Veterinary education in the area of food safety (including animal health, food pathogens and surveillance of foodborne diseases)

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Summary
The animal foodstuffs industry has changed in recent decades as a result of factors such as: human population growth and longer life expectancy, increasing urbanisation and migration, emerging zoonotic infectious diseases and foodborne diseases (FBDs), food security problems, technological advances in animal production systems, globalisation of trade and environmental changes. The Millennium Development Goals and the ‘One Health’ paradigm provide global guidelines on efficiently addressing the issues of consumer product safety, food security and risks associated with zoonoses. Professionals involved in the supply chain must therefore play an active role, based on knowledge and skills that meet current market requirements. Accordingly, it is necessary for the veterinary medicine curriculum, both undergraduate and postgraduate, to incorporate these skills. This article analyses the approach that veterinary education should adopt in relation to food safety, with an emphasis on animal health, food pathogens and FBD surveillance.

Keywords

Introduction

Advances and significant changes in the development, production and manufacturing of animal foodstuffs call for professionals involved in the supply chain to play an active role, based on knowledge and skills that meet current market requirements. With regard to animal products, veterinarians play a key role in both food production systems and preparation processes (which extend as far as the point of product distribution and marketing).

A variety of factors have caused these changes in the animal foodstuffs market: advances in technological processes; global integration of and interaction between markets leading to market globalisation; changes in eating habits; the emergence of infectious diseases in recent decades; the incorporation of drugs into livestock feed rations without due regard to the safety of the resulting animal foodstuffs; bioterrorism; and human demographics, the most important variables of which are growing world population and life expectancy, population ageing, urbanisation and migration (2).

As a result, almost half the world’s population now lives in cities (47%), with the percentage averaging 76% in developed countries and 41% in less developed ones. This process of rural depopulation has come about for many reasons: the failure of development models to create employment and ensure the provision of basic services in rural areas to ‘retain’ the population (20). Urban agglomerations are growing steadily all the time.

These population changes, particularly in the least developed countries, are raising a number of challenges relating to the health and welfare of their inhabitants. This is because of new and greater demands for more and better quality water, and for safe, healthy, and nutritious food that meets the organoleptic quality requirements of consumers and the safety standards of official organisations and is, therefore, safe for human and animal consumption (19).
Structural changes in the livestock sector, such as growth in intensive meat production systems; increased mono-species production; vertical integration and development of global distribution; and the establishment of intensive livestock-production systems close to urban centres, have created an animal–human–ecosystems interface that heightens the risk of new infectious diseases emerging or known ones intensifying (12).

In addition, climate change is altering rainfall patterns, which can affect the life cycle of animal and human pathogens and diseases (7). This may include the emergence of new syndromes and changes in the prevalence of existing diseases, particularly ones that are vector-borne.

The microbial flora in different ecological niches are transmitted, depending on their epidemiological chain, from one person to another, one animal to another, an animal to a person, an animal to a food or from a food to a person (26).

These aetiologic agents are associated with FBDs that pose a continuing threat to public health worldwide and are a major cause of morbidity.

Food safety requires livestock and poultry to be healthy and free from pathogens that can be transmitted to humans (5, 23). Furthermore, the use of veterinary products, especially antibiotics in animal feed, has been identified as a major contributing factor to the development of antimicrobial resistance in humans (24).

Foodborne disease surveillance and food contamination control systems should therefore generate the information required for the quantitative assessment of microbiological and chemical risks.

All the above factors affect the production and marketing of animal foodstuffs, making it necessary to implement strict quality controls in the food chain to prevent and control problems with final product composition and the presence of chemical, physical and biological contaminants.

**Importance of food safety and foodborne diseases**

Foodborne pathogenic microorganisms posing a health risk include bacteria, fungi, yeasts, protozoa, viruses, parasites and certain microscopic algae. These agents are involved in two key areas of sanitary microbiology: as a cause of food spoilage or as aetiologic agents of foodborne diseases (10).

Over the past three decades, partly because of emerging and re-emerging pathogens, there has been a change in the epidemiology of FBDs: there has been an increase in their occurrence and in their associations with food and new food vectors. Three of the leading FBDs are those caused by *Salmonella* spp., *Escherichia coli* and *Vibrio cholerae*. To prevent FBDs it is therefore crucial to control food pathogens.

There are strong links between food security, food safety and animal and human health. These concepts play a decisive role in the eradication of hunger and malnutrition, especially in low-income countries with food shortages (31), because animal foodstuffs such as milk and dairy products, meat and meat products, eggs and fishery products are rich in the essential nutrients that humans need to maintain proper growth and development.

Nevertheless, animal foodstuffs pose a high epidemiological risk as they are liable to deteriorate unless problems are controlled at all stages: from farm production, through preparation, to the point at which products reach the consumer's table.

Furthermore, chemicals in food are pollutants whose effects are often difficult to relate to a food. They include naturally occurring toxicants, such as mycotoxins, and environmental pollutants, such as dioxins, mercury, lead and radionuclides. This is compounded by the widespread use of food additives, pesticides and veterinary drugs whose safe use must be ensured.

Poor sanitary quality of foods is damaging in a variety of ways, resulting in disease, health care costs, economic losses from food spoilage, damage to tourism and even death (10).

The World Health Organization (WHO) defines FBDs as diseases, usually either infectious or toxic in nature, caused by agents that enter the body through the ingestion of food (30).

Foodborne diseases caused by microbiological hazards are a major and growing public health problem. Most countries with FBD reporting systems have documented significant increases in the incidence of diseases caused by microbiological hazards in recent decades, including *Salmonella* spp., *Campylobacter jejuni*, *Listeria monocytogenes* and *E. coli* O157:H7 (13).

For 2008, WHO estimates that 15.3% of global mortality was caused by infectious and parasitic diseases and, of these, diarrhoeal diseases were responsible for 4.3% of deaths. In the same year, in the low-income and average-income countries of the Latin American and Caribbean sub-region, 34,000 deaths were attributed
to diarrhoeal diseases, which is equivalent to 1% of total deaths and 6 deaths per 100,000 people. The WHO adds that, depending on the country, between 15% and 70% of cases of diarrhoea are caused by contaminated food. In Latin American and Caribbean countries the percentage is 70%. In the WHO Region of the Americas, an analysis of data reported to the event-management system of the International Health Regulations (IHR) has revealed that, between 2002 and the first quarter of 2012, a total of 161 of the 969 reported events were related to FBDs or zoonoses (16.6%), with a rising trend in recent years. Up to 29 February 2012, a total of 47 confirmed foodborne events had been reported (32).

The incomplete recording of FBD cases is a major drawback to data analysis and interpretation, even in developed countries. Over a nine-year period, the regional information system for the epidemiological surveillance of foodborne diseases (SIRVETA) of the WHO Pan American Health Organization (PAHO) received 6,511 outbreak reports from 22 Latin American and Caribbean countries; the outbreaks affected 250,000 people, of whom 317 died.

In Brazil, between 1999 and 2009, a total of 6,349 FBD outbreaks were reported, affecting 124,000 people and resulting in 70 deaths. A recent study by the Food and Agriculture Organization of the United Nations (FAO) in Central America (11) estimates that approximately 150,000 cases of diarrhoea occur in Costa Rica annually, costing an estimated US$11.25 million. In El Salvador, FBDs are estimated to cost more than US$23 million.

In Chile, during the spring/summer season, there is a seasonal upsurge in illnesses such as diarrhoea from *Vibrio para-haemolyticus*, *Salmonella* Enteritidis, *Shigella* sp. and other causes. Cases of typhoid and hepatitis A also increase during this season (22).

In 2010, a total of 742 FBD outbreaks were reported in Chile via the registration system of the Department of Health Statistics and Information (DEIS): a rate of 4.3 per 100,000 inhabitants. In 2011, a total of 976 FBD outbreaks were reported: 5.7 per 100,000 inhabitants (22).

In the United States, approximately 76 million FBD cases are reported every year, with 325,000 hospitalisations and 5,000 deaths (18), while in England and Wales, an annual 2,366,000 FBD cases are reported, with 21,138 hospitalisations and 718 deaths (1).

The globalisation of food production and trade continues to grow. For example, the number of products imported into the United States is estimated to have doubled over the past five years, and now comes from more than 240,000 establishments in 200 countries (25), increasing the risk of international incidents involving food contamination. Food safety must therefore be addressed at both international and regional levels.

The rise in the number of FBD cases worldwide stems from certain aspects of development, namely increasing international travel and migration, growing trade in live animals and food, rapid urbanisation in developing countries, changes in food handling and consumer practices, and the increasing number of immune-compromised individuals, largely as a result of HIV/AIDS, malaria and other diseases such as tuberculosis.

**Role of veterinarians**

Veterinary medicine is one of the health professions able to fight malnutrition by ensuring the production of safe, good quality animal protein, the shortage of which is the greatest human development constraint worldwide (27).

Veterinary medicine is a profession relevant to 21st Century society, as the exponential rise in human activity in recent decades has led to changes in biological systems on an unprecedented scale, in particular owing to mass worldwide transport of people and goods and to urbanisation. This has created a biological condition of insecurity, with a number of consequences: emerging diseases in animals and particularly in humans; zoonotic diseases; disruptions in ecological systems by invasive species; insufficient food production for the human population; and intensification of the number of human activities, which undermines levels of sustainability.

Both human and companion animal medicine focus on the diagnosis, treatment and healing of ill or injured individuals to reduce pain and prolong life. In contrast, livestock practitioners and other food and ecosystem veterinarians focus on systems to promote health, the production of safe food and other goals that avoid the occurrence of ill or injured individuals. Obviously, veterinarians require different skill sets, training and practice depending on their area of expertise (16).

The role of veterinarians in the production of animal foodstuffs has changed over the past century and needs to change faster still (6). Veterinarians should take a more comprehensive approach to animal health protection and productivity, combining production with a concern for the protection of human and animal health, as well as animal welfare. There is a new move away from a quantitative to a qualitative model of production.

Veterinarians are the only health professionals trained in multispecies comparative medicine and, as a result of this
training, they can provide a link between agriculture and human medicine, with activities relating directly to animal health, safe food production and the prevention, control and eradication of zoonotic diseases (15).

Veterinarians should be trained to act in new global scenarios and understand the need for interdisciplinarity, transdisciplinarity and the ‘One Health’ concept. The latter is a global movement to strengthen collaboration between different disciplines, for example, between doctors, veterinarians and other health professionals, in promoting leadership and skills management. The aim is to work together in the fields of human health, animal health and the environment, which should be considered interdependent. ‘One Health’ is a concept promoted by WHO, FAO, the World Organisation for Animal Health (OIE) and the World Bank (3).

Training project

As the traditional veterinary curriculum does not adequately prepare students for the new non-traditional career pathways (4) discussed in the introduction to this article, it is necessary to review existing models of veterinary education, comparing the engineering model (specialty training) of educational training with the veterinary model (generalist) (4).

Academia must respond to these new challenges by developing flexible, student-centred educational programmes, while reducing theoretical content and focusing on the development of problem-solving skills, greater use of multidisciplinary approaches and improved communication skills. It must also mainstream into curricula learning units designed to provide students with the skills they need to perform efficiently in a range of different settings and environments and to work in new areas of professional development relating to food safety and animal health (8, 9).

Given the need for a balance between animal health, sustainable production, animal welfare and public health, the curriculum should incorporate the concept of agricultural ecosystem health, promoting a shift away from the current quantitative food production model towards qualitative models, where the greatest challenge is to strike a balance between productivity and the maintenance of healthy ecosystems. This will necessitate opening up the production system to the entire ecological system in order to develop healthy ecosystems that take into account the biotic and abiotic environments as well as the social variables of productive efficiency (21).

Under this scenario, public health becomes the key tool for coordinating health problems arising from interaction between animals, humans and the environment. It should be incorporated throughout curricula from the start of undergraduate programmes through refresher training and subsequently into postgraduate education, and should include all the sectors involved in the ‘One Health’ concept: sustainable production systems, environmental health, the animal foodstuffs processing industry, quality assurance systems, food safety and quality and international trade (4).

It is increasingly difficult for students to learn all the subject areas required to work in a globalised world, but the current availability of online information and innovative learning resources makes this less important than it once was, academic training projects must change significantly and a competency-based curriculum should be developed. During their academic training, students must acquire certain essential knowledge as a basis for competent research, but the content must be adapted.

In their areas of activity relating to animal health, food pathogens and FBD surveillance, veterinarians require knowledge and skills of clinical veterinary practice, pathology, microbiology, epidemiology, quantitative and qualitative analysis, population-based preventive medicine, ecology, animal production and socio-economics. It is also essential for veterinarians to be trained in non-technical skills (14, 17, 28). All of this is a special priority for training veterinarians in public health, ecosystem health and food security and safety (29).

In the words of Dr Bernard Vallat, Director General of the OIE: ‘The OIE highlights the key contribution made by veterinarians in society to assure the health and well-being of animals, people and ecosystems and advocates for the importance of high-quality veterinary education – both initial and continuing’. The OIE is aware that veterinary education varies enormously throughout the world and is concerned to note the shortcomings that exist in most Member Countries in this area (33).

The OIE Ad hoc Group on Veterinary Education, comprising deans, academics and experts in the field of veterinary education from all five OIE regions, has therefore drawn up ‘OIE Recommendations on the competencies of graduating veterinarians (‘Day 1 graduates’) to assure National Veterinary Services of quality’ (‘Day 1 Competencies’), which set out the ‘minimum competencies needed by graduating veterinarians to be adequately prepared to participate in National Veterinary Services (both public and private sector) at the entry level’.

As all future veterinarians are responsible for promoting animal health, animal welfare, veterinary public health and food safety, graduates should possess the following specific skill set (which is based on the competencies set out by the OIE).
They must be able to identify the symptoms of common zoonoses, including foodborne zoonoses, and they must understand their aetiology, their pathogenesis and transmission, their consequences, and their impact on the human population.

They must know and understand the basic principles of epidemiology and its application to the prevention, control and/or eradication of diseases in populations, be able to apply the methodology of outbreak studies to address a health problem in the population (epidemiological investigation, sampling, results-analysis procedure), know the main techniques for diagnosing zoonotic pathogens and foodborne transmission and be able to interpret the results in the light of the epidemiological situation under study.

They must be able to design epidemiological surveillance studies for each link in the food chain, and subsequently to interpret the results properly.

As their sphere of operation cuts across the entire food chain, veterinarians must:

– know the principles governing food chain traceability and the main animal production systems and know how to manage basic strategies for the prevention and control of the chemical residues associated with livestock production and the food chain, ensuring environmental protection and its integration with animal production. Veterinarians should also know the principles of animal welfare and their implications for the food safety of animal products;

– know the animal foodstuffs industry, animal food processing technology and quality assurance systems such as: hazard analysis and critical control points (HACCP), standard operating procedures (SOP) and sanitation standard operating procedures (SSOP), total quality management and the standards of the International Organization for Standardization (ISO). Veterinarians should also know the criteria for ante- and post-mortem inspections and for animal products, as well as procedures for the humane killing of animals;

– assess the microbiology and chemical contamination of food as a tool for ensuring the health and hygiene of the final product. To be able to do this they must know the main food pathogens and food industry residues and understand the concept of antimicrobial resistance and its impact on public health. Veterinarians must be aware of their responsibility concerning the indiscriminate use of antimicrobial agents in livestock and know the appropriate criteria for the rational use of different drugs and biologicals in order to preserve the efficacy of antibiotics in both humans and animals;

– for FBD surveillance, veterinarians must know and understand risk analysis methodology and its application to veterinary public health. They must be able to assess potential microbiological and chemical risks in food for the purposes of hazard identification and characterisation to perform quantitative risk assessment, which is also used in FBD prevention in conjunction with risk management strategies (13).

In addition to the above-mentioned skills, veterinarians should also know the basic principles needed to develop programmes for animal health and zoonoses (problem trees and logical framework analysis), understand the concept of early detection and early warning of diseases and know the structure of a contingency plan.

Veterinarians must also have a good general knowledge of the basics of national legislation and local regulations, as well as the structure of government departments and international organisations relating to veterinary public health and international trade, their spheres of action, functions, main programmes, interactions between them and their relationship with private-sector veterinarians.

Their role as private or state veterinarians requires them to be able to perform a clinical examination of an animal or herd to certify the presence or absence of disease and issue a national certificate. Veterinarians must know the procedure for inspecting animal products and/or by-products for subsequent certification as fit for human consumption.

Finally, considering the importance of safe animal foodstuffs, veterinarians must have health education skills to enable them to impart basic knowledge to the public for the protection of animal and human health and food safety, applying the ethical standards of the profession when discharging their duties.
References


