

Essential veterinary education in infectious diseases of livestock and related scientific disciplines

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Summary

The World Organisation for Animal Health (commonly referred to by the acronym of its original French name *Office International des Epizooties* [OIE]) was created in 1924 with the aim of controlling the international spread of infectious animal diseases. The OIE mandate has broadened since then, but the prevention and control of infectious and parasitic diseases are still at the heart of OIE activities. To plan and implement effective disease control strategies the Veterinary Services of OIE Member Countries need well-educated veterinarians who have extensive knowledge of how and why outbreaks of infectious animal diseases occur and spread and how they can be prevented and controlled. The teaching of fundamental scientific disciplines – virology, bacteriology, parasitology, epidemiology, risk analysis, immunology and vaccinology – is therefore a vital component of all veterinary education programmes.

Keywords

Bacteriology – Emerging infection – Epidemiology – Immunology – Infectious disease – One World, One Health – Parasitology – Risk analysis – Vaccinology – Veterinary education – Virology – Zoonosis.

Introduction

In 1924, after the reintroduction of rinderpest into Belgium, the World Organisation for Animal Health (originally known as the *Office International des Epizooties* [OIE]) was created with the aim of controlling the international spread of infectious animal diseases. In 2003, the Organisation changed its name, but conserved its previous acronym. Over and above its original mission of controlling the spread of infectious diseases, its new mandate was, and continues to be, 'to improve animal health worldwide'. There is no doubt that improving animal health is a global public good. Even if the OIE has broadened its mandate, infectious diseases are still at the heart of OIE activities. To carry out these activities OIE Member Countries need well-qualified veterinarians who have extensive knowledge of how and why outbreaks of infectious animal diseases occur and spread and how they can be prevented and controlled.

A total of 120 infectious diseases currently appear on the OIE list of notifiable diseases and any occurrence of these diseases must be reported to the Organisation. The list includes 93 diseases of terrestrial animals (including birds and bees) and 27 diseases of fish, molluscs, crustaceans and amphibians. Details of the listed diseases can be found in the OIE *Terrestrial Animal Health Code* and *Aquatic Animal Health Code* (the *Codes*). According to their relative importance, the diseases were previously divided into two categories: A (the most important ones) and B (the less important ones). In 2005 these categories were abandoned and a single list is now used. Presently a special emphasis is placed on diseases of wildlife, zoonoses, and emerging infections.

In order for the Veterinary Services of OIE Member Countries to prepare and implement effective prevention and control strategies, and to support other OIE activities, they must have well-qualified veterinary staff with extensive understanding of infectious animal diseases. It is

important, therefore, that veterinary schools provide veterinarians with a solid basis in fundamental scientific disciplines, including virology, bacteriology, parasitology, epidemiology, risk analysis, immunology and vaccinology.

OIE listed diseases

According to the definitions of the *Codes* a 'zoonosis' is any disease or infection which is naturally transmissible from animals to humans. An 'emerging disease' means a new infection resulting from the evolution or change of an existing pathogenic agent, a known infection spreading to a new geographic area or population, or a previously unrecognised pathogenic agent or disease diagnosed for the first time and which has a significant impact on animal or public health. A 'transboundary disease' is any disease which can cross a national border. A 'zone/region' means a clearly defined part of a territory containing an animal subpopulation with a distinct health status with respect to a specific disease for which required surveillance, control and biosecurity measures have been applied for the purpose of international trade.

There are four criteria for listing a disease (16) (a disease meets the criteria if the answer to any of the following questions is 'yes'):

- International spread: has international spread been proven on three or more occasions? OR, are more than three countries with populations of susceptible animals free of the disease or facing impending freedom (based on the relevant provisions of the *Codes*)? OR do OIE annual reports indicate that a significant number of countries with susceptible populations have reported absence of the disease for several consecutive years?
- Zoonotic potential: has transmission to humans been proven (with the exception of artificial circumstances)? AND is human infection associated with severe consequences (death or prolonged illness)?
- Significant spread within naïve populations: does the disease exhibit significant mortality at the level of a country or a zone? OR does the disease exhibit significant morbidity at the level of a country or a zone?
- Emerging diseases: are there apparent zoonotic properties or is there a rapid spread?

The listed diseases have been classified as follows for terrestrial animals:

- category 1: multiple species diseases
- category 2: cattle diseases
- category 3: sheep and goat diseases
- category 4: equine diseases
- category 5: swine diseases

- category 6: avian diseases
- category 7: lagomorph diseases
- category 8: bee diseases
- category 9: other diseases (camel pox and leishmaniasis).

The listed diseases have been classified as follows for aquatic animals:

- category 1: diseases of fish
- category 2: diseases of molluscs
- category 3: diseases of crustaceans
- category 4: diseases of amphibians.

These lists show that the OIE is mainly concerned with food-producing animals and zoonoses. Because of this expertise in food-producing animals and the diseases that affect them the OIE is named in the Sanitary and Phytosanitary Agreement of the World Trade Organization as the organisation that sets standards for animal health and zoonoses. The OIE is thus able to help national governments to apply animal production food safety and animal health standards that enable them to ensure that consumers are being supplied with food that is safe to eat.

In an ideal world, well-educated veterinary students should have some knowledge of all the listed diseases. For each of these diseases, the veterinary student (during initial or continuing education and specialist studies) should receive the following information:

- description of the pathogenic agent (with an emphasis on specific characteristics such as antigenic variation, variation in virulence, existence of biotypes, life cycle)
- susceptibility of different species (including wildlife or reservoirs)
- zoonotic aspects
- pathogenesis
- clinical signs
- pathology
- epidemiology (nature of the disease [individual or herd disease], mode of transmission, ease of spread, geographic distribution)
- biology of the vector (for diseases transmitted by this means)
- control measures, including therapy, biosecurity, compartmentalisation, depopulation
- vaccination.

A special emphasis should be given to the laboratory (specific) diagnosis, either direct (the agent), indirect (serological evidence of infection) or by skin testing. As far as diagnosis is concerned it is also important to pay particular attention to the kind of sample that should be

sent to the laboratory and the best way to send it. In many instances, laboratory testing is becoming more important than observing the clinical signs or the pathology.

Students should be taught by professors who are specialists in the related scientific disciplines rather than by species specialists, i.e. viral diseases should be taught by a virologist; bacterial diseases by a bacteriologist and parasitic diseases by a parasitologist).

One World, One Health

Increasing attention is being paid to the effects of infectious diseases of animal origin on human health and the environment.

In 2008, four international organisations, the United Nations Food and Agriculture Organization (FAO), the OIE, the World Health Organization and the United Nations Children's Fund, along with the World Bank and the United Nations System Influenza Coordinator, joined forces to produce a strategic document entitled 'Contributing to One World, One Health: a Strategic Framework for Reducing Risks of Infectious Diseases at the Animal–Human–Ecosystems Interface'.

This document seeks to define a holistic approach to the prevention of epidemic/epizootic diseases, while maintaining the integrity of ecosystems for the benefit of mankind, our domestic animals and biodiversity, a topic that concerns us all.

Mankind is currently facing many different challenges which will require global solutions. One of these challenges is the spread of infectious diseases that emerge or re-emerge at the interfaces between animals, humans and the ecosystems in which they live.

This situation is the result of several factors, including the exponential growth in human and livestock populations, rapid urbanisation, changing farming systems, closer interaction between livestock and wildlife, forest encroachment, changes in ecosystems, and the globalisation of trade in animals and animal products.

The most important factor is undoubtedly the dramatic increase in the world's population, which is expected to reach 8 billion by 2025, mainly in Asia, Africa and Latin America. At the same time, some in-transition Asian countries are currently experiencing strong economic growth, with rapid urbanisation and greater demand for food, particularly of animal origin. Termed 'livestock revolution' by Delgado (4), this phenomenon is leading to rapid change in farming systems. In 2008, over 21 billion food animals were produced to help feed a population of

over 6 billion people. By 2020, this demand is expected to increase by 50%.

The increase in the human population is also putting pressure on land use, with further encroachment on natural forests and their rich and diverse fauna, thereby exposing humans and domestic animals to new pathogens.

The overarching objective of the strategic framework proposed in the 'One World, One Health' document is to minimise the global impact of diseases of animal origin, including zoonoses, especially those with pandemic potential. Minimising disease impact requires an international, interdisciplinary, cross-sectoral approach to the surveillance, control, prevention and mitigation of emerging diseases while preserving the environment, especially through compliance with the standards issued by the OIE (13, 14, 15, 16).

The document also emphasises the need to improve biosecurity measures to control the emergence and spread of infectious diseases. Unfortunately, levels of biosecurity vary depending on the economic and health conditions of communities and the types of farming systems practised.

Poor communities often lack the necessary resources to access public and veterinary health services. Poor sanitary conditions and inefficient management practices tend to result in numerous infectious agents becoming endemic.

Prevention of bioterrorism (or agroterrorism) is also a global public good. Surveillance and response strategies for infectious diseases must be directed against all potential emerging infections, both natural and deliberate.

Efforts to prevent and respond to the recent avian influenza epizootic have shown that many countries were unprepared to deal with this type of disaster. In many cases, countries did not sufficiently invest in their Veterinary or Public Health Services. Even if the Veterinary Services lie at the heart of intervention actions, they require a strong partnership with Public Health Services and Environment/Wildlife Services.

Both the OIE and FAO prefer the concept of 'One World, One Health', rather than 'One Medicine, One Health', since the OIE has a global mandate for animal health and welfare. There will never be only 'One Medicine': human and veterinary medicines can evolve hand in hand, but for philosophical and economic reasons there will always be differences between them. Nevertheless, veterinary medicine is increasingly working at the interface between human and animal health and is of course deeply involved in the prevention and control of zoonoses (the majority of emerging infectious diseases of humans are of zoonotic origin). The human and the veterinary medical professions have to collaborate, but also have to understand each

other's cultures and practices so as to be able to plan and execute joint programmes and policies.

Veterinarians must be on the front line of the surveillance and control of diseases at their animal source. Animal diseases not transmissible to humans can have a serious impact on the production of food of animal origin and undermine food security. As food security is also a public health concern, the concept 'One World, One Health' encompasses many non-zoonotic diseases.

Scientific disciplines in veterinary education

A comprehensive review (2) written at the beginning of this century identified 1,415 species of infectious organisms that were known to be pathogenic to humans, including 217 viruses and prions, 538 bacteria and rickettsia, 307 fungi, 66 protozoa and 287 helminths. Out of these, 868 (61%) were classified as zoonotic and 175 pathogenic species were considered to be associated with emerging diseases. Of this group of 175 emerging pathogens, 132 (75%) were zoonotic, the vast majority of which were from wildlife. Wildlife obviously constitutes an important potential source of new pathogenic agents for humans and domestic animals.

It is clear, therefore, that in our 'One World, One Health' context the future veterinarian will still need a solid scientific background in basic sciences such as virology, bacteriology, parasitology, epidemiology, immunology and vaccinology in the field of zoonotic and non-zoonotic animal diseases.

Virology, bacteriology and parasitology

Viruses, bacteria and parasites are the pathogenic agents responsible for infectious and parasitic diseases (7). It is therefore essential for the veterinary student to have a proper knowledge of these agents. For viruses, they should know the characteristics of the different families, including their genomic arrangement. Viruses are highly variable (particularly RNA viruses, as they have no repair mechanisms) leading to the existence of populations of quasi-species. Mutations can occur through deletions, integration, point mutations, recombination or reassortment. These mutations may impact on the antigenic make-up or the biological properties of the virus and sometimes lead to the emergence of new infections. It is part of the evolutionary nature of both veterinary and human medicine (11). The stability of viruses outside the organism, in the environment or in animal commodities is also of great importance, as is their susceptibility to different disinfectants.

For bacteria, the veterinary student should also have a good knowledge of the different families and their relative susceptibility to the different categories of antibiotics. Bacteria may become resistant to antibiotics and therefore the students should learn about their prudent use as well as the necessary withdrawal period after the treatment, in order to avoid the presence of residues in animal commodities (maximum residue limits).

Veterinary students should know the often complex life cycles of parasites and their relative susceptibility to anthelmintics. Anthelmintics should also be used prudently and appropriately (time of administration, etc.). The use of anthelmintics may also provoke the appearance of resistance and lead to the presence of residues in the animal after treatment and produce deleterious effects on the environment.

Epidemiology and risk analysis

Epidemiology is also an essential component of veterinary education. First of all, veterinary students should have a good knowledge of the modes and the source of transmission of the different pathogenic agents (including prions, which are responsible for transmissible spongiform encephalopathies). They should know if the agent will lead to latent or asymptomatic infections and how long the pathogenic agent may be excreted by the animal after infection.

The students should know how best to prevent or control a disease according to the pathogenesis of the infection and its mode of transmission. They should also know which vectors are responsible for transmission (vector-borne diseases) and whether or not a vaccine is available.

Notions of epidemiological surveillance and biosecurity are also of great importance (5) at a time when the increasing movements of animals, products of animal origin and humans multiply the risks of spreading pathogenic agents, and when global changes (notably to the climate) which affect natural ecosystems and farm production systems can give rise to the emergence of new diseases or the resurgence of those which had previously almost disappeared. It is particularly true for highly contagious transboundary diseases and newly emerging ones in naive animal populations. Veterinary students should also be taught the more theoretical aspects of epidemiology.

The students should also learn how to conduct a risk assessment and what would be the impact on infectious animal diseases of major changes occurring in the world (such as climate change).

Immunology

Nowadays, the immune system should be seen as a physiological system just like any other system in the animal organism, but one which plays a prominent role in animal health (9, 10). This system, which interacts with the whole body, functions in a similar way to the central nervous system, with two components: innate and adaptive (the adaptive immune system must be 'educated', for instance through vaccination).

Most of the basic knowledge in immunology comes from mouse and human studies; nevertheless 'chickens are not mice with feathers' (3).

Even if most of the basic mechanisms are common to several species, including mice and men, there are still differences between the domestic species and, within the same species, there may be differences between breeds, for instance in their capacity to react after vaccination (6). Therefore after a general introduction to immunology, the veterinary student should be educated in comparative immunology and receive instruction in the distinctive particularities of the different domestic species (for instance the method used to transfer passive immunity). Recent developments in genomics and the availability of the complete genome sequence of several domestic species will allow rapid progress in this field (12).

Special attention should also be given to the different methods used in immunodiagnosis, since many infectious diseases are specifically diagnosed using these technologies, either by detecting the pathogen or by measuring the immune reaction after infection (or vaccination).

It should always be remembered that it is necessary to wait a while after the infection has cleared before immune reaction can be measured.

Vaccinology

Vaccinology is also a key component of veterinary education. Vaccination, when available, is undoubtedly the most cost-effective means of preventing and controlling, and even eradicating (rinderpest [1]), infectious diseases. In the absence of broad spectrum antivirals it is the only available method of preventing, or sometimes curing, viral animal infections, and of avoiding whenever possible the alternative of mass slaughtering of livestock. In recent years vaccination has also been used for other purposes in animal health, production and welfare, e.g. immunocastration (8).

Acting through natural mechanisms, vaccination of animals serves many different purposes, such as

controlling animal infections and infestations (thus improving animal health and animal welfare); controlling anthroponoses and food poisoning (thereby protecting public health); solving problems associated with antibiotic and anthelmintic resistance; helping to leave food-producing animals free of chemical residues; protecting the environment and biodiversity; and ensuring farming sustainability. Vaccines should be designed to prevent infection and transmission of pathogens, rather than to prevent clinical signs of disease and should, wherever possible, produce sterile immunity.

Public perception and disapproval of some veterinary prophylactic measures, such as mass slaughtering of livestock to control epizootic diseases, serve to further promote the use of vaccination as an alternative disease control strategy, even if slaughtering of infected animals will still be necessary in many circumstances. This will be made easier thanks to recent progress in veterinary vaccinology such as the availability of marker (DIVA: differentiation of infected from vaccinated animals) vaccines. However, one of the drawbacks of vaccines is that they sometimes exert a selective pressure on the pathogens, as exemplified by Newcastle disease virus, Marek's disease virus and bovine respiratory syncytial virus.

Whatever their mode of production, vaccines are either attenuated (they multiply in the target animal) or inactivated, and act by different mechanisms. Veterinary students must clearly understand these differences in order to use vaccines appropriately according to the objectives. When using a vaccine one should take into account the species of animal, its breed, its age and its fate.

Conclusion

Leaving aside the economic and strategic importance of animal production sectors under threat from diseases in rich countries, which have very often already eliminated many diseases at great expense, livestock production plays a considerable role in the survival of poor rural communities in developing countries, where a large percentage of the human population still depends on livestock breeding to survive. The constant threat that diseases pose to livestock raised in poor countries is also a threat to poor rural and out-of-town communities. The losses they are currently suffering from animal diseases are already considerable and are likely to increase. It is important to reiterate that the control of animal infectious diseases makes an important contribution to the fight against poverty throughout the world in terms of both public health and support for the economic and social development of the populations and countries concerned.

Furthermore, effective control of animal diseases in these countries would help to give them access to valuable markets from which they are currently barred as they are not yet able to control or eliminate the most important diseases.

The fight against infectious animal diseases is really a global public good and the OIE relies upon large numbers of well-educated veterinarians who understand the nature

of these diseases to enable it to fulfil its objective of preventing and controlling animal disease. Fundamental scientific disciplines – virology, bacteriology, parasitology, epidemiology, risk analysis, immunology and vaccinology – are therefore an essential component of veterinary education. ■

Les fondamentaux de l'enseignement vétérinaire en matière de maladies infectieuses des animaux d'élevage et les disciplines scientifiques connexes

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Résumé

L'Organisation mondiale de la santé animale (le plus souvent désignée par l'acronyme de son ancien nom « Office international des épizooties » [OIE]) a été créée en 1924 dans le but d'empêcher la propagation internationale des maladies animales infectieuses. Cette mission s'est ensuite élargie mais la prévention et le contrôle des maladies infectieuses et parasitaires restent un objectif central des activités de l'OIE. Pour être à même de concevoir et de mettre en œuvre des stratégies de lutte efficaces contre les maladies, les Services vétérinaires des Pays Membres de l'OIE ont besoin de vétérinaires qualifiés et connaissant parfaitement le contexte et les raisons de l'émergence et de la propagation des maladies animales infectieuses. L'enseignement des matières scientifiques fondamentales (virologie, bactériologie, parasitologie, épidémiologie, analyse des risques, immunologie et vaccinologie) est donc une composante essentielle des programmes d'enseignement vétérinaire.

Mots-clés

Analyse du risque – Bactériologie – Enseignement vétérinaire – Épidémiologie – Immunologie – Infection émergente – Maladie infectieuse – Parasitologie – Un monde, une seule santé – Vaccinologie – Virologie – Zoonose. ■

Enseñanza veterinaria básica en materia de enfermedades infecciosas del ganado y disciplinas científicas conexas

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Resumen

La Organización Mundial de Sanidad Animal (a la que se suele aludir con las siglas de su denominación francesa original, *Office International des Epizooties* [OIE]) fue creada en 1924 con el objetivo de controlar la diseminación internacional de enfermedades animales infecciosas. Desde entonces el mandato de la OIE se ha ido ampliando, pero la prevención y el control de enfermedades infecciosas y parasitarias siguen constituyendo uno de los ejes de su labor. Para planificar y aplicar estrategias eficaces de control zoonosario, los Servicios Veterinarios de los Países Miembros de la OIE necesitan a veterinarios bien formados, con amplios conocimientos del cómo y el porqué surgen y se propagan los brotes de enfermedades animales infecciosas. La enseñanza de disciplinas científicas fundamentales (virología, bacteriología, parasitología, epidemiología, análisis del riesgo, inmunología y vacunología) es por lo tanto un componente vital de todo programa de enseñanza veterinaria.

Palabras clave

Análisis del riesgo – Bacteriología – Enfermedad infecciosa – Enseñanza veterinaria – Epidemiología – Infección emergente – Inmunología – Parasitología – Un mundo, una salud – Vacunología – Virología – Zoonosis.



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