterinary agricultural inspectors, is based on the Brazilian legislation described in the Regulation of Industrial and Sanitary Inspection of Products of Animal Origin of the Ministry of Agriculture, Livestock and Supply. On March 29, 2017, Decree No. 9,013 was published, which repeals Decree No. 30,691, of 1952, with this, major changes occurred in the legislation described in RIISPOA, such as the criteria used for judging carcasses. The objective of this study was to verify whether these changes had an impact on condemnations of bovine carcasses because of cysticercosis and tuberculosis in the State of Rio Grande do Sul. The number of animals slaughtered and the number of carcasses condemned because of tuberculosis and cysticercosis between 2014 and 2020 were obtained from the database of the Agricultural Defense System (SDA), the official data system of the Secretariat of Agriculture, Livestock and Rural Development (SEAPDR), it was possible to observe an increase in the number of cases of carcasses condemned because of cysticercosis and a reduction of animals affected by the disease in the period after the changes in the regulation. The number of carcasses condemned because of tuberculosis, as well as the number of animals affected by the disease, remained stable after the changes in the regulation. The results showed that the changes in federal legislation had a real impact on the historical series of condemnations of bovine carcasses due to cysticercosis in the state of Rio Grande do Sul. In carcasses affected by tuberculosis, the impact of carcass condemnation on the historical series after changes was not significant.
**Keywords:** RIISPOA; inspection; zoonoses; trend; kernel.

**Resumo**
A inspeção de produtos de origem animal, realizada por médicos veterinários fiscais agropecuários, é baseada na legislação brasileira descrita no Regulamento da Inspeção Industrial e Sanitária de Produtos de Origem Animal (RIISPOA) do Ministério da Agricultura, Pecuária e Abastecimento (MAPA). No dia 29 de março de 2017 foi publicado o Decreto nº 9.013, que revoga o Decreto nº 30.691, de 1952, com isso grandes alterações ocorreram na legislação descrita no RIISPOA, como os critérios de julgamento de carcaças. O objetivo desse estudo foi verificar, se essas alterações tiveram impacto nas condenações de carcaças de bovídeos por cisticercose e tuberculose no Estado do Rio Grande do Sul (RS). O número de animais abatidos e o número de carcaças condenadas por tuberculose e cisticercose entre 2014 e 2020 foram obtidos do banco de dados do Sistema de Defesa Agropecuária (SDA), sistema oficial de dados da Secretaria da Agricultura Pecuária e Desenvolvimento Rural (SEAPDR), foi possível observar aumento do número de casos de carcaças condenadas por cisticercose e redução de animais afetados pela enfermidade no período após as alterações no regulamento. O número de carcaças condenadas por tuberculose, assim como o número de animais afetados pela doença se manteve estável após as mudanças no regulamento. Os resultados encontrados mostraram que as modificações na legislação federal trouxeram impacto real na série histórica de condenações de carcaças bovídeas por cisticercose no âmbito do Estado do Rio Grande do Sul enquanto nas carcaças afetadas por tuberculose o impacto das condenações não foi significativo.
**Palavras-chave**: RIISPOA; inspeção; zoonoses; tendência; kernel.

Received: September 9, 2022. Accepted: November 21, 2022. Published: January 17, 2023.


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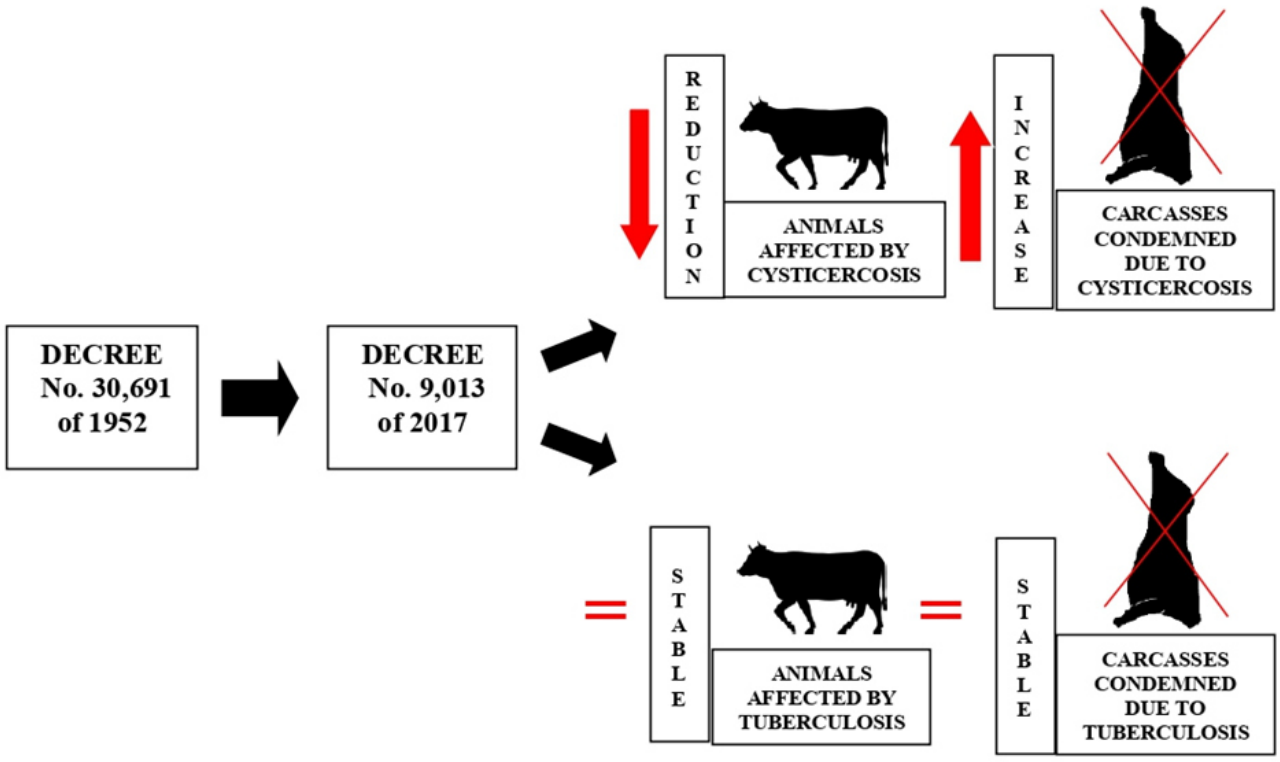



**Graphical abstract:** Impact on condemnations of bovine carcasses for tuberculosis and cysticercosis after changes in federal legislation in the state of Rio Grande do Sul (2014-2020)

## 1. Introduction

Slaughtered animals in Brazil are subject to ante-mortem and post-mortem inspection procedures, which follow the hygienic-sanitary and technological guidelines provided in the Brazilian Regulation for the Industrial and Sanitary Inspection of Animal Origin Products (RIISPOA). Condemnations during slaughter due to the identification of lesions suggestive of diseases of importance to public health are essential to guarantee the quality and health of products of animal origin. On the other hand, condemnation of carcasses, organs, and viscera are among the main causes of economic losses for the production chain.[1] In this sense, identifying the causes of carcass condemnation is important and provides support for improvements in the production process, helping to reduce losses.[1]

Cysticercosis is considered one of the main parasitic diseases responsible for condemnations and risks to public health in several countries.[2] Estimated data to calculate the economic impact caused by bovine cysticercosis are collected from various sources in the meat sectors and include value losses for infected carcasses, which undergo conditional use, and costs due to carcass condemnation.[3] Bovine tuberculosis is a zoonosis of great importance that requires control measures, as it negatively affects the economy, human health, and the health and welfare of animals.[4] Control programs have a high cost for the states, making it important that they are a long-term commitment.[5]

Among the main causes of condemnation of bovine carcasses in the State of Rio Grande do Sul, RS, Brazil, are those caused by diseases such as tuberculosis and cysticercosis. Both diseases cause not only financial losses but also major problems for public health.[6] Bovine cysticercosis is detected through routine inspection of slaughtered bovines. Animals with localized infections often do not have the detected cysts.[3] However, cysticercosis is the most frequently detected zoonosis in post-mortem inspection. Brazil has a lack of information on bovine cysticercosis epidemiology despite the wide data availability[7]. Cysticercosis and tuberculosis are causes of condemnation of carcasses in all regions of the State.[6] Routine inspection in slaughterhouses may not identify all animals with tuberculosis, and

discarded animals are often slaughtered in clandestine slaughterhouses or disposed of at the place of raising, which can interfere with the estimate of disease prevalence.[8]

Condemnation data obtained through the official health inspection system are an important tool to guide cysticercosis and tuberculosis control plans.[6] The norms that regulate the inspection and industrial and sanitary inspection of animal-origin products were established by Decree No. 30,691[9] of 3/29/1952. This decree was revoked by Decree No. 9,013[10] in 2017. As a result, changes occurred in the legislation described in RIISPOA, such as the criteria for judging carcasses with lesions suggestive of tuberculosis and cysticercosis. Importantly, Decree No. 10,468,[11] which revoked Decree No. 9,013 of 2017 and brought new changes to RIISPOA, was published on August 18, 2020. Subsequently, Normative Instruction No. 121[12] was published on February 26, 2021, aiming at adapting the slaughter establishments and determining a period of 18 months for the application of changes in the judgment of carcasses with cysticercosis. The deadline established by the normative instruction was aligned with the deadline determined for slaughter establishments to register producers and carry out programs to improve the quality of raw materials and continuing education.

In this context, this study aimed to evaluate whether changes in the RIISPOA legislation after the publication of Decree 9,013 on March 29, 2017, impacted the frequency and distribution of condemnations for cysticercosis and tuberculosis of bovine carcasses slaughtered in slaughterhouses under the inspection of the State of Rio Grande do Sul.

## 2. Material and methods

The number of slaughtered animals and the number of carcasses affected by lesions suggestive of cysticercosis and tuberculosis detected in the post-mortem inspection, responsible for the condemnation of carcasses, during the period from 2014 to 2020 were provided by the State Inspection Service (SIE). The condemnation data were obtained from the Agricultural Defense System (SDA) database, the official data system of the Secretariat of Agriculture, Livestock, and Rural Development (SEAPDR).

The database was analyzed, and the data were extracted and compiled into a new Excel spreadsheet. The total number of bovines slaughtered under state inspection in the State of Rio Grande do Sul, the total number of condemnations of carcasses due to cysticercosis and tuberculosis, and the total number of animals affected by both diseases were filtered in this spreadsheet. The data were subdivided by mesoregion of origin of the animals and covered the period from April 2014 to March 2017 and April 2017 to March 2020, totaling three years before the changes in RIISPOA and three years after the changes in the criteria of condemnations for these two diseases. The present study was submitted to the Committee on Ethics in the Use of Animals (CEUA-IPVDF) and dismissed through Official Letter No. 20/20 – CEUA/IPVDF for not using live animals in its design.

### 2.1. Statistical analyses

#### 2.1.1. Comparison of proportions

The paired Student t-test was used to compare the proportions of condemnations for cysticercosis and tuberculosis in the period before the law and after its modification. The data on the proportions of condemnations for cysticercosis and tuberculosis were previously tested for normality following a normal distribution.[13] A significance level of 0.05 was adopted.

#### 2.1.2. Time series of cysticercosis and tuberculosis condemnations

The studied phenomena consisted of condemnations of carcasses due to cysticercosis and tuberculosis, conditional use due to cold (cysticercosis), and the number of animals affected by both diseases. Time series were built with the absolute frequencies of the phenomena in each month of observation, three years before and three years after the modification in the legislation. Linear trend estimates were performed for each phenomenon and the factors that influenced the behavior of the series were evaluated. A generalized linear model using simple linear regression was used for trend analysis. The centered moving average on the number of periods that make up a repetition for all phenomena was used to remove the possible effect of the seasonality of the series. All analyses were performed using the MINITAB[14] software.

#### 2.1.3. Kernel density

A condemnation rate was created. The number of carcasses condemned for cysticercosis was added to the number of carcasses treated by cold and this value was divided by the total number of animals affected by cysticercosis in the period. The condemnation rate for carcasses condemned due to tuberculosis was created by dividing the number of condemned carcasses by the total number of animals affected by tuberculosis in the period. Kernel density estimation and geographic point clustering analyses were used to calculate the density and spatial distribution of carcass condemnations by mesoregion of animal origin and year, respectively, using QGIS software version 3.12.1.[15]

### 2.1.4. Directional distribution of cysticercosis and tuberculosis condemnation rates

A common way to measure the trend for a set of points or areas is to calculate the standard distance separately in the x, y, and z directions. These measures define the axes of an ellipse (or ellipsoid), covering the distribution of features (slaughterhouses). The ellipse is called a standard deviation ellipse, as the method calculates the standard deviation of the x and y coordinates from the mean center to define the axes of the ellipse. The standard deviation ellipse calculation makes the direction trend clear. Ellipses were calculated for the cysticercosis and tuberculosis condemnation rates. These standard deviation ellipses were calculated using the locations of slaughterhouses.[16)]

## 3. Results and discussion

According to the analyses carried out using official data on condemnations due to cysticercosis and tuberculosis, obtained from the Agricultural Defense System (SDA) database, the official data system of the Secretariat of Agriculture, Livestock, and Rural Development (SEAPDR) (Table 1), an increase in the frequency of condemnations due to cysticercosis was observed after 2017 (Figure 1A). This increase was probably due to changes in the criteria for judging carcasses from animals with cysticercosis after the publication of Decree No. 9,013. After these changes, the carcass with only a single cyst already calcified can be destined for human consumption without restrictions. On the other hand, carcasses with more than one *Cysticercus bovis* cyst, viable or calcified, must be destined for conditional utilization by the use of heat. However, slaughterhouses under state inspection in the State of Rio Grande do Sul do not have appropriate facilities for heat sterilization. Thus, carcasses with more than one cyst are condemned, unlike what happened before the changes in legislation, when only carcasses with intense infestation by *Cysticercus bovis* were condemned.

**Table 1.** Distribution of official data before and after changes in RIISPOA

| | | Tuberculosis | | Cysticercosis | | |
|---|---|---|---|---|---|---|
| | Total animals slaughtered | Affected | Condemned | Affected | Condemned | Cold treatment |
| Before regulatory changes | 2,929,315 | 3,520 | 3,103 | 44,606 | 521 | 3,556 |
| After regulatory changes | 3,002,818 | 4,737 | 4,001 | 24,398 | 1,757 | 3,516 |

An increasing linear trend in the number of carcasses condemned for cysticercosis can be observed in the periods before and after regulatory changes (Figure 1B–C). A decrease in the number of animals affected by cysticercosis was also observed in the analysis of the entire studied series (Figure 2A). The linear trend before changes was increasing and, after regulatory changes, the linear trend was decreasing for carcasses affected by cysticercosis (Figure 2B–C), which indicates a very satisfactory result, as the increase in control measures in the properties aiming the decrease of economic losses may be related to this downward trend in affected animals.

The adoption of prophylactic and control measures in endemic areas is fundamental even with a decrease in the prevalence of cysticercosis, aiming at reducing the financial loss for the beef production chain in Brazil.[17)] A study carried out in the State of Rio Grande do Sul from 2014 to 2018 in slaughtered carcasses showed a trend for a decrease in cysticercosis, whose variation was justified by the presence of risk factors, and an increase in the condemnation rate and cold treatment for cysticercosis.[18)]

The number of carcasses that received conditional use through cold treatment remained stable in the period before and after regulatory changes, but the number of animals affected by cysticercosis decreased, which defines a proportional increase in cold treatment of affected carcasses (Figure 3C). Changes in the regulation in 2017 established that the carcass must be destined to the conditional treatment by cold or salting in the case of a single viable cyst; before these changes, the carcass would only be destined to cold treatment in cases of a slight to moderate infestation, which justifies the increase in conditional use by cold treatment of carcasses affected by cysticercosis after changes in the regulation. A trend towards an increase in the number of cold-treated carcasses was observed before the changes, but the trend became downward after the changes, considering the total number of animals slaughtered in the period (Figure 3A–B).

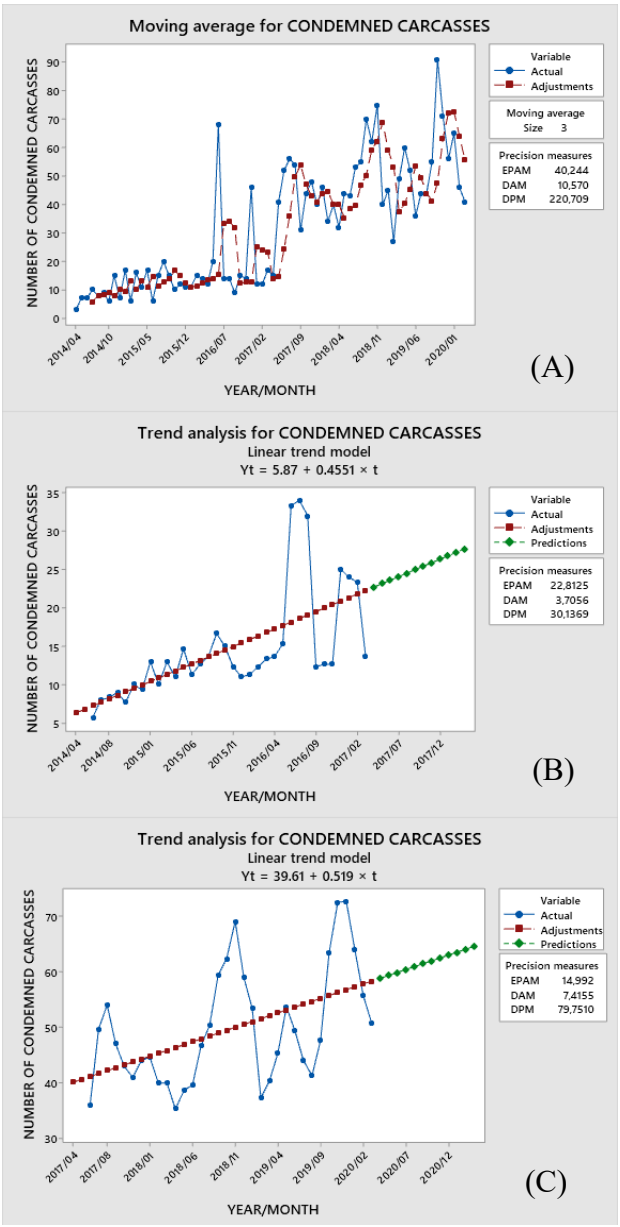



**Figure 1.** Number of carcasses condemned due to cysticercosis. (A) Moving average in the period from 04/2014 to 03/2020, the entire series, three years before and three years after changes in RIISPOA; (B) Linear trend in the period from 04/2014 to 03/2017, before changes in RIISPOA; (C) Linear trend in the period from 04/2017 to 04/2020, after changes in RIISPOA.

The main change in the regulation for carcasses from animals with tuberculosis was the detailing of the judgment criteria. The article was more clearly rewritten, which made it easier for official veterinarians to interpret. In addition to detailing the article, it defines that carcasses can only be released fresh when they have only a discrete tuberculous lesion located and completely calcified in a single organ or lymph node. However, these changes in legislation did not result in an increase in the historical series of carcasses condemned for tuberculosis (Figure 4A–C). A stable trend of animals affected by tuberculosis was observed during the total period of study (Figure 5A–C), with a slightly increasing linear trend after changes in legislation (Figure 5C).

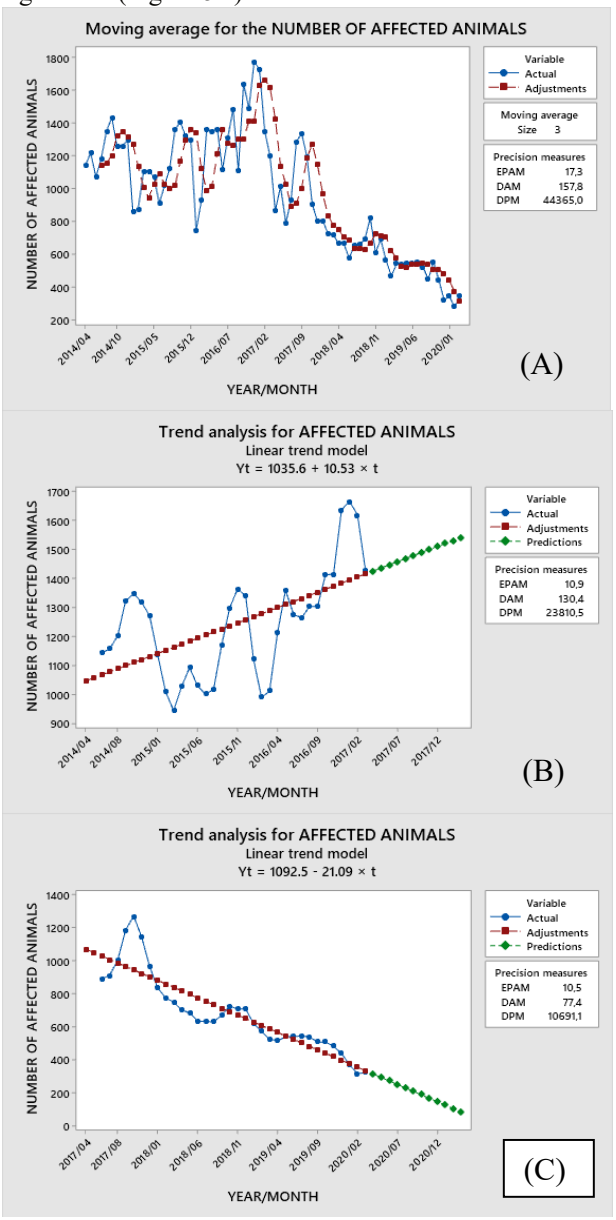



**Figure 2.** Animals affected by cysticercosis. (A) Moving average in the period from 04/2014 to 03/2020, the entire series, three years before and three years after changes in RIISPOA; (B) Linear trend in the period from 04/2014 to 03/2017, before changes in RIISPOA; (C) Linear trend in the period from 04/2017 to 04/2020, after changes in RIISPOA.

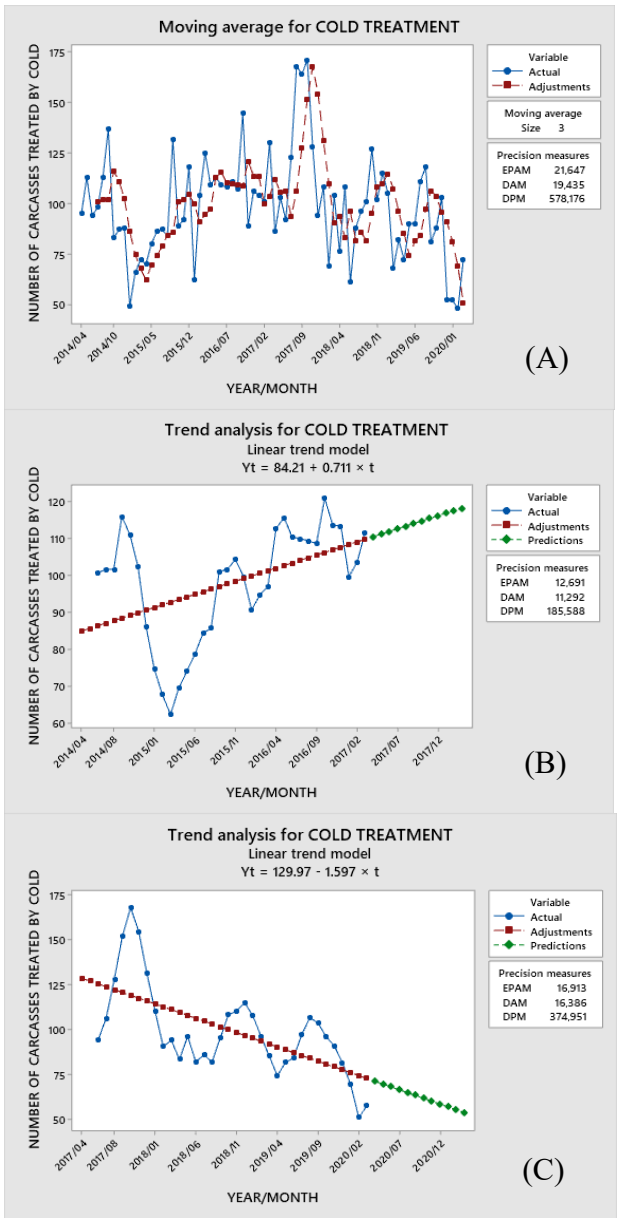



**Figure 3.** Carcasses affected by cysticercosis treated by cold. (A) Moving average in the period from 04/2014 to 03/2020, the entire series, three years before and three years after changes in RIISPOA; (B) Linear trend in the period from 04/2014 to 03/2017, before changes in RIISPOA; (C) Linear trend in the period from 04/2017 to 04/2020, after changes in RIISPOA.

Tuberculosis and cysticercosis are causes of condemnation in all regions of the state. A survey of condemnations between 2009 and 2016 of bovine carcasses, slaughtered under sanitary inspection by the Division of Inspection of Animal Origin Products (DIPOA) in the State of Rio Grande do Sul, demonstrated the presence of cysticercosis in 1.23% of bovine carcasses and tuberculosis in 0.14%.[6] In the present study, a high frequency of cysticercosis was also verified in comparison with tuberculosis throughout the study period. However, an inverse relationship with a high proportion of convictions for tuberculosis to the detriment of cysticercosis was observed when the proportions of condemnations were compared (Table 1).

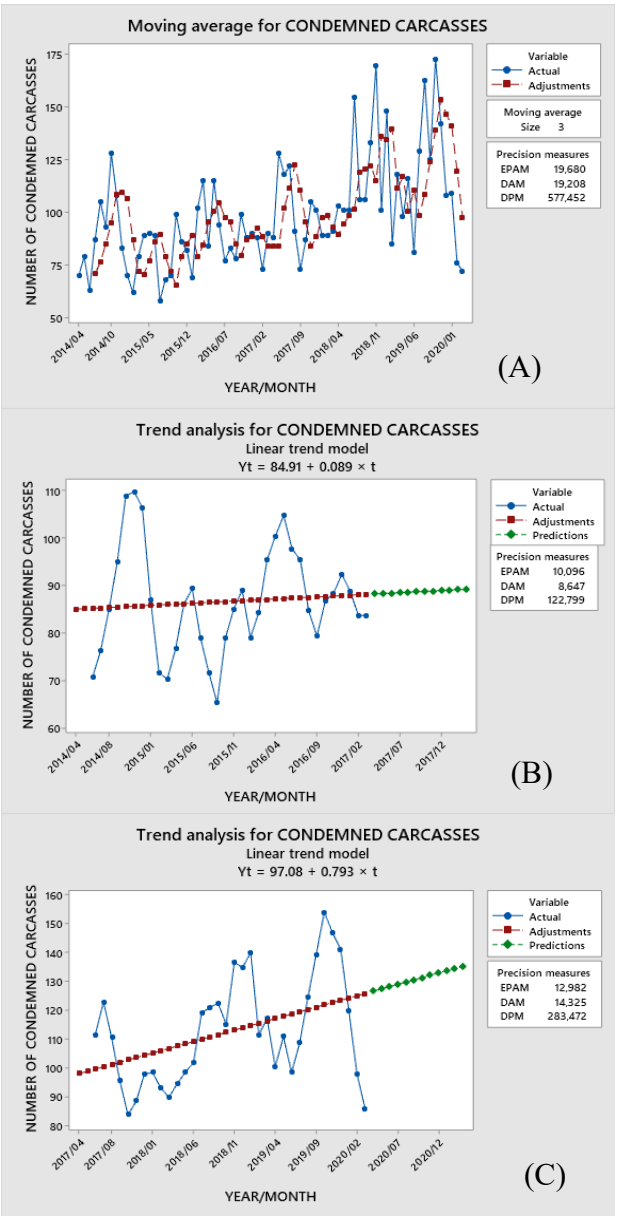



**Figure 4.** Number of carcasses condemned due to tuberculosis. (A) Moving average in the period from 04/2014 to 03/2020, the entire series, three years before and three years after changes in RIISPOA; (B) Linear trend in the period from 04/2014 to 03/2017, before changes in RIISPOA; (C) Linear trend in the period from 04/2017 to 04/2020, after changes in RIISPOA.

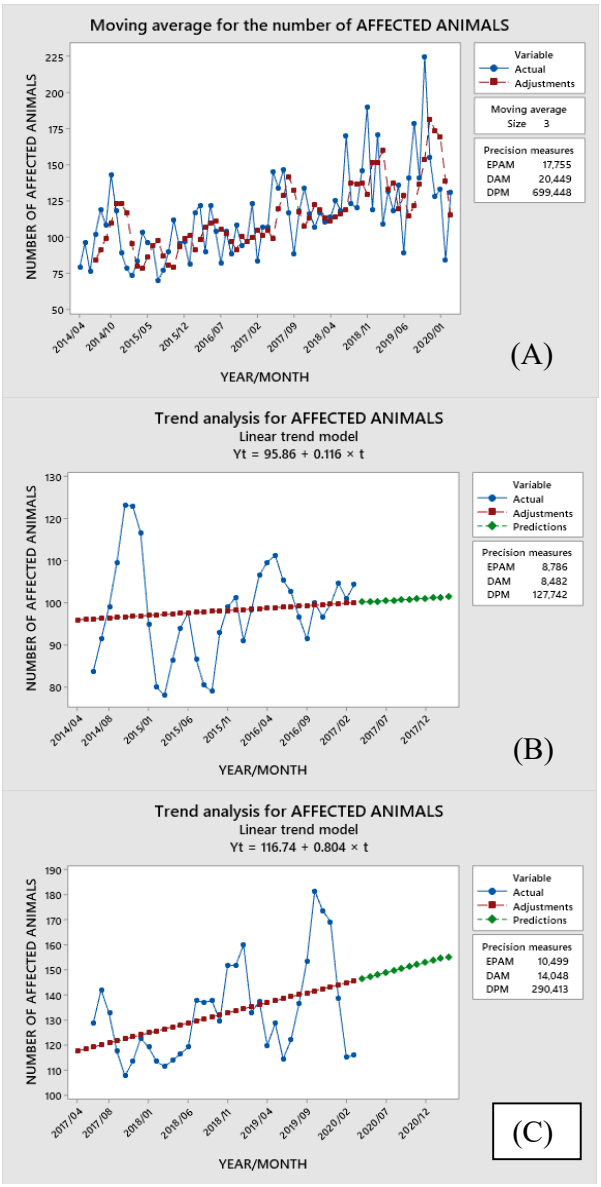
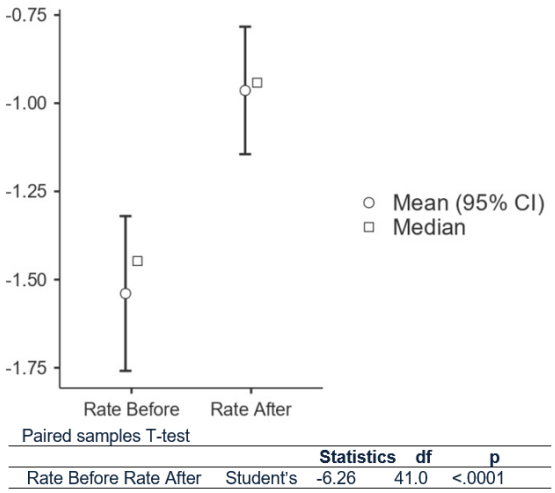


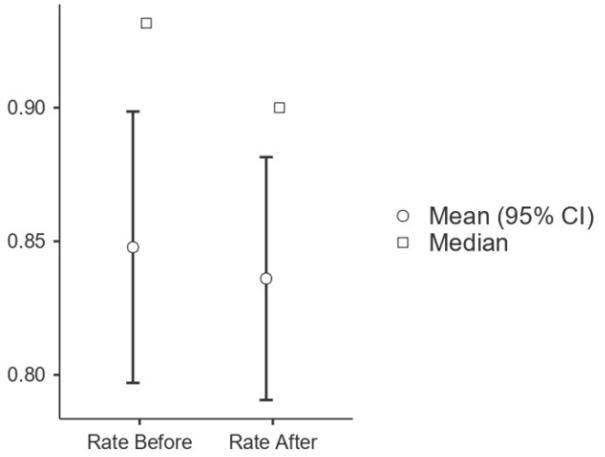

**Figure 5.** Animals affected by tuberculosis. (A) Moving average in the period from 04/2014 to 03/2020, the entire series, three years before and three years after changes in RIISPOA; (B) Linear trend in the period from 04/2014 to 03/2017, before changes in RIISPOA; (C) Linear trend in the period from 04/2017 to 04/2020, after changes in RIISPOA.

Good estimates of the frequency of tuberculosis can only be carried out with a survey of the disease in the properties with representative samples or even covering all the animals. Slaughterhouses have the role of "epidemiological sentinel" and the role of traceability within the scope of programs to combat diseases.[19] The data show that the condemnation rate due to tuberculosis was higher than the condemnation rate due to cysticercosis. The condemnation rate of carcasses due to cysticercosis increased significantly after the reform of the law compared to the period before it (Figure 6). The condemnation rates of carcasses due to tuberculosis were high before and after the law reforms but the proportions did not differ statistically (Figure 7).




| | | Statistics | df | p |
|---|---|---|---|---|
| Rate Before Rate After | Student's | -6.26 | 41.0 | <.0001 |

**Figure 6.** Comparison between the condemnation rate of carcasses due to cysticercosis in the period from 04/2014 to 03/2017, before changes in the Brazilian Regulation for the Industrial and Sanitary Inspection of Animal Origin Products (RIISPOA), and the condemnation rate of carcasses due to cysticercosis in the period from 04/2017 to 03/2020, after changes in the Brazilian Regulation for the Industrial and Sanitary Inspection of Animal Origin Products (RIISPOA).




| | | Statistics | p |
|---|---|---|---|
| Rate Before Rate After | Wilcoxon W | 1070[a] | 0.1649 |

**Figure 7.** Comparison between the condemnation rate of carcasses due to tuberculosis in the period from 04/2014 to 03/2017, before changes in the Brazilian Regulation for the Industrial and Sanitary Inspection of Animal Origin Products (RIISPOA), and the condemnation rate of carcasses due to tuberculosis in the period from 04/2017 to 03/2020, after changes in the Brazilian Regulation for the Industrial and Sanitary Inspection of Animal Origin Products (RIISPOA).

The application of spatial analysis techniques in the field of health is essential, and the kernel is a useful tool to

obtain data on epidemiology, as it represents the relationship between regions.[20] Studies with spatial mapping techniques are invaluable for the analysis of diseases such as tuberculosis in historical times.[21] A spatial change of the places with the highest density of condemnation could be observed for both diseases. Tuberculosis showed an expansion profile, especially in the south and southeast of the state, which can be explained by the large number of non-certified properties in the state, which contribute to the disease expansion. Despite the persistence of places with low density of condemnation for tuberculosis (places in the north and northeast), the state had a higher homogenization, with a high condemnation (Figure 8A–B). The spatial change in the condemnation density observed for tuberculosis is believed to be not directly related to changes in the inspection regulations. According to Kaoa et al.,[22] the occurrence of tuberculosis transmission via local dissemination to non-infected herds is possible due to the proximity to infected herds. Cysticercosis showed maintenance of locations in the northeast and north of the state but with an expansion to places in the central region of the state probably caused by an increase in the condemnation rate due to changes in Federal Legislation and deficiencies in the basic sanitation and animal handling (Figure 9A–B).

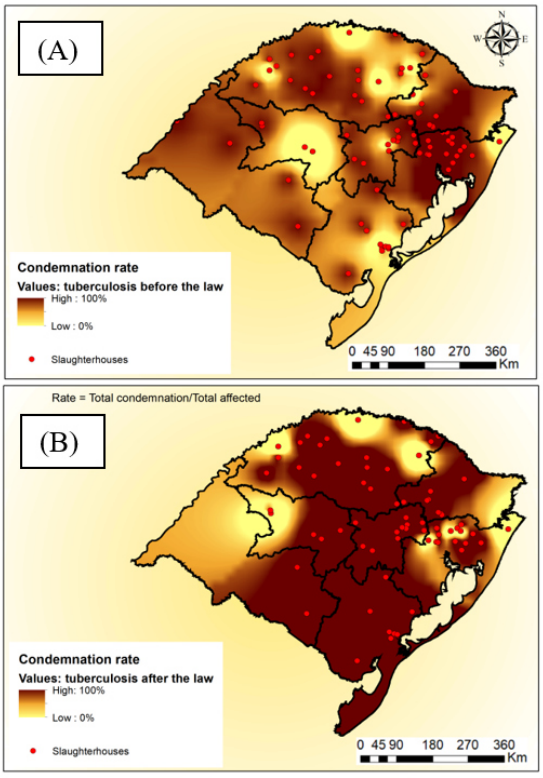



**Figure 8.** (A) Condemnation rate of carcasses due to tuberculosis in its location of origin by kernel density in the period from 04/2014 to 03/2017, before changes in the Brazilian Regulation for the Industrial and Sanitary Inspection of Animal Origin Products (RIISPOA); (B) Condemnation rate of carcasses due to tuberculosis in its location of origin by kernel density in the period from 04/2017 to 03/2020, after changes in the Brazilian Regulation for the Industrial and Sanitary Inspection of Animal Origin Products (RIISPOA).

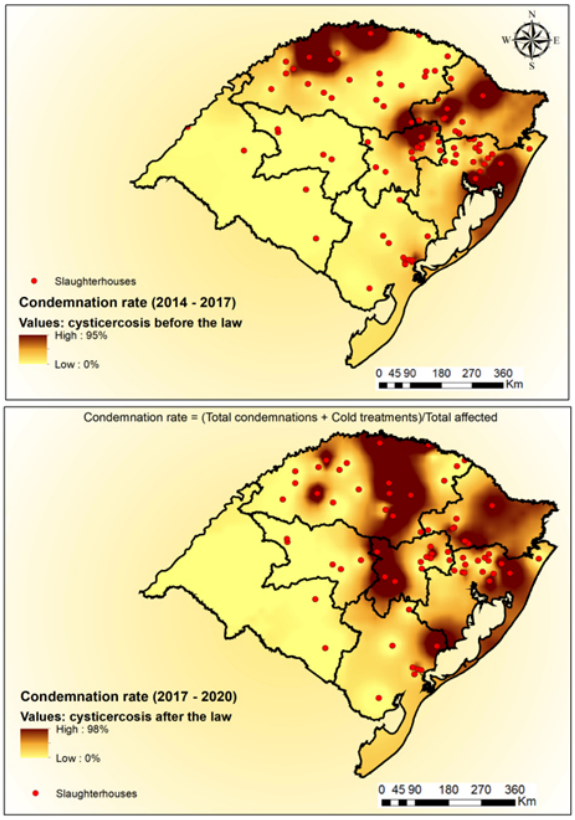



**Figure 9.** (A) Condemnation rate of carcasses due to cysticercosis in its location of origin by Kernel density in the period from 04/2014 to 03/2017, before changes in the Brazilian Regulation for the Industrial and Sanitary Inspection of Animal Origin Products (RIISPOA); (B) Condemnation rate of carcasses due to cysticercosis in its location of origin by Kernel density in the period from 04/2017 to 03/2020, after changes in the Brazilian Regulation for the Industrial and Sanitary Inspection of Animal Origin Products (RIISPOA).

Methods that use kernel density estimation, which combines elements of time and space, are especially useful for studies on infectious diseases.[23] The discrepancy in the incidence of diseases in different locations can be useful for the development of future research, aiming to identify the factors responsible for the difference.[24] The study was carried out to show the density of condemnation by the diseases and, therefore, the number of affected animals was considered and not the total population of animals in the regions, differing from other studies, in which the distribution of diseases was calculated using the total population of animals, making a comparative analysis impossible.

The directional distribution by ellipses of the condemnation rates due to cysticercosis and tuberculosis in the location of slaughterhouses in the periods before and after changes in the Brazilian Regulation for the Industrial and Sanitary Inspection of Animal Origin

Products (RIISPOA) showed a slight displacement towards the eastern region of Rio Grande do Sul. This displacement may have occurred naturally, considering the spatial pattern of both diseases (Figure 10).

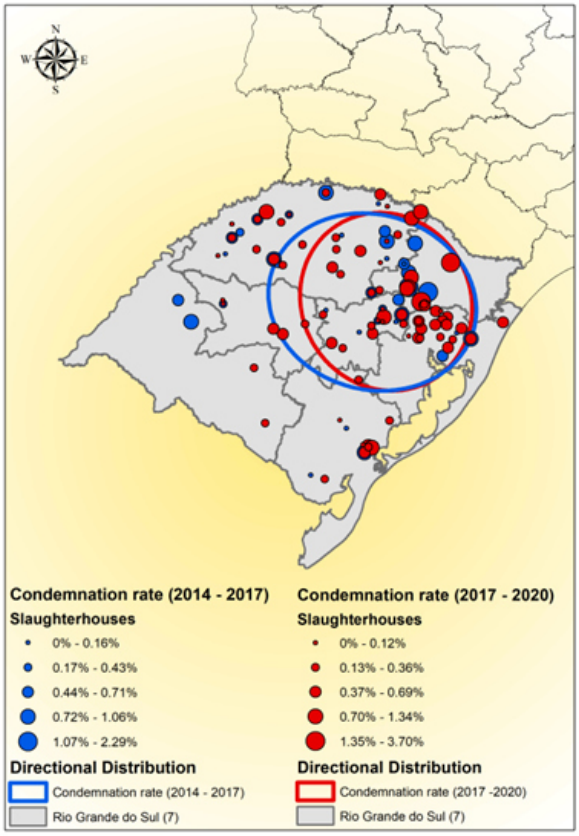



**Figure 10.** Directional distribution (ellipses) of condemnation rates due to cysticercosis and tuberculosis in the region of Rio Grande do Sul in the location of origin of slaughterhouses in the period from 04/2014 to 03/2017, before changes in the Brazilian Regulation for the Industrial and Sanitary Inspection of Animal Origin Products (RIISPOA), and 04/2017 to 03/2020, after changes in the Brazilian Regulation for the Industrial and Sanitary Inspection of Animal Origin Products (RIISPOA), represented by colors blue and red, respectively.

Barbosa et al.[25] observed that the results of studies carried out in the Northeast of Brazil have contributed to the knowledge of the spatial distribution of tuberculosis in the region. Therefore, interventions to control the disease can be directed according to the importance of the category of space to methodologically assist in the planning, monitoring, and evaluation of health actions. According to Queiroz et al.,[26] the implementation of a risk-based surveillance system is the best strategy for the detection and sanitation of tuberculosis foci.

Importantly, private companies were accredited in 2018 to carry out outsourced inspections under the supervision of the Official Service in some state inspection establishments in Rio Grande do Sul. This replacement of the official service in several establishments with state inspection by veterinarians hired to carry out a daily inspection may have influenced the results, as the interpretation of the Brazilian Regulation for the Industrial and Sanitary Inspection of Animal Origin Products (RIISPOA) and judgment of carcasses was not carried out only by official veterinarians after 2018.

Inspection of products of animal origin in Brazil occurs in a decentralized manner, divided into Federal Inspection, State Inspection, and Municipal Inspection. Thus, different realities are highlighted when conducting studies to discuss the current spheres of inspection. There was a need to increase official surveillance in the states and municipal inspection systems, thus assisting in the surveillance of bovine diseases of interest to the federation. Furthermore, this increase in official presence would help to improve ante-mortem and post-mortem inspection of slaughtered cattle in Brazil, with an impact on food safety and public health.[27] Records of official service databases provide important information for public health, and the analysis of these data is essential for defining surveillance strategies in different regions.[18]

## 4. Conclusion

The new criteria for judging carcasses, which came into force after 2017 with Decree No. 9,013, had a real impact on the number of carcasses condemned due to cysticercosis, while no significant increase was observed in the number of carcasses condemned due to tuberculosis after changes in RIISPOA. The results of this study allow an evaluation of the judging criteria for carcasses of cattle affected by cysticercosis and tuberculosis after changes in RIISPOA in 2017, contributing to future publications and updates of decrees carried out by the Ministry of Agriculture, Livestock, and Food Supply (MAPA).

### Declaration of conflict of interest

The authors have no conflict of interest to declare.

### Author contributions

*Conceptualization:* E. L. Motta and R. O. Rodrigues. *Data curation:* E. L. Motta. *Formal analysis:* E. L. Motta and R. O. Rodrigues. *Investigation:* E. L. Motta. *Methodology:* E. L. Motta and R. O. Rodrigues. *Project management:* E. L. Motta. *Visualization:* E. L. Motta. *Software*: R. R. Nicolino and R. O. Rodrigues. *Writing (original draft):* E. L. Motta. *Writing (revision and editing):* A. C. B. Rodrigues and R. O. Rodrigues.

### Acknowledgments

We would like to thank the Sanitary Information Control Division of the Secretariat of Agriculture, Livestock, and Rural Development of Rio Grande do Sul (DCIS/DDA/SEAPDR/RS)

for making the data available for this study.

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