Computerised methods for animal health risk assessment using the EPIZOO® 2.6 program

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Summary
A computerised set of methods for the risk assessment of infectious diseases has been developed as part of a software package which deals with animal population health and disease analyses and programming (EPIZOO®, version 2.6). This set includes methods for calculating the following:
- general indicators of risk of animal disease
- risk probability assessment of propagation of disease
- risk probability assessment of the introduction of disease through the importation of animals and their products, based on predefined criteria and on non-predefined criteria
- risk comparison of the introduction of one disease agent from several territories
- risk comparison of the introduction of several disease agents from one territory
- risk of disease propagation related to the movement and concentration of the animal population
- risk of disease propagation related to the transfer of animal products
- risk of the probability of negative test results in infected animals
- risk of the probability that at least one imported animal or animal product unit is infected.

Keywords

Introduction
With the increase in national and international trade of animals and animal products, the use of quantitative risk assessment methods has become very important. These methods, together with qualitative risk assessment methods, are needed to assist in the decision-making for such trade.

Any importation of animals and raw animal products brings a potential risk, not only of the introduction of disease agents but also of such diseases spreading (multiplying negative impact can reach catastrophic proportions in some cases). This is not the case when importing other commodities.

Several software programs have been developed in regard to this issue. However, these contain only a few methods for the calculation of disease risk, i.e., general indicators applicable to the local conditions of the exposed population. These programs include EPI INFO® (12), EPISODE® (13) and EPIZOO® (14), etc. For operational evaluation of the risk when deciding on the importation of animals or their products, HANDISTATUS® (Help with World Animal Disease Status), which provides a comparison of the officially reported disease situations in importing and exporting countries, has proved a useful information software package (15). There are also software programs which deal generally with risk calculation, such as the commercial simulation computer software package @RISK® (16), which is also partially applicable to animal disease risk assessment. Another package called RISK ASSISTANT® (17) contains analytical tools and databases to assist in the exposure and risk assessment of chemically contaminated sites. Unfortunately, specific computerised analytical methods covering the major range of different animal disease risks have been lacking.
There is a need for a more objective approach to disease risk assessment, related mainly to the importation of animals and animal products. Such an approach demands more specific and more varied computerised methods.

With the aim of helping to fill the gap and to facilitate quantitative analyses of animal disease risk, a special set of risk assessment computer methods has been developed and tested. Particular priority was given to risks related to the export and import of animals and their products.

Materials and methods

Initial risk analysis methods have been amended by other methods from different sources (references are given at particular subprograms). Their procedures were converted into a software language and included in the new enlarged and improved version (2.6) of the EPIZOO® software package (written in English). A detailed description of this integrated analytical and programming system is given in publications by the author (4, 6).

The main criteria in developing particular subprograms related to animal disease risk assessment were as follows:
- to develop computerised methods suitable for action-oriented decisions
- to develop general methods which would be applicable to most animal diseases
- to include a flexible subprogram which would give the user the chance to select and formulate evaluation criteria
- to ensure that the risk criteria are reasonable and of limited number
- to ensure that the risk criteria combine the occurrence and behaviour of the disease with the ability of the Veterinary Service to detect and control this disease
- to base the input on a question-and-answer format and to ensure that the output is obtained immediately in the form of text and, eventually, tables and graphs
- to ensure that it is easy to print input data and results directly from the screen
- to ensure that the new subprograms to be included in the existing software package as integral components remain within the limit of one 1.4 megabyte (Mb) diskette (without compression)
- to tailor the package for IBM-compatible personal computers which use the MS-DOS operating system.

Results

Computerised analytical methods were developed and tested, as described below.

General indicators of animal disease risk assessment

These indicators have been described in various papers (1, 2, 3, 5, 8, 10, 11), and are as follows:
- grade of relative risk (risk ratio)
- grade of attributable (differential) risk
- fraction of attributable risk
- percentage of attributable risk
- grade of risk superiority (risk odds ratio)
- grade of individual risk of exposed animals
- grade of individual risk of non-exposed animals.

Risk assessment of the probability of animal disease spread

This subprogram calculates the probability of the potential risk of a specific disease agent spreading from the existing foci and creating new foci.

The following criteria were used to determine the situation in the original territory/population/unit:
- the period prevalence and incidence of the specific disease and the focality of that disease
- the tendency of the specific epizootic process (stagnating, increasing or decreasing)
- the estimated level of the tendency to increase or decrease of the specific disease process (the interaction of population, pathogens and environment, the stage of development), also considering the role of influencing factors, previous propagation intensity, etc.
- the estimated level of inability to reduce the number of foci due to the lack of effective field measures to reduce, eliminate and/or eradicate the disease, of animal health control measures and of adequate veterinary field and laboratory service capabilities
- the estimated level of inability to protect the specific disease-free part of the population thereby avoiding new foci, due to the lack of effective protection measures against contacts with intrafocal animals and their products and/or with other aetiological sources (vectors or wild animal reservoirs, etc.), lack of specific resistance in the population, insufficient diagnostic methods and/or veterinary service capabilities, etc.

Risk assessment of the probability of disease introduction, based on predefined criteria

This subprogram calculates the probability of the potential risk of a specific disease agent being introduced into a territory (country, province, region, ranch, etc.) from abroad. Selected criteria of 'inability' (i.e., lack of power or means) are used in the form of failure grades (numbers between 0 and 1). The multiple of these grades represents the result. The subprogram is subdivided according to the direction of selected criteria, i.e., whether such criteria increase or
decrease the risk of introducing the disease agent and whether the objects are the animals or their products.

In addition to specific disease prevalence, the following criteria were used to determine the situation in the original exporting territory/population/unit:

For animals

a) the estimated level of inability to identify all specifically diseased animals and herds. The following items were considered:
- sensitivity and specificity of diagnostic methods used
- population investigation grade
- field and laboratory service capabilities
- active field surveys
- reporting/information systems, etc.

b) the estimated level of inability to confine the specific disease (new foci, incidence of foci), due to lack of effective isolation of foci or lack of control/protective field measures during the previous crucial period

c) the estimated level of inability to avoid diseased (infected) animals being exported. The following items were considered:
- pre-export animal selection, testing, treatment and control measures
- confidence in the certification provided
- eventuality of previous cases of exporting infected animals or their products, etc.

The results are the values of the risk probability of disease introduction and the probable number of imported diseased animals.

For animal products

A similar principle is used for risk assessment of the probability of the introduction of an animal disease agent through animal products. The procedure is adjusted to the specific characteristics of the given products. That is, it includes the estimated level of inability to avoid the contamination of healthy products by specific pathogens during processing, storing and transport, etc.

The results are the values of the risk probability of the introduction of the disease and the probable quantity of imported infected products.

Risk assessment of the probability of introducing disease, based on non-predefined criteria

This subprogram gives the user the chance to formulate the disease risk criteria, according to particular situations, conditions and needs.

The result of this subprogram is the multiple of the disease occurrence grade and the probability grades of particular criteria. This ‘user model’ subprogram is subdivided according to the selected criteria, i.e., whether they increase or decrease the risk of introducing the disease agent. Such criteria could include the following:
- disease transmissibility
- resistance or susceptibility of exposed animals
- ability or inability to discover all infected animals/herds
- ability or inability to avoid spread of the agent
- effectiveness or ineffectiveness of pre-export ‘filters’.

The grading range is the same as in the previously described subprograms.

Risk comparison of the introduction of disease from several territories

This subprogram compares the relative risks of a specific disease being introduced by direct importation from territories which are not free of the disease. The criteria are as follows:
- grade of disease transmissibility
- grade of disease occurrence (prevalence, incidence and spread/distribution)
- level of inability to identify all infected animals and herds
- level of inability to confine the disease (emergence of new foci), i.e., inability to protect specific disease-free animals, herds and territory
- level of inability to reduce disease occurrence
- grade of ineffectiveness of the pre-export ‘filter’.

All partial values are corrected by multiplier indexes of importance.

Risk comparison of the introduction of several diseases from one territory

This subprogram compares the relative risks of specific diseases being introduced by direct importation from a territory which is not free of these diseases. The criteria related to the exporting territory are the same as in the previous subprogram.

Animal population movement as a potential risk for disease propagation

This subprogram analyses animal population movement in terms of distance and time, as well as in terms of indicators
related to movement extent (range), dispersion and convergency.

**Transfer of animal products as a potential risk for disease propagation**

This subprogram calculates indicators related to the transfer of animal products and distribution, such as extent, dispersion and convergency.

**Animal population density as a potential risk for disease propagation**

This subprogram calculates indicators related to the grade of animal population density in local surface space and territory as well as in the volume space of the environment.

**Risk probability of negative test results in infected animals**

This subprogram uses the approach described by MacDiarmid (7) and calculates the following:

- the probability that an animal which gives negative results in disease testing is actually infected with the disease agent
- the probability that an animal which gives negative results in disease testing and is actually infected will be included in the export group
- the probability of a given test failing to detect at least one positive animal in an infected group.

**Risk probability that at least one imported animal or animal product unit is infected**

This subprogram uses the approach described by Morley (9) and calculates the probability that no single imported animal or animal product unit is infected.

**Other subprograms related to disease risk assessment**

Other subprograms related to disease risk assessment are as follows:

a) The subprogram ‘Per capita consumption of food of animal origin as potential zoonoses risk’ analyses the average consumption of food of animal origin per person, according to food type, place and time.

b) The subprogram ‘Rates of spread of animal disease outbreaks’ evaluates the rates and ratios of primary and secondary outbreaks.

c) Subprograms related to chi-square tests, contingency tables, etc. (1, 2, 5, 8, 10, 11) provide odds ratios as one of the general indicators.

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**Software size and structure**

After including the set of disease risk assessment methods, the new version 2.6 of EPIZOO® contains: 14 modules, 156 subprograms, 32 methods supported by 14,804 operation command lines, which use 803,151 bytes.

The list of modules is as follows:

- animal population – characteristics of health importance
- animal population health analysis – system of basic indicators
- adjustment (standardisation) of animal population health rates
- selected indicators of animal population health structures
- selected indicators of epizootic process dynamics
- consequences of animal population health and disease
- investigation of animal population health situation
- methods related to sampling in population investigations
- selected aspects of animal population health programmes
- cost and efficiency of animal population health programmes
- selected methods of animal disease risk assessment
- complementary subprograms
- selected statistical methods used in epizootiological practice – I
- selected statistical methods used in epizootiological practice – II.

**Discussion and conclusion**

There are many methods for animal disease risk assessment. Some are based on relatively simple criteria and indicators, while others use sophisticated procedures based on mathematical analysis of available data or estimates. Computerisation of these methods facilitates their use and helps in achieving some sort of standardisation.

Calculated disease risks expressed numerically should be understood as an important and useful tool in aiding decisions on the introduction (importation) of particular animals and their products.

The input and interpretation of results should be based upon theoretical knowledge and practical experience and should be meaningful. A unilateral mathematical approach which does not respect biological facts, the influence of external factors and the capabilities of the Veterinary Services to detect, survey and control the health/disease status of animal populations could lead to false or even absurd conclusions. Mathematical analysis alone cannot replace the complex analyses performed by veterinary professionals.
The differing needs and situations in exporting and importing countries (territories, populations, units), in terms of animal disease morbidity, nidality, distribution, husbandry technology, veterinary field and laboratory diagnostic service capabilities (such as staffing, materials, facilities, funds, etc.), mean that each individual case requires a different approach, but the methods by which each case is evaluated should respect general principles. The complexity of the problem is multiplied by the variability of the characteristics of the specific disease. Such characteristics often differ greatly, according to the animal species and categories (breed, age, type of production, etc.), as well as to features of the aetiological agents and the particular environmental conditions.

The basic prerequisite for reasonable risk assessment is a good knowledge of the animal population disease situation. This requires effective investigation and surveillance systems. One must be very careful if the disease situation is only known superficially or is not yet being monitored. New 'emerging' diseases, which were unknown in the past, represent serious difficulties when trying to assess their risk.

Disease risk reduction can be achieved by effective risk management measures (however, this is not the subject of this paper).

In this software package, only the first subprogram of general risk indicators, based on known analytical methods, parallels functions in the other software packages mentioned above. The other subprograms are original procedures.

This newly developed software package, tailored specifically for animal population health, is quite independent. That is, it requires no other software and can be run directly from the disk drive or from the hard drive after installation. It is easy to operate and does not require any special manual or training (internal instructions are components of the individual subprograms).

This original set of computerised methods for animal disease risk assessment represents a contribution towards filling the gap in this field of veterinary medicine.

EPIZOO® can be obtained free of charge by writing to the Chief of Veterinary Public Health, Division of Communicable Diseases, World Health Organisation, CH-1211 Geneva 27, Switzerland. The request must be accompanied by a formatted 3.5 inch high-density diskette (1.44 Mb). This software may be freely copied.

EPIZOO® is also available on the Internet at http://tron.is.s.u-tokyo.ac.jp/WHO/whosis/vph/epizoo/epizoo.htm. It may be downloaded to unzip and run locally by clicking on epizoo.zip.

Méthodes informatisées applicables à l'évaluation des risques zoosanitaires, utilisant le programme EPIZOO® 2.6

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Résumé
Un ensemble informatisé de méthodes d'évaluation des risques de maladies infectieuses a été mis au point dans le cadre d'un progiciel d'analyse des données et de programmation, applicable à la santé animale (EPIZOO®, version 2.6). Ce progiciel comprend des méthodes permettant de calculer :
- les indicateurs généraux de risque de maladies animales ;
- l'évaluation des probabilités de risque de propagation de maladies ;
- l'évaluation des probabilités de risque d'introduction de maladies lors d'exportation ou d'importation d'animaux et de produits d'origine animale, sur la base de critères prédéfinis ou non ;
- les risques comparés d'introduction d'un agent pathogène à partir de plusieurs territoires ;
- les risques comparés d'introduction de plusieurs agents pathogènes à partir d'un seul territoire ;
Métodos informatizados para la evaluación de riesgos zoosanitarios mediante el programa EPIZOO® 2.6

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Resumen
El autor describe una serie de métodos informatizados para evaluar los riesgos de enfermedades infecciosas, parte integrante de un conjunto de programas informáticos concebido para el análisis y la programación de datos relativos a la sanidad animal y a las enfermedades en poblaciones animales (EPIZOO®, versión 2.6). Los métodos incluidos en dicho conjunto permiten realizar los siguientes cálculos:
- indicadores generales del riesgo de enfermedades animales;
- estimación de probabilidades de riesgo de propagación de enfermedades;
- estimación de probabilidades de riesgo de la introducción de enfermedades a través de animales o productos de origen animal exportados/importados, cálculo que puede basarse en criterios predefinidos o no predefinidos;
- comparación del riesgo de introducción de un agente patógeno desde distintos territorios;
- comparación del riesgo de introducción de distintos agentes patógenos desde un único territorio;
- riesgo de propagación de una enfermedad ligado a los movimientos y la concentración de la población animal;
- riesgo de propagación de una enfermedad ligado al transporte de productos de origen animal;
- riesgo de que los resultados de una prueba de diagnóstico sean negativos a pesar de que el animal está infectado;
- riesgo de que por lo menos un animal o un producto de origen animal estén infectados en el momento de su importación.

Palabras clave
References


List of software


13. EPISCOPE© (1990). - Computer programs in veterinary epidemiology. Developed by the Agriculture University in Wageningen, together with the Royal Veterinary and Agriculture University in Copenhagen.


15. HANDISTATUS© (1996). - Help with Animal Disease Status is a database program which contains information about animal diseases important to international trade or human health. The main sources of information are the Animal Health Yearbook of the Food and Agriculture Organisation of the United Nations (FAO), Office International des Epizooties (OIE) and the World Health Organisation (WHO), published by the FAO, and the International Animal Health Code and World Animal Health, produced by the OIE. The program was prepared by Theresa Bernardo, Inter-American Institute for Cooperation on Agriculture (IICA), San José, Costa Rica.

16. @RISK© (1993). - Computer software package of the Palisade Corporation, Newfield, New York, used for commercial simulation models in the form of spreadsheets and risk estimate curves.

17. RISK ASSISTANT® for Windows (1995). - This contains analytical tools and databases to assist in the exposure and risk assessment of chemical-contaminated sites. Developed by Hampshire Research Institute, United States of America.