Economic analysis of animal disease outbreaks – BSE and Bluetongue disease as examples

Analyse der ökonomischen Auswirkungen von Tierseuchenausbrüchen

Summary

Although there is a long tradition of research on animal disease control, economic evaluation of control measures is rather limited in veterinary medicine. This may, on the one hand, be due to the different types of costs and refunds and the different people and organizations bearing them, such as animal holders, county, region, state or European Union, but it may also be due to the fact that economic analyses are both complex and time consuming. Only recently attention has turned towards economic analysis in animal disease control. Examples include situations, when decisions between different control measures must be taken, especially if alternatives to culling or compulsory vaccination are under discussion. To determine an optimal combination of control measures (strategy), a cost-benefit analysis should be performed. It is not necessary to take decisions only based on the financial impact, but it becomes possible to take economic aspects into account. To this end, the costs caused by the animal disease and the adopted control measures must be assessed. This article presents a brief overview of the methodological approaches used to retrospectively analyse the economic impact of two particular relevant diseases in Germany in the last few years: Bluetongue disease (BT) and Bovine Spongiform Encephalopathy (BSE).

Keywords: animal disease, animal health economics, cost-benefit analysis, bovine spongiform encephalopathy, BSE, bluetongue disease

Zusammenfassung


Schlüsselwörter: Tierseuche, Tiergesundheitsökonomie, Kosten-Nutzen-Analyse, Bovine Spongiforme Enzephalopathie, Blauzungenkrankheit
TABLE 1: Selected studies on animal health economics

<table>
<thead>
<tr>
<th>Type of analysis</th>
<th>Disease</th>
<th>Control strategy</th>
<th>Net benefit</th>
<th>Losses</th>
<th>Years</th>
<th>Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animal disease impact study</td>
<td>Foot-and-Mouth Disease</td>
<td>n. a.</td>
<td>n. a.</td>
<td>GBP 8 billion</td>
<td>2001</td>
<td>Richard Eales (2002)</td>
</tr>
</tbody>
</table>

n. a. = not applicable
The difference between the gross margins of a farm under "normal" circumstances ($GM_0$), i.e. in absence of a disease, and under the influence of a disease outbreak ($GM_D$) gives us the direct costs (DC) on the farm level, which we then can extrapolate for the entire population. Direct costs include the difference (usually reduction) of farm outputs ($\Delta O$) and the difference of variable costs ($\Delta VC$) due to the disease itself. Direct costs are generally borne by the farmers and can be described as follows:

$$ (3) \quad DC = \Delta O + \Delta VC $$

Variable costs might either increase, e.g. due to treatment of infected animals (T) or expenditures on other (non-veterinary) resources (R) (e.g. lower feed conversion of the animals), or diminish, e.g. in terms of otherwise resulting costs (e.g. reduced feed intake) (B) for "benefit" due to the disease. Hence, direct costs on farm level can be described more precisely as follows:

$$ (4) \quad DC = \Delta O + (T + R - B) $$

The second component needed to calculate the total costs is composed of the indirect costs (IC). Indirect costs usually accrue to the region or federal state, the country or the EU and include the costs of all measures taken to prevent, diagnose and control the disease on both farm level (e.g. vaccination, insecticide treatment) and population level (e.g. epidemiological investigations, culling, monitoring/surveillance, removal of specified risk material). They also include the economic impact on national markets, e.g. due to export bans, changed consumer behaviour, cheaper prices for animal products, increased need for research, or reduced tourism (Dijkhuizen and Morris 2002, Rushton et al. 1999). To estimate indirect costs, all these factors are added up, for example:

$$ (5) \quad IC = M + A + S + E + RS + K $$

where M stands for control measures, A for administrative costs, S for monitoring/surveillance, E for export, RS for research, and K for the effects on the market.

(II) Estimating the benefit of control measures: cost-benefit analysis

Cost analyses can help to determine which factors have the greatest impact on the total costs. However, they are not suitable for weighing costs against expected benefits of control measures, or in choosing between different control strategies. For this purpose, the cost-benefit analysis is the method of choice. Benefits include a situation where there are less infected animals than in absence of the implementation of a disease control strategy, thereby leading to reduced losses in income, reduced costs for treatment etc., which are usually more difficult to quantify than (actually incurred) costs. Relating both direct and indirect costs of the disease with the benefits of the control measures yields the total economic impact of the disease.

In a cost-benefit analysis, the Net Benefit (NB) describes the difference between costs and benefit between two strategies. For example if the standard strategy is without vaccination and the alternative strategy includes vaccination, the difference in the Benefits (B) can be the difference in losses between both strategies (e.g. reduction in infected animals, a reduction of losses in income and lower costs for treatment). On the other hand, the vaccination strategy causes additional Costs (C) for vaccines and for vaccinating the animals. A cost-benefit analysis can be described by the following formula

$$ (6) \quad NB = \Sigma_{t=0}^{\infty} B_t - C_v $$

where NB stands for Net Benefit, B for the difference in the Benefit, C for difference in the Costs and t for time (years).

If control programs are running over a long time (e.g. BSE), the costs and benefits need to be corrected by inflation and interests. In control programs running for more than one year, the costs and benefits have to be calculated for all years.

Material and Methods

For our two examples, first, we collected epidemiologically relevant and economic data from different sources, including the German Federal Ministry of Food and Agriculture, the Federal Statistical Office (Destatis), official reports, and scientific publications. Due to the decentralized structure of Germany, the main information sources were the Federal States, the animal health services, the animal compensation funds (Tierseuchenkassen), the German animal disease notification system (TSN), and the central animal movement database (HI-Tier). All collected data were included in a standard spreadsheet (Microsoft Excel 2010). If data were incomplete or uncertain, we had to use empirical distributions if data existed or to model distributions (uniform, triangular), if only expert opinion were available. These distributions were used in a stochastic simulation model (@Risk 5.7, Palladium Corporation, Ithaca, New York, USA).

Regarding BT, both direct and indirect costs were estimated for a time period of six years. Regarding BSE, we focused on the costs incurred by the measures to control the disease and to prevent exposure of consumers to the causative agent over a time period of ten years.

Example 1: Bluetongue disease

The costs for Bluetongue were analysed for the period between 2006 and 2011. In a first step, a gross margin analysis was carried out to estimate the direct costs of the disease on farm level for different species (cattle and sheep), production types (dairy or meat) and – for dairy farms only – years. The herd level model was based on an analysis of affected farms in North Rhine-Westphalia. As the milk price changed over the years, we had to analyse the costs for an affected animal for all analysed years. In sheep, the variability of the meat price was low, hence we used only one estimate. The result was a distribution of the direct costs on animal level.

For modelling costs on country level, we estimated the number of clinically affected animals in the population and multiplied it with the direct costs on the animal level.

For the indirect costs, we included the following cost factors in the analysis: Bluetongue surveillance (S), additional testing for export (E), control measures (M), and administrative costs (A).

$$ (7) \quad TC_{BT} = \sum_{y=2006}^{2011} DC_y + \sum_{y=2006}^{2011} (S_y + M_y + E_y + A_y) $$

Surveillance included a cross-sectional study, an active surveillance system (sentinel surveillance and annual surveillance to demonstrate freedom from disease) and vector monitoring. The control measures included treatment with insecticides and vaccination. The administrative costs included epidemiological investigations, disease confirmation (farm visits) as well
as the establishment of restriction zones and additional time to enter information on new outbreaks into the databases.

To estimate the additional export costs, we used the number of cattle and sheep exported and multiplied it with the costs for the test to confirm that an animal was free from bluetongue disease. As the disease had started in August 2006 in the western part of Germany and had not affected the whole country until October 2007, we estimated the fraction of animals that was affected by export restrictions in both years, 2006 and 2007.

Example 1: Bluetongue disease (BT)
The total costs caused by BTV-8 for the years 2006–2011 were estimated at 200 million Euros, with a maximum of 87 million Euros in 2007. In 2006 and 2007, the highest costs were induced by production losses and fallen stock, while between 2008 and 2010, the highest costs were induced by vaccination.

Example 2: Bovine Spongiform Encephalopathy (BSE)
The total costs of BSE were estimated to range between 1,847 and 2,094 million Euros. More than half of the costs (approximately 1,000 million Euros) were incurred by the extension of the feed ban for animal protein to all farmed livestock. Active surveillance accounted for 21% (405 million Euros), the incineration of animal protein for 13% (249 million Euros) and the removal of specified risk material for 11% (225 million Euros). Only 1% of the costs were related to response measures after detecting a BSE-positive animal, including indemnity payments for culled cattle and confiscated carcasses at the slaughterhouse.

Discussion
Cost analyses of animal diseases follow a multidisciplinary approach and include animal production, product processing, veterinary, epidemiological and economic expertise. In both examples presented in this article, BT and BSE, the most time-consuming step was collecting data and preparing them for analysis. Probably, this holds true for most economic studies. In both studies, the total costs widely depended on some variables that were estimated with a high level of uncertainty (e. g. costs of substituting animal protein with soybeans). This shows that after performing an economic analysis, quantifying its reliability, e. g. by means of a sensitivity analysis, is of utmost importance. Concerning BT, the estimated morbidity had the biggest influence on the outcome of the model. For the costs of BSE, sensitivity analysis showed that the admission fee for animal proteins at the incineration plant had the strongest impact.

In both studies, the direct and indirect costs as well as the benefits of control measures turned out to be interdependent. They influenced each other in different ways. In the example of BT, short-term costs for having animals treated by a veterinarian may discourage farmers to treat their animals. On the other hand, if the animals are not treated, the farmer may save money in the short-term, but the farm output could be substantially lowered in the long run. In the case of BSE, decreased consumption and prices of beef may have resulted in an increased consumption and prices of other types of meat, milk products or vegetables. These examples show how important it is to take potential temporal effects on the economic analysis sufficiently into account.

In both studies, total costs varied considerably across regions and from year to year. Depending on the type of costs, they are borne by different stakeholders, precisely by farmers, the industry and the public. Regarding bluetongue disease, (mainly direct) costs were borne by the farmers between 2006 and 2007, whereas the main costs (vaccination) were covered by the animal disease compensation funds in the years 2008 and 2009. Concerning BSE, the costs were borne by farmers, processors, consumers, the German government and the federal states. Sometimes the cost distribution was not obvious and difficult to assign precisely to the different contributors, especially when it came to indirect reimbursements.

Results
Example 1: Bluetongue disease (BT)
The total costs caused by BTV-8 for the years 2006–2011 were estimated at 200 million Euros, with a maximum of

\[ T_{BSE} = \sum_{y=2000}^{2010} (M_S + M_F) + \sum_{y=2000}^{2001} (S_R + S_M + F_e + I_e) \]

Concerning BSE surveillance, we differentiated between compulsory surveillance as stipulated by EU legislation, compulsory surveillance in accordance with national German regulations (beyond EU legislation) and voluntary testing. We also differentiated between cattle slaughtered for human consumption and fallen stock (risk cattle).

With regard to the response measures at the slaughterhouse, we took into account the value of the carcasses that were destroyed after the detection of a BSE case in routinely slaughtered cattle. The response measures on the farm of origin include the labour costs for undertaking epidemiological investigations and the costs for cohort culling.

The recurrent costs for the safe removal of SRM from slaughter cattle were calculated by multiplying the number of slaughtered cattle with the costs per animal. Since the list of SRM depended on the age of the animal, we differentiated between three different age categories, i. e. animals of < 12 months, 12–24 months, and > 24 months of age.

Regarding the costs of the extension of the feed ban, we took into account the costs for the destruction of all stocks of animal protein and feed containing it, the lost revenues from the sale of animal protein to the feed industry, the additional costs of substituting animal protein with soybeans in livestock feed, and the official tests to control the feed ban.

The costs for the incineration of animal protein were estimated by multiplying the amount of protein incinerated with the average admission fee that had to be paid for incineration.
or distortions on the animal production value chain, e. g. due to reduced meat consumption or reduced beef prices.

Both studies also show the large impact of the disease, but also of the control measures on domestic and international markets. Disease outbreaks and the necessary measures to manage and control them may change the profitability of the whole production chain. To adopt effective control strategies for controlling a disease in livestock animals remains a major challenge, if the whole range of direct and indirect cost factors of both the disease and the control measures is taken into account.

Due to the paucity of comparable data, potential bias and the high complexity of influencing factors, especially in the case of BSE, it is difficult if not impossible to compare them with other studies (Tab. 1). Like most other recently published cost analyses, both studies have been performed retrospectively, i. e. years after the decisions on the control strategies had been taken.

Regarding BT, serotype 8, the member states of the European Union decided to carry out a compulsory vaccination program in 2008 without performing a cost-benefit-analysis beforehand. Although the vaccination program was successful in controlling the disease, retrospective analysis showed that it had been very expensive. The same applies to BSE: the control measures in their entity were successful in combating the disease and in preventing exposure of consumers. However, most if not all decisions on the control of the disease on the level of legislation were adopted without taking economic considerations into account. Of course, this approach was influenced by the anticipated impact of BSE on human health, i.e. the emergence of an epidemic of variant Creutzfeldt-Jakob disease in the human population.

To provide decision makers with solid economic arguments before a control strategy is implemented, costs (and benefits) of a disease and control measures should be anticipated in a prospective cost-benefit analysis, if possible. The major challenge of a prospective analysis relates to estimating what could occur in the case of a disease outbreak and in the presence or absence of different alternative control measures. Therefore, high-quality data on various levels of the feed and food production chain need to be compiled and constantly updated, even before a disease outbreak occurs.

Conflict of interest

The authors declare no conflict of interest.

References


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