The role of models in estimating consequences as part of the risk assessment process

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Summary

The degree of disease risk represented by the introduction, spread, or establishment of one or several diseases through the importation of animals and animal products is assessed by importing countries through an analysis of risk. The components of a risk analysis include hazard identification, risk assessment, risk management, and risk communication. A risk assessment starts with identification of the hazard(s) and then continues with four interrelated steps: release assessment, exposure assessment, consequence assessment, and risk estimation. Risk assessments may be either qualitative or quantitative. This paper describes how, through the integration of epidemiological and economic models, the potential adverse biological and economic consequences of exposure can be quantified.

Keywords


Introduction

Decision-makers within the international animal health community require objective, repeatable, documented assessments of the risks posed by the importation of animals and their products in order to make defensible decisions and manage risk (3). In this paper, the authors outline the key steps for developing a risk assessment, with emphasis placed on the consequence assessment. In addition, they characterise the role that models can play in quantifying the biological and economic consequences of disease exposure and provide some guiding principles for developing and applying models.

The terms ‘risk’, ‘risk analysis’ and ‘risk assessment’ are often used interchangeably. In this paper, these terms are used as follows (3):

- **risk** can be defined as the probability of an adverse event occurring and the magnitude of the consequences and corresponding impact
- **risk analysis** refers to a systematic process which is comprised of four components: a description of the identified hazards, a qualitative or quantitative assessment of the risk, the resultant strategies employed to avoid or mitigate risk, and the resources and tools used to communicate risk to stakeholders
- **risk assessment** is a component of risk analysis and involves identification, evaluation, and estimation of risk and is characterised by four interrelated steps: release assessment, exposure assessment, consequence assessment, and risk estimation.

Components of a risk assessment

In the context of an animal import risk analysis, a risk assessment is a systematic evaluation of the probability of an adverse event occurring following exposure in a naive animal population. This scientific process starts with the identification of a hazard and then continues with four interrelated steps: release assessment, exposure assessment, consequence assessment, and risk estimation (3).
Hazard identification involves identifying the pathogenic agent(s) which could potentially produce adverse consequences if imported into a region.

The release assessment identifies and describes the potential risk pathway(s) which could lead to the introduction of the pathogenic agent(s) into the country of destination and estimates the probability of occurrence.

The exposure assessment describes the biological pathway(s) and conditions necessary for exposure of susceptible animals and/or humans in the importing country to the pathogenic agent(s) of concern and estimates the likelihood of them occurring. This estimate may be either qualitative or quantitative.

The consequence assessment identifies potential outcomes and describes the corresponding adverse biological and economic consequences of disease exposure. This is followed by an estimate (qualitative or quantitative) of the probability of the consequence(s) occurring.

Risk estimation consists of integrating results from the release assessment, exposure assessment, and consequence assessment to produce an overall measure of risk associated with the hazard(s) identified at the outset. Thus, risk estimation takes into account the whole risk pathway from the identified hazard to the unwanted event.

Role of epidemiological and economic models in estimating the consequences of disease introduction

The World Trade Organization (WTO) Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) states that ‘… Members shall take into account as relevant economic factors: the potential damage in terms of loss of production or sales in the event of entry, establishment or spread of a pest or disease; the costs of control or eradication in the territory of the importing Member; and the relative cost-effectiveness of alternative approaches to limiting risks’ (4). In order to meet the provisions specified in the WTO SPS Agreement, risk analysts can implement a multidisciplinary approach by integrating epidemiological modelling with economic modelling and/or modelling techniques to evaluate a variety of outbreak scenarios. This enables them to describe and quantify the direct and indirect consequences of disease establishing or spreading in the importing country. Examples of ‘direct’ consequences of disease introduction and spread include the number of animals affected, production losses, and public health and environmental

Box 1

Brief summary of a study describing the integration of epidemiological and economic models to estimate the consequences of highly pathogenic avian influenza introduction in North Carolina, United States

The study by Stone et al., entitled ‘Economic impacts of an outbreak of highly pathogenic avian influenza and potential market disruptions’ (2), measured the economic impact of a simulated outbreak of highly pathogenic avian influenza, subtype H5N1, in a backyard flock in North Carolina, the United States, using results from the North American Animal Disease Spread Model to shock a partial equilibrium economic model. Shocks were introduced to the model as changes in production, trade, and demand. In this case, disease negatively influenced these variables. Additionally, the study included an analysis of trade market recovery. The results showed that producers are negatively affected due to the loss of foreign markets and, to a lesser extent, production losses, while consumers gain due to increased product availability in the domestic market. Adverse reaction by consumers to an outbreak of disease negatively affects both producers and consumers, but these impacts are expected to be short-lived, thus tempering the economic impacts. Regionalisation of North Carolina decreases trade impacts of the disease outbreak since the rest of the United States maintains its trade status. Therefore, regionalisation was determined to be an attractive mitigation strategy.

References


The NAADSM has been developed through a continuing international collaboration involving researchers from the United States and Canada, along with support, involvement, and advice from a broad international pool of subject-matter experts. The NAADSM application is freely available via the internet at: www.naadsm.org.

Box 1 provides an example of using the NAADSM to estimate the consequences of the introduction of highly pathogenic avian influenza (HPAI) subtype H5N1 into commercial and backyard poultry in the United States. Table 1 illustrates the economic consequences of this introduction (2).

Principles of developing and using models to inform the consequence assessment

Some basic principles to consider when using models to develop the consequence assessment component of the risk assessment follow:

– the model should be designed and developed to meet the specific objectives or purpose for which it was intended

– the model should be fully documented and transparent and include a comprehensive description of its assumptions, limitations, and simplifications

– the model should be evaluated: means of evaluation may include peer review, verification (testing to ensure the model behaves according to its specifications), and validation (comparing model output with field data).

The model inputs, such as the population(s) of interest and other relevant factors, should be based on the best available information and supported with references to the scientific literature and other sources, including expert opinion. The uncertainties and assumptions, and the effect of those on the assessment, should be well documented.

Conclusion

Risk analysis seeks to provide decision-makers with an assessment of the risks by answering the following questions (3):

– what are the undesirable events that could lead to adverse consequences?

– what and how severe are the consequences?
Models have the potential to play an important role when addressing the consequence component of a risk assessment. A multidisciplinary approach that employs epidemiological and economic models can be used to estimate and quantify the potential adverse biological and economic consequences of exposure.

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Peligro, determinación del riesgo, gestión del riesgo y comunicación sobre el riesgo. La determinación del riesgo empieza con la identificación del o de los peligros y prosigue con cuatro etapas relacionadas entre sí: evaluación de la posible liberación del agente al medio, de la exposición y de las consecuencias, a lo que se agrega una estimación del riesgo. El proceso de determinación puede ser cualitativo o cuantitativo. Los autores describen cómo, gracias a la integración de modelos epidemiológicos y económicos, es posible cuantificar las eventuales consecuencias negativas, tanto biológicas como económicas, de la exposición a un agente infeccioso.

**Palabras clave**
Consecuencias biológicas – Consecuencias económicas – Determinación cuantitativa del riesgo – Determinación de consecuencias – Modelos.

**References**


