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Patterns of animal diseases and their control

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Summary

Despite enormous progress in scientific knowledge and improvements in sanitary standards in livestock production, the world has recently been confronted with several animal disease epidemics which have caused significant economic losses. General awareness regarding unusual clinical signs and prompt reporting of disease is an important requirement in disease detection and control and needs to be promoted among farmers and veterinarians. Unexpected clinical syndromes are of increasing importance for public health. Syndromic surveillance has been shown to be a key element in detecting emerging diseases. Once detected and diagnosed, surveillance programmes constitute the first step towards determining the disease pattern with regard to time and space. This pattern of disease occurrence becomes the basis for selecting approaches for further disease investigation and for disease control.

Keywords

Animal diseases, Control programmes, Disease patterns, Disease awareness, Surveillance.

Modelli di malattie animali e loro controllo

Riassunto

Nonostante il grande progresso della scienza e i miglioramenti degli standard sanitari nella produzione zootecnica, il mondo ha dovuto affrontare di recente diverse epidemie di malattie animali che hanno provocato ingenti perdite economiche. L'attenzione verso sintomi clinici anomali e la tempestiva comunicazione della presenza di una malattia sono un elemento importante nell'individuazione e nel controllo di una patologia ed è necessaria la loro diffusione tra allevatori e veterinari. Sindromi cliniche impreviste sono di crescente importanza per la sanità pubblica. È dimostrato che la sorveglianza sindromica è un elemento chiave nello studio delle malattie emergenti. Una volta scoperta e diagnosticata la malattia, i programmi di sorveglianza rappresentano il primo passo verso l'analisi spazio temporale della sua evoluzione. Questo modello di presentazione della malattia diventa la base per selezionare i successivi schemi di ricerca delle patologie e loro controllo.

Parole chiave

Conoscenza della malattia, Malattie animali, Modelli di malattia, Programmi di controllo, Sorveglianza.

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Introduction

Animal health issues are of great importance in the livestock sector. As a result, a good working partnership has developed throughout much of the world between farmers, veterinarians and government institutions, as well as international organisations. The most important organisations involved in animal health and international trade are the World organisation for animal health (OIE: Office International des Épizooties) (www.oie.int) and the Food and Agriculture Organization (FAO) of the United Nations (www.fao.org).

One of the principal objectives of the OIE is to ensure transparency in the global animal disease situation (including zoonotic diseases). Many of the emerging infectious diseases are zoonoses (11). The OIE is committed to defining the factors involved in disease occurrence, determining the relative importance of each factor and defining the extent and distribution of the disease.

The interest of the FAO in zoonotic and emerging diseases derives from its role as the United Nations agency mandated to ensure food quality and safety. The Food Quality and Standards Service of the FAO Food and Nutrition Division is active in all areas related to food safety and implements the FAO/World Health Organization Food Standards Program. Its activities include providing assistance to FAO member nations in addressing problems, strengthening infra-structures, promoting standardisation as a means of facilitating trade and safeguarding the interests of consumers (19).

Despite enormous progress in scientific knowledge and improvements in sanitary standards in livestock production, several countries and regions across the globe have recently witnessed animal disease epidemics that have caused severe economic losses (Table I).

Disease definition

Disease may be defined as an alteration of the state of the entire body or of some of its organs, which interrupts or disturbs the proper performance of body functions. The functional disturbance is most often manifested by visual physical signs. In the case of livestock disease, these clinical signs are observed by those involved in livestock handling. Consequently, farmers and veterinarians are often the first to detect disease.

Diseases may be of *internal* or *external* origin (Table II). They may be due to multiple interacting causes. However, little is known about the fundamental causes of intrinsic livestock diseases. These include metabolic and endocrine disturbances, degeneration of organs from age, neoplasm and autoimmunity. It is likely that some of these disorders are also initiated by extrinsic causes. The external causes of disease may be living agents, such as viruses, bacteria or parasites, which are referred to as 'infectious diseases'. Disease may also be brought about by non-living aetiologies, such as trauma, heat, cold, chemical agents and food deficiencies.

Infectious diseases can be introduced into a country or region by various means. The main risk of introduction is considered to be the (illegal) importation of animals and animal products (Table III) (31). Furthermore, it is well known that wildlife represents an important reservoir in the transmission of diseases such as classical swine fever (hog cholera) (1, 9, 14, 30). With regard to recent outbreaks of highly pathogenic avian influenza (HPAI), it became apparent in 2005 that migratory birds were an additional and significant source of international spread of the virus (26). The details of this spread, however, remain poorly understood and are subject to continuing debates. The death of more than 6 000 migratory birds infected with the highly pathogenic H5N1 virus, that began at the Qinghai Lake Nature Reserve in central China

Table I
Recent examples of outbreaks of highly contagious diseases in Europe

Outbreak characteristics	Classical swine fever (hog cholera) 1997-1998	Foot and mouth disease 2001	Highly pathogenic avian influenza 2003, 2005, 2006
Special affected	Pigs	Cloven-hoofed animals	Poultry, turkey, wild birds, other mammals, humans
Agent	Virus	Virus	Virus
OIE listed	Yes	Yes	Yes
Disease pattern	High morbidity and mortality	High morbidity, low mortality	High morbidity and high mortality in poultry
Disease cycle	Epidemic	Epidemic	Pandemic
Duration of outbreaks	16 months	10 months	Three months in 2003, from October 2005 onwards, more than six months
Index country	Netherlands	United Kingdom	Netherlands (2003), Turkey, Romania, Croatia (2005), several other European countries (2006)
No. of farms affected	429	2 030	NA
Spread to	Spain	Ireland, France, Netherlands	Austria, France, Germany, Italy, Sweden, Switzerland and others (2006) (disasters.jrc.it/AvianFlu/Europe/)
No. of animals killed[a]	10 million	6.5 million	NA[b]
Economic losses	US$2.5 billion	US$13 billion	NA

NA not avalaible
a) including welfare slaughter
b) currently no exact data avalaible from Europe; in Asia, more than 200 million poultry were destroyed from mid-2003 onwards

Table II
External causes of disease

Infectious	Non-infectious
Virus	Trauma
Bacteria	Intoxication
Parasite	Heat
Prion	Food-related
Fungi	Irradiation

in late April 2005, was highly unusual and probably unprecedented (15). There is a concern that countries that lie along the flight pathways of birds migrating from central Asia may face a persistent risk of introduction or re-introduction of the virus to domestic poultry flocks (34).

Livestock disease transmission pathways caused by infectious agents

It is uncommon to find a disease that perfectly fits the classic textbook description. The successful investigator thus requires sound knowledge and understanding of the ways in which a condition may behave to allow thoughtful comparison and consideration of options in reaching a diagnosis.

Table III
Main risks to biosecurity

Risk	Predisposing factors
Importation of live animals, animal products	Illegal movements or imports from food companies or travellers
Livestock movement	Illegal movements or imports from food companies or travellers
Animal to animal spread	Density of animals within holdings, different species within a holding
Extension of the range of disease vectors and/or change in vector competence	Changes in climate, changes in the host population
Migrating birds or other wild animals	Contact between wild birds / animals and livestock (for example, free range holdings)

The investigator must also recognise the potential complexity of a disease or production-limiting problem and consider those aspects of the environment which are likely to influence its progression (16).

Occurrence, spread and characteristics of an infectious disease are influenced by the following factors:

- properties of the infectious agent
- host population characteristics (e.g. genetics, animal demographics, movement patterns, interactions with wild animals, animal use)
- environmental factors.

There are three principal transmission pathways of infectious diseases between infected and susceptible hosts (7), as follows:

- contact transmission (horizontal or vertical)
- vehicular transmission
- vector transmission (mechanical or biological).

In contact transmission, the infective agent passes through direct or indirect physical contact between the infected individual and the susceptible host. Indirect contact would occur if the infective agent has been transmitted through urine, faeces, placental fluids, milk and aerosols. Contact transmission can be further distinguished in horizontal transmission between individuals by direct contact and vertical transmission between individuals and their offspring. Vertical transmission of infective agents usually occurs between the dam and offspring during gestation or through colostrum after birth.

In vehicular transmission, the infective agent is transferred between the infected individual and the susceptible host through non-living objects, such as water, foodstuffs, bedding material, pharmaceuticals, veterinary equipment, shoes, tyres and other items. The duration of survival of the infectious agent in or on the vehicle can be for an extended time and consequently the agent can be transmitted over great distances for long periods of time (7).

In vector transmission, the infective agent is transferred between the infected individual and the susceptible host through an invertebrate host (vector). The vector can transmit the infective agent mechanically (without undergoing a stage of development or multiplication) or biologically (undergoing a stage of development or multiplication).

Models of disease transmission constitute an important tool to provide information on specific, underlying causes of disease (5). The understanding of specific causes of diseases is crucial when selecting intervention and control measures.

Most infectious diseases of importance for the

livestock industry are those listed by the OIE. The OIE publishes the *Terrestrial* and *Aquatic animal health codes* to ensure the sanitary safety of international trade in terrestrial and aquatic animals and their products.

In the *Terrestrial code*, criteria for listing diseases are described, as follows:

- international spread
- significant spread within naive populations
- zoonotic potential
- emerging diseases.

With a few exceptions, the diseases listed follow the disease pattern of high morbidity and occasionally high mortality. The latter is dependent on the virulence of the virus, the host (immune status, genetic background) and other factors.

Animal disease agents can cause a wide variety of disease patterns. The diseases are commonly grouped into two categories: 'zoonotic' and 'others'. Classic zoonotic diseases, such as anthrax and tuberculosis, still have a serious public health impact, although in industrialised countries some of the latent zoonotic infections, such as *Escherichia coli* O157:H7, have become very important. Since animals infected with some of these pathogens show only mild transient disease or no clinical signs at all, new concepts are necessary to avoid human infection.

Patterns of disease occurrence

The general patterns of disease occurrence reflect the randomness or non-randomness of their distribution in the dimensions of time and space. The first step towards determining the importance of distribution over time and in space is counting cases. Cases may be represented by deaths, illness or by some other measure. The clustering of disease events in space can often be demonstrated by the use of conventional mapping techniques. The development of geographic information systems (GIS) allow epidemiologists to map environmental factors associated with disease events. These systems have become particularly important in the surveillance of infectious and vector-borne diseases (29). The Knox test, a classic space-time analysis technique, enables the detection of clustering in time and space in a retrospective and a prospective manner (21, 29).

In general, the distribution of disease events in populations in time and space can be described by the four descriptive terms listed below (7, 27).

Sporadic disease occurrence

Sporadic disease occurrence can be thought of as a random occurrence without clustering; distribution is irregular in space and time. This distribution is rare. Equine infectious anaemia in France has been a sporadic disease event over the past twenty years.

Endemic disease occurrence

An endemic disease represents a clustering of cases in space but not in time. An endemic disease may or may not produce clinical disease and is constantly present in a population in a given region. For example, bovine tuberculosis is an endemic infectious disease in animals in many countries or regions.

Epidemic disease occurrence

In an epidemic disease, there is a clustering both in time and in space. This means the disease affects more individuals in a specific region during a specific time than would be expected. For example, if two to three disease outbreaks are usually expected during a particular time of the year in a zone or compartment of a country and suddenly forty or more outbreaks occur in the region in a couple of months, the disease is epidemic (Table I).

Pandemic disease occurrence

A pandemic is a large epidemic affecting several countries or even one or more continents. Examples from human medicine are pandemics of influenza that have occurred and HPAI that has occurred recently on a pandemic scale.

Animal disease control programmes

National veterinary services implement a variety of animal disease control programmes.

Current animal disease control programmes would include information on epidemiological surveillance, official control and eradication programmes for specific diseases or disease complexes and animal disease emergency preparedness (20). Reliable animal disease control programmes are also very important for international trade and food safety. The scientific framework for these programmes has been set by the World Trade Organization (WTO), OIE, Codex Alimentarius Commission, European Union and national governments. The OIE *Terrestrial animal health code* provides guidelines for international trade in animals and animal products (17).

Surveillance is always a component of a disease control programme and an updated assessment of the current animal health disease status is an essential and significant procedure (24, 25). Surveillance programmes may include passive or active surveillance. Passive surveillance is an ongoing, continuous watch over the endemic disease profile of a population so that unexpected changes can be recognised. Active surveillance involves the gathering of information on a specific disease so that its level in a defined population can be measured, or its absence reliably substantiated (8).

Vourc'h *et al.* recently described 'syndromic surveillance' systems with the aim to detect emerging, atypical clinical diseases (32). Early detection of the unknown, unexpected and atypical clinical disease is essential in diagnosing emerging diseases (2). Syndromic surveillance focuses on clinical features rather than clinical diagnosis. Therefore, clinical disease trends are monitored and grouped into syndromes. However, atypical disease case detection is limited by the experience of the field veterinarians (3). These surveillance systems must be sufficiently attractive for practitioners to keep them engaged and to encourage them to submit their case data (32). Syndromic surveillance can indicate unusual events that require additional measures. A number of emerging diseases are zoonotic and are potential future health hazards for humans as well as animals (11). Much work is required to determine the 'normal' disease event to be able to differentiate between well-known clinical diseases, rare disease events and emerging diseases (10). The development of efficient and reliable surveillance systems is therefore most challenging.

Surveillance programmes may also include monitoring activities where the programme aims at the control of a disease that is present in some zones or areas but absent from others that contain susceptible populations. In general, this programme has the purpose of identifying problems and taking corrective action (33). Laboratory testing is an important part of any surveillance or control programme (22). Most countries have a national laboratory which tests for foreign animal diseases (FADs) and provides support for national disease eradication programmes. However, the interpretation of laboratory test results deserves special attention. Many national and state laboratories are developing quality assurance programmes (e.g. ISO 17025 accreditation) to ensure the reliability of test results. Veterinary services are reliant on the diagnostic expertise of their laboratory system which must be able to support the surveillance programmes needed to detect the introduction of diseases, provide the testing needed to support a FAD control programme and to certify freedom from disease (18).

Data from monitoring and surveillance programmes are used for risk assessments. Risk assessment is a component of risk analysis which estimates risks

associated with a hazard. The other components of a risk analysis are hazard identification, risk management and risk communication. A risk analysis is particularly important for international trade and food safety (17, 24). For diseases listed in the *Terrestrial animal health code*, well developed internationally agreed standards exist for risk assessment and guidelines to determine the likely risks with regard to a specific disease.

A series of techniques are available, either alone or in combination, to achieve the 'disease-free' status of a herd that was previously classified as infected. These techniques include treatment, vaccination, elimination of infected individual animals ('test and remove'), partial depopulation or total depopulation ('stamping-out'). The *Terrestrial animal health code* provides requirements to declare a country, zone or compartment free from disease/infection, either with or without surveillance (17). The above-mentioned techniques are accompanied by cleaning and disinfection measures (23).

The disease-free or pathogen-free status of a country needs to be certified and maintained. For the documentation of the status, monitoring and surveillance strategies can be applied. Passive surveillance would include clinical follow-up visits and disease notification systems. Active surveillance necessitates random sampling of a population to test for the presence or absence of the disease. When planning random surveys, statistical and epidemiological considerations must be addressed. For the sustainable maintenance of the disease or pathogen-free status, the following are needed: biosecurity measures at the individual farm level, import restrictions, early warning systems and surveillance programmes. In addition, the control of wildlife reservoirs, movement control within a country, screening and zoning may be part of a disease control programme. These methods have been important components of the control of the recent outbreaks of HPAI (12, 13, 28).

General awareness regarding unusual clinical signs needs to be promoted among farmers and veterinarians. If a disease or an agent is absent from a herd or region for a long time, the risk awareness decreases. In situations where farmers, producers, importers or veterinarians feel 'safe', mistakes can occur, leading to an increased risk of re-infection.

Conclusions

Many different agents and factors can cause diseases of livestock. The most important animal diseases for international trade are those listed by the OIE. Animal disease agents can have a major impact on livestock health and production and the zoonotic agents can also cause human as well as animal diseases. In addition, it must be remembered that changes in virulence of the causative agent can occur, which can result in a change in the clinical features of the disease.

To safeguard national animal herds and flocks, animal health officials and field veterinarians need to know the clinical features of the disease, the worldwide distribution of the major diseases (in particular foot and mouth disease, classical swine fever and other diseases that cause epidemics) and those countries that have been affected recently; these countries are the most likely source of infection (20). In addition, information on recent trading and tourist patterns can be of great importance (4).

The likelihood of introducing a FAD has increased in recent years. In addition, the risk to public health perceived by consumers has undergone marked change and needs to be addressed (6). Therefore, a competent cadre of specialists is required that can be called upon to assist in the event of the occurrence of an outbreak of a notifiable animal disease. Since diseases respect no borders, not only national but also international collaboration is essential.

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