Animal disease outbreak control: the use of crisis management tools

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Summary
In this era of globalisation the effective control of animal disease outbreaks requires powerful crisis management tools. In the 1990s software packages for different sectors of the government and agricultural industry began to be developed. In 2004, as a special application for tracking the movement of animals and animal products, the European Union developed the Trade Control and Expert System (TRACES) on the basis of its predecessor, the Animal MOVement (ANIMO) project. The nationwide use of the ANIMO system by the veterinary authorities in Germany marked the beginning of the development in 1993 of a computerised national animal disease reporting system – the TierSeuchen-Nachrichten (TSN) – using the ANIMO hardware and software components. In addition to TRACES and TSN the third pillar for the management of animal disease outbreaks and crises in Germany is the national cattle and swine database – called Herkunftssicherungs- und Informationssystem für Tiere. A high degree of standardisation is necessary when integrating the different solutions at all levels of government and with the private sector. In this paper, the authors describe the use of these tools on the basis of their experience and in relation to what we can do now and what we should opt for in the future.

Keywords

Introduction
In a global market that includes the international trade of animals and animal products, animal disease outbreak control, response, and crisis management require powerful software tools. Multiple outbreaks of classical swine fever (CSF), foot and mouth disease (FMD) and highly pathogenic avian influenza (HPAI) highlight the necessity of the prompt availability of information on a number of different issues, such as:

a) contact between farms: this is of the utmost importance from an epidemiological point of view, as contact between animals from different herds is the main route of infection.

Knowledge about national and international animal trade and/or movement is essential if contact with contagious herds is to be avoided

b) the ‘curriculum vitae’ of animals; for instance, in the case of bovine spongiform encephalopathy (BSE), knowledge about the origin of the animals is crucial in identifying the specific cohort that must be considered exposed to the BSE agent

c) data relating to farms in the affected regions, more specifically:

– the number of farms in the region at the different administrative levels, including detailed information about the registered farms at the national and regional levels
- the number of susceptible animals by species in the region
- farm locations: the classification at municipality level is usually not precise enough for regional crisis management; ideally, the geographic coordinates of each premise where herds are kept should be registered so that they can be entered into a geographical information system (GIS)
- the number and composition of mixed farms for the analysis of multiple species diseases
- the numbers and kinds of infected farms, and of those farms free of disease
- the number of animals that are kept on infected farms and on disease-free farms

\[ \text{d) up-to-date epidemiological status reports: early warning systems are needed and must be electronically supported with the latest information on the epidemiological situation nationally and worldwide} \]

\[ \text{e) agreed responses: availability of central databases (CDB) with an official handbook on disease control and crisis management.} \]

Epidemiological instruments required for animal disease monitoring and for outbreak investigations

Ideally, the following databases should be available to the Veterinary Services:

\[ \text{a) a complete inventory of all farms and other animal holdings} \]

\[ \text{b) diagnostic results from all tested animals (infected and uninfected)} \]

\[ \text{c) case/outbreak data.} \]

In Germany, these databases exist but they cannot all be accessed at all levels. Inventories of farms and animal holdings are maintained at the district or town level. Due to data protection regulations, only the local veterinary authorities have full access to these data, which include addresses, telephone numbers, etc. Diagnostic data recorded by the veterinary investigation centres (VIC) are also maintained in electronic databases but access is restricted to the VIC staff. An online database of animal disease outbreaks with detailed information on the affected animals and the locations of the outbreaks is maintained at the national level; access is restricted to the veterinary authorities at national, state and local level.

To analyse data as part of regular animal disease monitoring and surveillance activities and in the course of outbreak investigations, animal and disease data must be electronically available at all times, preferably online and in a geo-referenced format. These data can then be used when analysing the temporal and spatial behaviour of disease, to predict its kinetics, and to study transmission pathways as part of the required tracing-back and tracing-forward.

Incoming data and information on suspected outbreaks can also be used as an early-warning system.

On the basis of the outbreak data, and the numbers of affected animals, farms or holdings, and products (e.g. milk, eggs, slaughter pigs), the personnel and logistical resources that are required to control the outbreak can be planned.

Veterinary officers and veterinary epidemiologists must be trained so that they can enter data, preferably in the field, and utilise the available databases without delay to contain any outbreak as quickly as possible. Appropriate software must be provided that supports outbreak management. This can be better achieved by implementing a GIS that
spatially locates diseased farms, can establish restriction zones, can calculate the numbers of animals that will be affected by the measures to be taken, and helps to notify farmers individually and regionally.

Geographical information systems – indispensable for modern crisis management

Geographical information systems are computer-based tools that can store, analyse and display both spatial and non-spatial data (3); GIS software can be split into three functional groups:

a) GIS, in a more narrow sense, with the ability to generate, modify, transform and analyse geographically referenced data

b) mapping software to visualise the spatial data without the possibility of manipulating the geometric feature database

c) database management systems (DBMS) as general-purpose software products which can store but also analyse small to extremely large geographical datasets without visualisation.

The traditional distinctions between these are vanishing through the hardware and software revolutions of the past decade; desktop GIS software, geographically-enabled programming languages, embedding of GIS functionality in application software, and mapping on the Internet have allowed the application of a broad spectrum of analyses and visualisation techniques of spatial epidemiological data. Nevertheless, it is necessary to define the purpose of the analysis to determine the appropriate GIS tool.

Geographical information systems and spatial epidemiology are playing an increasingly important role in animal disease control. For some time, district veterinary authorities and laboratories in Germany and other European Union (EU) member states (e.g. the Netherlands, the United Kingdom, Denmark) have been using GIS in applied disease control. This has been mainly in outbreaks of notifiable diseases by supporting district veterinary officers in the definition of restriction areas, and in planning control measures and eradication strategies. With the help of GIS and new spatial statistical methods, the spatial and temporal spread of diseases can be analysed and the risks defined.

Existing tools for animal disease outbreak control and crisis management in Germany

TRACES: Trade Control and Expert System

With the introduction of the common market within the EU on the 1 January 1993, the border veterinary inspection posts between member states were closed. To keep the transport of animals and products of animal origin within the EU under control, the European Commission (EC) developed an automated network between the various EU veterinary authorities called ANimal MOvement (ANIMO) on the basis of Council Directive 90/425/EEC of 26 June 1990 (11). With this system the responsibility for checking animals and animal products was shifted to the veterinary offices at the place from which the animals/products originated and at the final destination. To that end the responsible veterinary office at the point of origin entered the health certificate into the computer and transferred it to the central EU ANIMO server in Dublin. The responsible veterinary office at the destination could then download the health certificate from the server and then, if necessary, take samples when the consignment arrived. The same procedure was applied to imports from, or exports to, third countries: the responsible border inspection post from where the consignment left the EU would create an ANIMO message for the veterinary office at the destination (importing country) or, the border inspection post from where the consignment entered the EU would receive an ANIMO message from the veterinary office at the point of origin (exporting country), respectively.

To make the communications with the EU ANIMO server more effective, and to give the senior veterinary authorities the opportunity to access their national animal data traffic, a national ANIMO server was installed at the Institute of Epidemiology at the Federal Research Centre for Virus Diseases of Animals (now the Friedrich-Loeffler-Institute). Instead of each directly communicating with the central EU ANIMO Server, the German ANIMO units (veterinary authorities and the border inspection posts at the EU border with third countries) communicated exclusively over this national ANIMO server with the EU ANIMO server in Dublin. The ANIMO system was introduced in Germany on 1 September 1993. Regular operation (data communication with the EU ANIMO Server) started on 1 June 1994. Despite the initial shortcomings of this system (see below) and the extra work the veterinary officials had to do in ‘times of peace’ (i.e. in disease-free periods), ANIMO proved to be a success in Germany in the following ‘times of crisis’.
1996: outbreaks of CSF in the Netherlands
2001: outbreaks of FMD in Great Britain, France and the Netherlands

During these outbreaks it was possible to locate consignments of animals coming from these countries into Germany and to initiate appropriate measures which helped to prevent these diseases from spreading into the country.

Although ANIMO represented progress regarding the documentation relating to the transport of animals and animal products between member states of the EU, it still had several shortcomings:

- no data transfer in real time, so it could take several days until the receiver got the ANIMO message
- no facility to respond to the sender if the consignment did not correspond to what was described in the documentation or if the competent authority of the place of destination was legally required to inform the competent authority of the place of origin that the consignment had arrived (Council Decision 1774/2002 of 3 October 2002 [6])
- misdirected messages because of wrong addresses
- extra data-entry work for the sending veterinary authority
- no possibility of using this system for animal welfare.

At approximately the same time as the ANIMO system came on line, a similar system was beginning to be developed for use at veterinary inspection posts (road, railway, airport, port) at EU borders with third countries. This System to assist with the Health controls of Imports of items of veterinary concern at Frontier inspection posts from Third countries (SHIFT system) was due to be developed on the basis of the Council Decisions 92/438/EEC of 13 July 1992 (12) and 92/563/EEC of 19 November 1992 (13), but it did not get beyond the development of several prototypes. For this reason, the EC launched the Trade Control and Expert System (TRACES) (regulation 2003/24/EC of 30 December 2002 [7]). The system has the following goals:

- integration of the existing ANIMO system with the SHIFT system
- development of an integrated database
- improved control and tracing of consignments of animals and animal products
- decision support in regard to imports of animals and animal products from third countries
- introduction of a central alert system
- risk assessment
- reduction in the administrative workload.

As a web-application (one central web server with a CDB and online access from clients with a browser), TRACES provides fast and up-to-date information for the responsible veterinary authorities and it enables electronic certification (Fig. 1).

TRACES is multilingual, so all member states can use it in their own languages and all of the current 32 different health certificates can be displayed and printed out in all of the different languages. Commercial operators can now use TRACES by entering their consignment data themselves, with the result that the relevant veterinary office only needs to certify the consignment. This allows a reduction in the administrative workload of the veterinary authorities. The integration of private veterinarians and/or veterinarians approved by the veterinary authorities is also possible, but this has not been implemented in Germany. It is envisaged that veterinary authorities and organisations in third countries will be able to connect to TRACES and thus reduce the administrative workload at the border inspection posts, because these organisations will have entered their consignment data in advance.

When a health certificate has been entered, the users responsible (e.g. the veterinary officers [or commercial operators that use TRACES] in importing countries) are notified by e-mail, indicating that there is a certificate to be processed. Then the responsible authority can initiate controls or other measures concerning the consignment and enter the results into TRACES (Fig. 2).

The system was gradually introduced in 2004 and the use of TRACES has been obligatory for all EU member states since 1 January 2005 (Decision 2004/292/EC of 30 March 2004 [9] and regulation 599/2004 of 30 March 2004 [8]). Further information regarding TRACES can be found at http://www.traces-cbt.net.

The national animal disease reporting system in Germany

Since the introduction of ANIMO in 1993 every district veterinary office in Germany has been equipped with a personal computer, modem and communication software as a prerequisite for computer-aided communication within the government Veterinary Services. This equipment was also needed for the development of the computer-supported national animal disease information system – or Tierseuchen-Nachrichten (TSN) – at the Institute of Epidemiology attached to the former Federal Research Centre for Virus Diseases of Animals (now the
Fig. 1
Architecture of the European Union (EU) Trade Control and Expert System (TRACES)
The database is designed to facilitate trade in animals and animal products and track consignments moving within the EU and leaving/entering the EU for/from third countries (4)

Fig. 2
Example query using the European Union Trade Control and Expert System (TRACES): query of all incoming animal consignments from the Netherlands with departure dates between 1 September 2005 and 1 October 2005
Friedrich-Loeffler-Institute, Federal Research Institute for Animal Health [15, 16]). The official nationwide start of TSN was 1 January 1995, as stipulated by national legislation. The first Windows® version was implemented in December 2000. This also marked the beginning of its transformation into a crisis management system.

The TSN system has two components. The client component in the local veterinary office is used for offline data acquisition. Disease outbreak information is then transmitted to the centralised animal disease database (CADDB) on the server (second component) at the Friedrich-Loeffler-Institute in Wusterhausen. In Wusterhausen, information is stored in a structured query language database. Only authorised users have access. The data flow is shown in Figure 3 (14, 17).

The TSN can be used in local area and wide area networks. As many districts and towns as required, with separate local veterinary authorities, can be installed in one place. Therefore, data acquisition and query are possible from different computers and various localities. This is especially necessary during epidemics that affect more than one district or town.

During an epidemic extensive information needs to be collected for each outbreak. These data can then be managed and edited in the outbreak explorer or editor. Data acquisition is based on default values, which allow maximum plausibility control. Entry fields are compulsory or voluntary depending on the information value for disease control. Changes in animal disease notification and/or data record definitions can and should be taken into account immediately via the automated synchronisation of master data by communication with the CADDB; the dynamic data are synchronised in the same manner. Master data are available for different entry fields, e.g. for diseases, pathogens, species, diagnostic methods, and sources of infection. These master data are regularly updated in compliance with national and international laws and regulations (10, 19).

Crisis management demands complex farm and livestock management in connection with geo-referenced positions of the animal disease outbreaks and of all affected farms and associated agricultural business, such as abattoirs, dairies, and rendering plants. The TSN system offers diverse farm management and GIS functions concerning animal disease outbreak control, response, and crisis management (17, 18). Animal disease cases and farms can be localised precisely by using digital topographical maps accessible via mouse click (geo-referencing). The spatial distribution of animal disease cases can be shown at different resolutions and/or administrative levels. The geo-referencing of all farms will be completed in all districts and federal states of Germany in the near future. Districts with geo-referenced farm databases can manage and analyse spatial data as follows:

- automated presentation of the spatial distribution of farms on digital topographical maps; e.g. for inspection visits by field task forces
- automated creation of farm lists and addresses
- livestock composition analysis
- transmission and exchange of data files, e.g. between task forces, by standardised visualisation of the zones via TSN
- fast and precise creation of restriction and surveillance zones. These zones can be visualised in the form of radii or polygons that can be defined without any restrictions. A flexible presentation of the livestock of these areas can also be produced by the software, as illustrated in Figure 4. For publication purposes this display example is much simplified. The actual display can have a wealth of detail, including houses, woods, roads, streams and rivers.

An important point with both suspected and confirmed outbreaks is to be up-to-date on diagnostic methods and to have task force guidelines, such as for the duties of each member of the task force and for coordination in space and time. An HTML-based collection of diagnostic methods is integrated into TSN. The national reference laboratories for notifiable diseases are responsible for updating this information. A search function and a glossary are included. A standardised handbook for animal disease eradication is currently under development. The CADDB can also be used for communication between the involved authorities at the federal state level and the Federal Ministry of Consumer Protection, Food and Agriculture.

Furthermore, when queried, CADDB can provide information in different formats, e.g. it can supply official certificates, tables and maps (Figure 5 – national situation of transmissible spongiform encephalopathy cases in 2004) and provide access to official statistics and to an address list of veterinary authorities. Each veterinary office can update its own address. The CADDB address link can be used as an early warning system based on email notification. Responsible official veterinarians can activate this optional function.

The TSN software will be upgraded in the near future. A so-called crisis module will be implemented that allows the management of bigger restriction and surveillance zones, for example, several overlapping districts and/or federal states. The improved system will be able to process data about epidemiological surveys, livestock estimates, clinical examinations and culling (14).
Centralised animal disease database
(data, analysis software, web server)

- Federal states authorities
- National reference laboratories
- Ministry of consumer protection, food and agriculture
- EC OIE, official publications

Fig. 3
The flow of data in the national animal disease reporting system in Germany

Fig. 4
An example of the way in which restriction and surveillance zones can be depicted using the German animal disease reporting system: solid black squares (restricted farms), open circles (farms under surveillance)
Herkunftssicherungs- und Informationssystem für Tiere – the national cattle and swine database

The Herkunftssicherungs- und Informationssystem für Tiere (HI-Tier) is the computerised, Internet-based herd and animal identification and registration (I&RS) system that was established in Germany in 1999 on the basis of Regulation (EU) No. 820/97 (5) and the corresponding national regulation (www.hi-tier.de). According to these regulations all holdings and holders of cattle, including traders and slaughterhouses, have to be registered and have to report all changes in their stock (births, on and off movements, imports, exports, deaths or slaughter) to a national CDB. The reporting can be done either via Internet, phone code system or by postcards (1, 2).

In addition to the veterinary regulations, EU-premium payments for cattle in Germany are allocated on the basis of the information in the CDB. This puts enormous pressure on all sectors of the livestock industry, including farmers, traders, exporters and slaughterhouses, to report all changes correctly and promptly to the CDB.

To ensure the best possible data quality in the HI-Tier, a strict two-step quality assurance programme was established. In the first step each report is checked before storage for completeness and correctness. Only correct and complete reports are stored. In a second step after storage all reports on individual animals (identified by ear tag number) are checked against all other reports about this same animal. In the event of discrepancies or contradictions the report holders are informed via Internet or letter and asked to confirm or correct their report.

The HI-Tier CDB receives about 40 million reports from cattle holders every year; the average per day is about 110,000, and more than 85% of all reports arrive via the Internet.

Since 2002, in addition to the I&RS functions of the system, the veterinary laboratories and the Veterinary Services store certain individual disease data in the CDB, e.g. test results for BSE, bovine herpesvirus type 1, and bovine viral diarrhoea. Furthermore, information about the vaccination of individual animals can also be stored and retrieved. Contrary to most other veterinary databases for cattle, HI-Tier is based on detailed information about individual animals (obtained through ear tag numbers) and not on summarised information about herds.

This specific information in the CDB from various sources allows the Veterinary Services in combination with web access via Internet to make a wide range of epidemiological enquiries at any time and in any place.
To trace an individual animal, the specific ear tag number merely has to be entered into the query 'Einzeltierverfolgung'. This will provide all reports on one animal including the date of birth, movements, slaughter (including the holding where this took place), as well as the test results for specific diseases. In a second step, all possible contacts of an animal can immediately be retrieved by using the hyperlink on the herd registration number ('Betrieb'). For female animals, all calves of the dam can be retrieved via the link 'Kalbungen'.

Under the query 'Bestandsregister' (farm registry) the herd registration number allows an investigator to retrieve the farm registry, identifying all animals individually, for any specific herd in Germany for a defined day or period since 1999.

Information about the number of herds in a specific area as well as the number of cattle within these herds, including information on their specific disease status can be retrieved with a query called 'Allgemeine Betriebs-Tier-Ubersicht'. This query offers more than 20 different selection criteria according to the different categories of information in the CDB. For example, it is possible to analyse how many cattle in a specific county were born after a certain date and are female.

In case of animal disease outbreaks in cattle and pig holdings, connections with the animal disease reporting system or EU expert systems can be established, epidemiological tracing investigations can be carried out immediately, and the necessary staff and equipment for disease control measures in restriction or vaccination zones can be planned precisely.

Conclusions

Since the 1990s European countries have been confronted with several epidemics of diseases such as BSE, CSF, FMD and HPAI. Because of the high densities of livestock and farms in certain areas in Europe, including some German regions, controlling these epidemics has required superior crisis management. Superior crisis management comprises well coordinated use of the available, but maybe limited, material capacities and a number of specialists in task forces in combination with support services. Other vital components of effective crisis management are the aggregated mapping of livestock in affected regions and the rapid identification, by ear-tag number, of individual animals on named and geo-referenced recorded farms and of contacts between animals and specified farms.

Considering the enormous volumes of data in multiple fields, powerful software packages are required. In Germany such packages are available and utilised. The nationwide use of the EU project TRACES and the German projects TSN and HI-Tier allow the country to take proper measures for animal disease outbreak control, response and crisis management according to modern standards.

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Le contrôle des foyers de maladies animales : utilisation des outils de gestion de crise

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Résumé

À notre époque de mondialisation, le contrôle efficace des foyers de maladies animales nécessite des outils puissants de gestion des crises. Pendant les années 90 des progiciels pour divers secteurs de l'administration et de l'agriculture ont commencé à être mis à point. En 2004 l'Union européenne a mis en œuvre une application spéciale pour suivre les déplacements des animaux et des produits d'origine animale, le Trade Control and Expert System (TRACES : Système de contrôle du commerce et d'expertise), sur la base de son prédécesseur, le projet ANimal MOvement (ANIMO). L'utilisation dans toute l'Allemagne du système ANIMO par les autorités vétérinaires de ce pays.
Utilización de herramientas de gestión de crisis para luchar contra brotes zoosanitarios

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Resumen
Para combatir eficazmente un brote zoosanitario en la actual era de la mundialización se necesitan potentes herramientas de gestión de crisis. En los años noventa se empezaron a crear módulos informáticos para distintos sectores de los poderes públicos y la industria agropecuaria. En 2004 la Unión Europea elaboró una aplicación especial para seguir los movimientos de animales y productos de origen animal, el sistema TRACES (sistema experto de control del comercio), basándose para ello en un proyecto anterior que respondía al nombre de ANIMO (ANimal MOvement). La aplicación del sistema ANIMO en todo el territorio alemán por parte de las autoridades veterinarias del país marcó el inicio de la elaboración, en 1993, de un sistema nacional informatizado de notificación de enfermedades animales, el TierSeuchen-Nachrichten (TSN), que utilizaba componentes de hardware y software del ANIMO. Junto con el TRACES y el TSN, el tercer pilar de la gestión de crisis y brotes zoosanitarios en Alemania es la base de datos nacional de bovinos y porcinos, denominada Herkunftssicherungs- und Informationssystem für Tiere. Para integrar las distintas soluciones en todos los niveles de gobierno, concertadamente con el sector privado, se requiere un alto grado de estandarización. Los autores describen el uso de estas herramientas basándose en su experiencia y pensando en lo que es factible hoy en día y conveniente de cara al futuro.

Palabras clave
References


