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REDUCING THE RISK OF INTRODUCING EXOTIC ANIMAL DISEASE INTO A COUNTRY: COMPUTER SIMULATION TO HELP SET PRIORITIES IN POLICY MAKING

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Une prévention efficace des maladies animales et un programme d'éradication des maladies exotiques sont d'une grande importance, spécialement pour les pays avec une population de cheptel dense et à grande exportation de viande. Les données historiques et expérimentales permettant d'appuyer ces programmes sont rares. Des travaux vétérinaires et épidémiologiques approfondis ont été effectués mais une approche complète combinant les différents aspects de l'épizootie et quantifiant les risques et les conséquences économiques faisait défaut.

Ce papier décrit un projet visant à développer une telle approche. Au sein de ce projet, le modèle de simulation VIRIS est développé. Ce modèle simule l'introduction d'épizooties de maladies contagieuses au sein d'un pays, dans cette étude, la Hollande. Ce modèle intègre les informations objectives et subjectives concernant les risques et les conséquences économiques d'une introduction virale et présente les décideurs politiques avec un outil pratique pour évaluer les programmes de prévention existants et les alternatives possibles. Ce rapport décrit le développement du modèle général VIRIS. Les résultats et les applications possibles sont illustrés pour les maladies du pied et de la bouche (VIRIS-FMD) et pour la fièvre porcine classique (VIRIS-CSF). Les études de scénarios effectuées avec VIRIS montrent, pour les deux maladies, que la largeur de l'intervalle entre l'infection et la détection d'une épizootie est cruciale pour l'importance des pertes. Les résultats montrent, également, que l'élimination du facteur de risque « returning trucks » constitue une réduction des pertes attendues dues aux épizooties de FMD et CSF, en Hollande, de 10 millions de florins. Les décideurs politiques peuvent utiliser cette information pour des propositions d'analyses coût - bénéfice.

INTRODUCTION

The Dutch livestock sector is characterised by a high density of animals and farms and export oriented production. Outbreaks of OIE list A diseases, such as Foot and Mouth Disease (FMD) and Classical Swine Fever (CSF), will have severe economic consequences. Therefore, an effective disease prevention and eradication program for exotic animal disease is of great importance. Historical and experimental data to base these programs on is scarce. Extensive research has been done, but mainly focused on the biological aspects of virus and virus spread, not so much on virus introduction. Also an integrated approach which combines the various aspects of outbreaks and quantifies the risks and economic consequences is lacking.

Concerted action by the government and private industry in the Netherlands has resulted in a research project aimed at gaining more insight into the risk and economic consequences of virus introduction into the Netherlands. The project resulted in a general outline for an integrated approach, described by Horst et al. (1996). Based on this approach, a simulation model was developed to evaluate the process of virus introduction from European countries into the Netherlands and to identify the key risk factors. The model, called VIRiS (Virus Introduction Risk Simulation) focuses on CSF and FMD and is based on historical and experimental data, where available and applicable. Expert knowledge was required and was used as an additional source of information. To rate the information obtained by the VIRiS-model at its true, the results obtained were combined with information from models describing the spread of virus within a country (Jalvingh et al., 1996; Saatkamp, 1996) and thereafter translated into their economic consequences. In this way alternative strategies to prevent introduction of virus in the Netherlands could be evaluated on their merits concerning reduction of losses due to outbreaks.

MATERIAL & METHODS

The VIRiS model

The VIRiS model is based on Monte Carlo sampling. This type of modelling uses randomly drawn numbers from specified distributions and therefore acknowledges the fact that there is variation in the system to be modelled. This variation is due to uncertainty of the exact value of the input parameters and to the nature of the system itself, i.e., also in reality outbreaks may vary in duration, number of outbreaks may differ between years. When such a Monte Carlo simulation model is run repeatedly, the distribution of output values will realistically reflect the possible behaviour of the system under study.

A complete VIRiS run has a time horizon of 5 years. The model uses time steps of one day. Each 'day', the model starts with sampling for new outbreaks in the countries in Europe. If in one of these countries (grouped into five clustered for pragmatic reasons) an outbreak is sampled, the model 'follows' the disease up to a possible introduction of virus into the Netherlands. Distributions based on quantitative information on

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epidemiology, animal density and trade flows determine the location of the possible outbreak in the Netherlands. The number, location and cause (country and method of transmission) of occurring Dutch outbreaks are stored. Intermediate year results are calculated. Days and years are linked to each other in order to follow the evolution of outbreaks.

Input for VIRiS: elicitation of expert knowledge
Three major aspects determine the risk of virus introduction:

1. Frequency of outbreaks in European countries;
   A higher outbreak frequency in countries with which the Netherlands has any kind of relationship (e.g. trade) results in a higher introduction risk for the Netherlands
2. Duration of the High Risk period
   The High Risk period (HRP) defines the period in which virus is already present in a country but not yet detected or under control. During this period virus might be transferred easily to another country.
3. Risk factors
   Risk factors are the vehicles used for virus transfer. Examples of risk factors are: import of livestock, import of animal products, and returning empty trucks (used for livestock export).

Information on these three aspects was obtained from scientific literature, statistics of the National Product Boards, and databases such as the Animal Disease Notification System of the EU. However, changing circumstances such as increased free-trade within the EU, increasing importance of Eastern European countries as trade partner, and ongoing developments in animal health programs and animal health legislation make it difficult to base assumptions and estimates on historical data only. Therefore additional information was sought by experts, people involved in the development and execution of disease eradication and prevention programs. Their expertise combines experience and understanding of current and future circumstances and was therefore seen as a useful and necessary addition.
To elicit and quantify expert information, workshops were organised during which the participants were asked to complete a computerised questionnaire. The questionnaire was self-explanatory in order to minimise the interaction of the participants with each other of with the workshop facilitators. Several elicitation techniques were used, among others the so-called 'Conjoint Analysis technique' (CA). CA is widely used in market research to elicit the subjective views and preferences of consumers (Cattin & Wittink, 1982). The technique is based on the assumption that a product or event can be evaluated as a package of characteristics or attributes and that the overall judgement of the package is based on the individual importance of each of these attributes. CA starts with the overall judgements of respondents on a set of alternatives (i.e., combinations of attributes) and breaks these overall judgements down into the contribution of each attribute, by using ordinary least-squares (OLS) regression analysis. The technique was used in this study to elicit the relative importance of the risk factors. A detailed description of the workshop experiment is given by Horst et al. (1997). Because of the positive evaluation, the same technique was used in a Swiss experiment, aimed at the elicitation of knowledge on introduction and spread of CSF in Switzerland, described by Stärk (1997).

Spread of virus within the country
Models of Jalvingh et al. (1996) and Saatkamp (1996) describe the consequences of primary outbreaks of restively FMD and CSF in the Netherlands. The blue print of the FMD model was developed in New Zealand. Jalvingh et al. (1996) adapted the model to Dutch circumstances. As VIRiS, also InterSpread is a Monte Carlo simulation model. Saatkamp (1996) developed a state-transition model (with some Monte Carlo elements) describing the spread of CSF within Belgium. The model was adapted to Dutch circumstances.
Both 'spread models' provide insight into the number of infected and affected farms (affected by movement restrictions), and the duration of the outbreak, under various eradication strategies. In this study, the minimal EU standard strategy was applied.

Economic consequences of outbreaks
In close corporation with representatives from the livestock production sector, losses due to outbreaks of CSF and FMD were calculated, for all parts of the production chain. Losses were due to slaughtering of infected herds, production stand-still (farms, slaughterhouses), movement restrictions, buying-up measures (government buys and destroys animals from farms within the restriction zones, to avoid problems with welfare, virus transfer and oversupply on the internal market due to trade bans), and organisational costs.

RESULTS
VIRiS results show that most primary CSF outbreaks are expected to occur in the southern region of the Netherlands (41%) followed by the eastern region (34%). Least outbreaks are expected in the northern and western region, 12 and 13% respectively. The most likely area in the Netherlands for a primary FMD outbreak is the eastern part (38%). In the southern, western and northern part the expected percentage of primary outbreaks in 26, 22, and 14% respectively. These probabilities have a high and positive correlation with the animal and farm density of the respective areas, which is due to the great influence of the risk factor 'import of livestock'. More than 50% of the expected primary FMD outbreaks were caused by this factor. Also for CSF the import of livestock is the most important risk factor. Other important risk factors are 'returning trucks' (both diseases) and 'swill feeding' (CSF). Most outbreaks of both disease are originating from southern European countries or from countries neighbouring the Netherlands.
Table I shows the results of the base and some alternative scenarios of the VIRiS model. The base scenario describes the current situation in the Netherlands, based on the assumption that, most likely, 2.5 CSF and 1

FMD outbreak will occur in the next five year. The calculations are based on the average duration and magnitude of outbreaks (results of the 'spread models'). Outbreaks were stamped out in accordance with minimal EU-standards. The results show that on average, expected annual losses due to CSF outbreaks are 77 million Dutch guilders (about US$ 39 million). Expected annual losses due to FMD outbreaks are lower because the frequency of such outbreaks is lower and also losses per outbreak are lower (duration of outbreaks is shorter).

The alternative scenarios show the importance of early detection of outbreaks. Doubling HRP1 (interval infection - detection) results in a considerable increase in the expected annual losses. The complete elimination of the risk associated with returning trucks results in a reduction of expected annual losses of more than 10 million Dutch guilders. The reduction in losses, obtained by the alternative scenarios, might be seen as an indication for the financial space available for measures aimed at the realisation of the respective scenarios. In this way, VIRiS can add to the evaluation of animal disease prevention programs and serve as a useful tool for policy makers.

Table I
Number of outbreaks per year and losses per year (in million Dutch guilders)

	FMD		CSF	
Scenario	Outbreaks/year	Losses/year	Outbreaks/year	Losses/year
Base	0.2	25	0.5	77
HRP*2	+ 0.17	+ 80%	+ 0.13	+ 26%
No risk of:				
-import livestock	- 0.098	- 66%	- 0.28	- 61%
- returning trucks	- 0.066	- 30%	- 0.08	- 6%

CONCLUDING REMARKS

Simulation modelling is a powerful technique to gain insight into complex problem situations. The described VIRiS model is flexible and can easily be adapted to new situations and new information. The current model is partly based on expert information. As long as historical data and/or experimental research are not available to provide better predictive results, the use of such expert information will be necessary in models describing risks and consequences of contagious animal disease outbreaks. The Monte Carlo technique enables an optimal use of this information.

The study shows that the integration of models describing introduction, spread and economic consequences of disease outbreaks provides useful information for the evaluation of animal disease prevention programs.

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