Cost-effectiveness analysis: adding value to assessment of animal health, welfare and production

S. Babo Martins* & J. Rushton

The Royal Veterinary College, Hawkshead Lane, North Mymms, Hatfield, Hertfordshire AL9 7TA, United Kingdom
*Corresponding author: sarababo@gmail.com

Summary
Cost-effectiveness analysis (CEA) has been extensively used in economic assessments in fields related to animal health, namely in human health where it provides a decision-making framework for choices about the allocation of healthcare resources. Conversely, in animal health, cost-benefit analysis has been the preferred tool for economic analysis. In this paper, the use of CEA in related areas and the role of this technique in assessments of animal health, welfare and production are reviewed. Cost-effectiveness analysis can add further value to these assessments, particularly in programmes targeting animal welfare or animal diseases with an impact on human health, where outcomes are best valued in natural effects rather than in monetary units. Importantly, CEA can be performed during programme implementation stages to assess alternative courses of action in real time.

Keywords

Introduction
There is increasing awareness of the need to underpin decisions on resource allocation for animal health, welfare and production measures with structured and transparent frameworks (1, 2). Through comparative analysis of alternative courses of action in terms of cost and consequences, economic analysis provides such a decision-making framework and helps to guide decision-makers in integrating evidence in the allocation of scarce resources (1, 3, 4).

Various economic evaluation tools based on a range of economic theories are available according to the objective of the analysis. Cost-benefit analysis (CBA) and cost-effectiveness analysis (CEA) are the most commonly used.

Cost-benefit analysis uses monetary units to quantify costs and outcomes and has a broader scope of application than other types of analysis, providing information on the allocation of resources across different sectors of the economy. Nevertheless, because of the well-known problems associated with CBA, particularly the difficulty of measuring health, biological and environmental effects in monetary units and the ethical concerns surrounding this exercise, there has been limited use of CBA in human health and other areas (3, 5, 6).

Cost-effectiveness analysis overcomes this problem of attributing monetary figures to some effects, by calculating, within a fixed budget, the incremental costs in units of currency while expressing benefits in the most appropriate natural non-monetary effects. Unlike CBA, CEA requires an external standard such as a budget constraint or threshold to assess the value of the programme. In addition, by using non-monetary effects to express the benefits, CEA is programme specific and can only compare interventions that use the same units of effectiveness (1, 4, 7).

In the analysis of animal health, welfare or production interventions, CBA has been the preferred tool for economic evaluation to date (8) and is used either to justify a defined strategy (ex-ante analysis) or to assess the impact of a past programme (ex-post analysis) (9). However, during the implementation stage, CBA has shown limitations for assessing the effectiveness of resource use (10). In fact, economic tools and skills are rarely used during this phase of animal health programmes, meaning that economics is
not contributing and adding value to the largest element of animal health projects.

Significant lessons can be learned from a literature review of how CEA has been applied in related fields, namely in human health. This paper reviews the fundamentals of CEA and its application in related areas and addresses its present use and the potential added value in animal health, production and welfare interventions.

General framework of cost-effectiveness analysis

In a CEA, a series of steps should be undertaken to reach a cost-effectiveness ratio that allows comparison of decision options (Fig. 1).

Identification of the problem and establishment of the conceptual model

Identification of the problem, the intervention and its alternatives are the first steps of the analysis. The conceptual model, outlining the full range of events arising from the intervention, is frequently shown using a decision tree (5).

Establishment of the analytic perspective

The analysis can be undertaken from a number of perspectives, as the people involved may have differing views on the most advantageous policy (4). Usually CEA takes either the societal or the programme perspective, with costs and benefits of the interventions valued differently (5, 7). Whereas in the programme perspective only outcomes and costs experienced by the entity of interest are taken into consideration (7, 11), in the societal perspective all significant outcomes and costs are determined independently of who pays or benefits from the effects (7).

Identification and estimation of costs

Total direct costs compose the numerator of the cost-effectiveness ratio and include all goods, services and other resources that are consumed in the provision of an intervention or in dealing with its side effects and the present and future consequences associated with the intervention (7).

In human health, methodological guidelines clearly establish the categories of cost that should be considered in the calculation of total direct costs. The direct costs of the intervention, such as tests, drugs, personnel, rent and costs of patients’ time, should be included. In addition, costs associated with caregivers’ time and direct non-healthcare costs should be considered (4, 5, 7).

Micro-costing techniques, where the correct monetary value of every input used is enumerated, provide an option for valuation of costs but can be time consuming and therefore uneconomic. As a result, gross costing, where estimates of costs are obtained, is more frequently used (5).

Because cost-effectiveness results are sensitive to the time horizon of the analysis, it is important to cover the entire period of time on which the intervention has an effect (4), and both costs and benefits when spread over time should be discounted and take inflation into consideration (5).

Identification and estimation of outcomes

Effectiveness estimations constitute the denominator of the cost-effectiveness ratio (7) and a vast range of measures of effectiveness can be used, reflecting the diversity of effects (4).

Fig. 1
Steps in cost-effectiveness analysis
Adapted from Petitti (5)
In human health, common outcomes that are used are changes in life expectancy and/or improvement of quality of life, such as quality-adjusted life years (QALYs) and disability-adjusted life years (DALYs) (12). These can be measured across various interventions and allow comparison.

To evaluate effectiveness, data might be sourced from randomised control trials or observational studies. As in the estimation of monetary benefits for an animal health CBA, collecting primary data can consume both time and resources. Outcome data are most frequently derived using mathematical modelling, meta-analysis and Bayesian methods (4).

**Estimation of cost effectiveness and sensitivity analysis**

The results of a CEA are normally presented in the form of a ratio that expresses the price per effectiveness unit. Cost-effectiveness ratios can be reported in two forms. As an average ratio, where

\[
CE \text{ ratio} = \frac{\text{cost of the intervention}}{\text{effectiveness of the intervention}}
\]

or as an incremental cost-effectiveness ratio, where programme alternatives are compared:

\[
CE \text{ ratio} = \frac{\text{cost of the intervention} - \text{cost alternative}}{\text{effectiveness intervention} - \text{effectiveness alternative}}
\]

Incremental cost-effectiveness ratios (13) are generally presented in the analysis of mutually exclusive programmes, as a direct comparison of the alternatives, but do not allow examination of whether current practice is efficient (3). Importantly, incremental comparisons should be made with the next-best option to avoid distortions in the calculations (4, 14). Sensitivity analysis should assess the effect on the conclusion of the various assumptions made in the analysis (4).

**Current role of cost-effectiveness analysis in assessment of animal health, welfare and production**

In human health the use of CEA as a basis for decision-making shows an exponential trend (3), but the technique is not as widely used in veterinary medicine, where CBA and cost analysis have been more common (8, 20, 21, 22, 23, 24, 25), as it is possible to place a value on the majority of mortality and morbidity impacts in animal disease.

Studies on the use of CEA in the field of animal health intervention have generally analysed programmes focusing on the control of zoonotic diseases but have also assessed the cost-effectiveness of diagnostic tests and measures for the prevention of disease introduction. Most reports used ex-ante analysis to compare alternative strategies to achieve an effect. Outcomes of interest vary widely from life years gained to reduction in risk and increased sensitivity of a diagnostic test. Table I summarises the main features of some of these studies.

An example of a recent application of CEA for assessment of animal health, welfare and production is given by Lyons et al. (46). The authors evaluated the cost-effectiveness of a series of interventions for control of verotoxin-producing Escherichia coli (VTEC) in dairy farms in the United Kingdom. The epidemiological information and selection of interventions assessed in the study were determined in a previous randomised control trial. The authors then developed cost models for the interventions, considering the measures individually and in combination. The outputs (effects) considered were measures of the effect of the interventions in the randomised control trial in terms of risk ratio, which was then converted to the attributable fraction in order to estimate the proportional reduction in the prevalence if the intervention measures
<table>
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<td>Estimates the health and economic consequences of non-compliance with antimicrobial treatment of canine skin infections</td>
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<td>(33)</td>
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<td>Effectiveness determined by modelling; costs calculated using market prices</td>
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<td>Compares the cost-effectiveness of decontamination technologies in pig abattoirs</td>
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<td>Compares different testing strategies for detection of paratuberculosis</td>
<td>Effectiveness determined by modelling; costs calculated using market prices</td>
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were implemented. Subsequently, the cost-effectiveness ratio was calculated as the intervention cost per dairy cow divided by the attributable fraction (46). Unlike a CBA, in this CEA the effect chosen by the authors focused on a technical parameter outcome with an impact on the economic profitability of the farm, but the benefits were not monetised.

**Discussion**

A well-conducted CEA provides quality information to inform the setting and prioritisation of policy (4, 47). As in human health, it is likely that CEA will become increasingly predominant in assessments of animal health, production and welfare, emphasising the importance of understanding the strengths and limitations of this tool.

The limitations of CEA have been discussed in the context of its widespread use in human medicine. Although CEA aids decision-making, it is not sufficient in itself for making complex decisions on resource allocation, as it does not incorporate aspects of overall budgetary impact, feasibility and societal values such as equity and fairness (4, 48).

Further, the economic foundations of CEA are a matter of much discussion; for example, on controversial methodological aspects such as the inclusion of indirect and productivity costs and discounting of health effects (26). The absence of a clear common acceptable threshold dividing an acceptable from a non-acceptable cost-effectiveness ratio is also considered a constraint. In human health, where attempts to quantify the affordability of a certain threshold have been developed, this is strongly linked to the prosperity of the country, making it difficult to define a common threshold (4, 13).

Other controversial aspects of the analysis relate to ethical concerns arising from the valuation of natural effects, including health. Discounting benefits, for example, implies that an effect observed in the present is more valuable than if observed in the future (27).

Nevertheless, CEA presents various advantages that have contributed to its widespread use in many areas. It is a user-friendly economic tool, as it uses effectiveness measures that reflect the interests of people involved in the process and that can be estimated and used for real-time decision-making.

In assessments of animal health, welfare and production, CBA can be used for ex-ante and ex-post evaluations where costs and benefits can be estimated in a monetary valuation, such as programmes dealing with livestock diseases and production. When benefits include welfare
changes for humans and/or animals that are complex to measure in monetary terms, CEA is an alternative tool that could capture more appropriately the desired outcomes from a change. These typically include programmes that target control of zoonoses, intervention in companion animals and changes in animal production, with an impact on animal welfare, human health or on the environment.

Currently, economics are not routinely used during implementation, and this potentially leads to less than efficient outcomes from animal health, welfare and production programmes. Cost-benefit analysis can be considered too unwieldy a tool for the implementation phase, as too much time is needed for the estimation of benefits. Such an estimation requires epidemiological modelling to determine risk factors for disease, examine the impact of the presence of disease on production and, for wide-scale programmes, consider the impacts on markets. What is needed is a simpler list of technical outcomes that are, or can be, reasonably measured. Cost-effectiveness analysis could add significant value to this stage, as it focuses on technical parameter outcomes that would influence a monetised estimation of economic profitability.

As with CBA, challenges for the use of CEA in the assessment of interventions in animal health, welfare and production include setting the outcomes of interest and the availability and quality of data. These challenges have not been addressed by looking more carefully at how data collection can be improved but by increasing the complexity of simulations of the real world. Many of the models generated are based on limited data sets and very often are not validated against real scenarios. In essence they represent ‘best guesses’ but are often presented as scientifically objective. More work is required on improvement of existing structures of outcome estimations or on simplification of the estimated outcomes to what can be reasonably measured within the resources available.

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L’analyse coûts-efficacité : une valeur ajoutée apportée à l’évaluation de la santé, du bien-être et de la production des animaux

S. Babo Martins & J. Rushton

Résumé

L’analyse coûts-efficacité est un outil d’évaluation économique très répandu dans plusieurs domaines en lien avec la santé animale, par exemple en santé humaine où elle fournit un cadre décisionnel pour répartir les ressources allouées aux différentes prestations sanitaires. En revanche, dans le domaine de la santé animale c’est l’analyse coûts-bénéfices qui constitue l’outil de choix pour conduire des analyses économiques. Les auteurs font le point sur le recours à l’analyse coûts-efficacité dans des domaines connexes et sur l’importance de cette technique dans les évaluations sur la santé, le bien-être et la production des animaux. L’analyse coûts-efficacité apporte une valeur ajoutée à ces évaluations, en particulier dans les programmes d’amélioration du bien-être animal ou de lutte contre des maladies animales ayant une incidence sur la santé humaine, car leurs résultats se mesurent en termes d’impact induit plutôt que d’unités monétaires. Qui plus est, les analyses coûts-efficacité peuvent être réalisées pendant les phases successives de mise en œuvre d’un programme, ce qui permet d’évaluer les différentes possibilités d’action en temps réel.

Mots-clés

El análisis de la relación costo-eficacia como valor añadido a las evaluaciones de salud, bienestar y producción animales

S. Babo Martins & J. Rushton

Resumen
El análisis de la relación costo-eficacia (ACE) es una herramienta muy utilizada para efectuar evaluaciones económicas en ámbitos vinculados a la sanidad animal, y en particular en la salud humana, a la que aporta elementos de juicio para decidir acerca de la asignación de recursos de atención sanitaria. En sanidad animal, a la inversa, el análisis de la relación costo-beneficio ha sido el instrumento predilecto para realizar análisis económicos. Los autores pasan revista al uso del ACE en ámbitos conexos y a la función de esta técnica en las evaluaciones de sanidad, bienestar y producción animales. El análisis de la relación costo-eficacia puede aportar valor añadido a esas evaluaciones, especialmente en programas dedicados a temas zoosanitarios o de bienestar animal que incidan en la salud humana, pues la mejor forma de valorar sus resultados es en términos de efectos naturales, y no de unidades monetarias. También es importante el hecho de que el ACE pueda efectuarse simultáneamente a la ejecución de un programa para sopesar, en tiempo real, líneas de trabajo alternativas.

Palabras clave

References


