Preventive Veterinary Medicine 118 (2015) 351–358

Contents lists available at ScienceDirect

Preventive Veterinary Medicine

journal homepage: www.elsevier.com/locate/prevetmed

# Economic analysis of vaccination to control bovine brucellosis in the States of Sao Paulo and Mato Grosso, Brazil

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ARTICLE INFO

*Article history:*
Received 5 March 2014
Received in revised form
17 November 2014
Accepted 10 December 2014

*Keywords:*
Brucellosis
Bovine
Economic analysis
Vaccination

ABSTRACT

Brucellosis is a zoonotic disease that causes important economic losses in Brazil, and the country has therefore established a national program for its control and eradication. Using data generated in the last national brucellosis survey, we conducted an economic analysis in two Brazilian States with different brucellosis status, Mato Grosso (with high prevalence) and Sao Paulo (with low prevalence). The economic analysis was based on the calculation of the additional benefits and costs of controlling bovine brucellosis through the vaccination of heifers aged between 3 and 8 months with S19 vaccine, considering maximal and minimal impacts of the disease. The analysis showed that vaccinating 90% of the replacement heifers aged 3–8 months of age offers the best economic performance in a vaccination program against bovine brucellosis if compared to vaccination rates of 70% and 80%. Moreover, regions with higher prevalences of bovine brucellosis would experience significant economic advantages when implementing a vaccination strategy to control the disease. This economic analysis will allow decision makers to plan more economically effective vaccination programs.



## 1. Introduction

The bacterium *Brucella abortus*, which is responsible for brucellosis in cattle, is transmitted through abortion products and vaginal discharge. The main symptom of the disease is abortion. *Brucella melitensis* can also cause brucellosis in cattle, although has not been isolated in Brazil (Poester et al., 2002). Brucellosis is a zoonotic disease, so it can be transmitted from animals to man (Acha and Szyfres, 1986). The negative impacts of brucellosis in livestock include reduced milk production, reduced feed conversion, abortion, infertility and mortality in aborting females, perinatal mortality, increased calving intervals and an increased need for animal replacement (Pacheco and Mello, 1956; Sheperd et al., 1980; Faria, 1984; Bernués et al., 1997).

Although national programs against brucellosis were established worldwide since 1896, just a few countries have reached the elimination of the circulation of the *B. abortus* in their herds. With the exception of the Western European countries and Canada, most of them are islands (Paulin and Ferreira Neto, 2003).

The National Program for the Control and Eradication of Animal Brucellosis and Tuberculosis (PNCEBT) was established in 2001 by the Brazilian Ministry of Agriculture, Livestock and Food Supply (MAPA), with the aim of reducing the negative impacts of this

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http://dx.doi.org/10.1016/j.prevetmed.2014.12.010
0167-5877/

disease on human health and promoting the competitiveness of the national livestock industry (MAPA, 2006).

The PNCEBT introduced compulsory vaccination against brucellosis in bovine and buffalo females aged between 3 and 8 months with the S19 vaccine throughout the country and implemented a strategy for certifying brucellosis-free farms (MAPA, 2006). An epidemiological study was conducted in 15 Brazilian States based on sampling farms displaying reproductive activity from 2001 and 2004. Results of that study were published as a special issue of the *Brazilian Journal of Veterinary and Animal Sciences* (61(1) (2009) 1–141).

Most of the control measures are paid for by farmers, such as vaccination of heifers, diagnostic tests and veterinary services. The official veterinary service is only responsible for auditing these activities and for the certification of brucellosis-free farms.

Although the vaccination of heifers aged between 3 and 8 months is compulsory in Brazil (except in the State of Santa Catarina), the vaccination coverage is below 100%, and few farms have been certified as being brucellosis free thus, making the demand for official auditing variable and difficult to plan.

In decision making on animal health problems, economic methods can be of great support. In this area, also referred as "Economics of Animal Health", quantification of the economic effects of a disease, optimization of decisions to be made when the disease is present and determination of costs and benefits when preventive measures are being implemented represent important decision-making tools in disease control and eradication programs (Dijkhuizen et al., 1995; Otte and Chilonda, 2000; James, 2004; Vanni et al., 2009).

With the major expansion of the Brazilian beef production, losses caused by infectious agents are growing in importance. Increasing organization of the production sector along with the gradual organization of veterinary services has resulted in higher productivity and increased credibility of the country as a beef exporter. However, infectious diseases still circulate in the Brazilian territory, including bovine brucellosis. For the decision to vaccinate in order to control bovine brucellosis, knowledge on the economic effects is useful. In Brazil, a single paper about economic losses caused by brucellosis was identified by the time of writing (Santos et al., 2013), estimating annual losses of US$448 million and the variation of US$78 million for each change of 1% of the prevalence of the disease.

Considering that there are still high prevalences of bovine brucellosis in Brazil and vaccination as an effective control strategy for this disease, the aim of the present work was to conduct an economic evaluation of the adoption of brucellosis control measures from the perspective of the private sector, as government participation is restricted to vaccination and certification auditing. We considered only control measures based on vaccination because at the time of writing, most Brazilian States continued to exhibit a high brucellosis prevalence, which does not justify the application of eradication measures.

## 2. Materials and methods

### 2.1. Study area

For the economic analysis of brucellosis control measures, we selected two Brazilian States in which various factors, such as the epidemiological status of the disease, the structure and operational logistics of the official veterinary services and production systems differ: Sao Paulo (SP) and Mato Grosso (MT) (Table 1). The choice of such different scenarios was made to evaluate the robustness of the results.

SP is the most populous state in Brazil (IBGE, 2010). Despite its smaller herd size, it presents significant dairy production and is the main beef exporter in Brazil (IBGE, 2011). SP receives live animals to be slaughtered from other Brazilian States. Moreover, SP has been shown to have low brucellosis prevalence, estimated in 3.8% of females over two years of age, in 2001 (Dias et al., 2009).

In MT, the livestock system is mainly extensive, with intermediate to low technology levels, low stocking densities and properties of large areas. This state exhibits the largest livestock herd (IBGE, 2011) and the highest brucellosis prevalence among the Brazilian States, estimated in 10.2% of females over two years of age, in 2003 (Negreiros et al., 2009).

Each of the selected states (SP and MT) was considered as a single production unit, and the outcomes were evaluated in terms of the benefits and costs for the meat and milk production chains.

### 2.2. General structure of the model

The model was constructed to calculate two economic indicators (net present value – *NPV* – and payback period) for different vaccination strategies against brucellosis in two Brazilian States using S19 vaccine in two distinct epidemiological situations of bovine brucellosis. To achieve that, both costs and benefits of the implementation of vaccination strategies were calculated as present values (*PV*) for different durations of vaccination programs (Assaf Neto, 2012). The mathematical model proposed by Amaku et al. (2009) was used to re-calculate the decrease in prevalence under vaccination efforts of 70%, 80% and 90% to determine the duration of the vaccination programs in both states. The explanation of this model can be found in the Supplementary material. Calculations were performed in Matlab software, version R2013a. According to Amaku et al. (2009), a threshold of 2% prevalence was defined as the criteria for changing the control strategy for eradication. Therefore, the simulations were run until 2% prevalence was reached. The period of time of the shortest vaccination program was used to compare *NPV* among the vaccination strategies in both states, since different periods of vaccination programs were expected. This fixed time horizon used for the model were during that time, animals would be vaccinated was called "payback period".

The additional benefits achieved with the adoption of each vaccination strategy were compared with respective additional costs. The herd sizes were kept constant to allow the comparison of the effects of the vaccination strategies