

# Food systems and the changing patterns of food-borne zoonoses

A.A. MacKenzie <sup>(1)</sup>, D.G. Allard <sup>(1)</sup>, E. Perez <sup>(2)</sup> & S. Hathaway <sup>(3)</sup>

(1) Canadian Food Inspection Agency, 59 Camelot Drive, Ottawa, Ontario, Canada

(2) Pan American Institute for Food Protection and Zoonoses, Pan American Health Organization/World Health Organization, Talcahuano 1660, B1640CZT, Martinez, Buenos Aires, Argentina

(3) New Zealand Food Safety Authority, P.O. Box 646, Gisborne, New Zealand

## Summary

This paper discusses food-borne zoonotic diseases by considering contemporary influences on food safety and examining pathogens at the human/animal interface. The authors also discuss the epidemiological surveillance of food-borne illnesses and the differences in disease statistics from one country to another. Before concluding with a number of recommendations, the paper highlights the importance of a collaborative approach to the prevention and control of food-borne diseases and discusses the need to co-ordinate the efforts of international agencies working in human health, animal health and food production. A regional case study is also included, in which the authors describe the food-borne disease situation in Latin America, as reported by surveillance systems in this region.

## Keywords

Animal health – Emergence – Food industry – Food safety – Food-borne – Human health – Surveillance – Zoonosis.

## Introduction

Technological advances within the food industry and a growing awareness that food safety is an issue that must be addressed along the agri-food continuum – from inputs such as feeds, seeds and fertilisers to on-farm production, plant processing and food consumption – are clearly influencing global food systems. Against this background of change in food systems, food-borne zoonoses are emerging, influenced by evolving risk factors, which are impacting both animal and human health. Determining with any scientific certainty that a particular zoonotic disease is food-borne, requires local, national and international diagnostic and surveillance systems that are sophisticated enough to identify that this is the case. The international food safety community can then respond to this increasingly complex situation with appropriate regulatory measures that are based on reliable scientific information. Countries often turn to international standard setting organisations for assistance in dealing with food-borne zoonoses, but much still remains to be done if there is to be an integrated national and international response. Increased collaboration between the World Organisation for Animal Health (OIE), the Food and Agriculture

Organization (FAO) and the World Health Organization (WHO) on scientific and technical matters relating to food safety and zoonotic disease is of paramount importance.

## What is a food-borne zoonosis?

A specific, universally accepted definition of a food-borne zoonosis is difficult to find. A recent publication referred to zoonoses as ‘infectious diseases transmissible from animals to humans and vice versa’ (7). In discussions, only bacterial diseases seem to be labelled food-borne zoonoses, with viral and parasitic agents not being considered.

Furthermore, the often used descriptor ‘emerging’ as in ‘emerging food-borne zoonotic disease’ makes the classification even less clear. The WHO defines ‘emerging infections’ as ‘infectious diseases that have been identified and taxonomically classified recently. ... Some appear to be ‘new’ diseases of humans, others may have existed for many centuries and have been recognised only recently

because ecological or other environmental changes have increased the risk of human infection. Re-emerging infections are certain 'old' diseases ... that have experienced a resurgence because of changed host-agent-environment conditions' (18).

For the purpose of this issue of the *Review*, the OIE has used the following definition of an emerging zoonosis: 'a zoonosis that is newly recognised or newly evolved, or that has occurred previously but shows an increase in incidence or expansion in geographic, host, or vector range. Some of these diseases may further evolve and become effectively and essentially transmissible from human to human.'

In this paper, a food-borne zoonotic disease is defined as follows: an infection of man transmitted through food where the source of the infection is an animal.

## Contemporary influences in food safety

Before examining food-borne zoonoses, the broader subject of contemporary influences on food safety should be considered. Four of the major developments that have had and continue to have a significant effect on the safety and suitability of food are as follows:

- a) changes in the nature and concentration of hazards in food
- b) changes in the controls used to ensure that food is safe to eat
- c) a shift of the primary responsibility for food safety to an increasingly consolidated industry
- d) changes in consumer habits.

In the 1980s, the main concerns about food safety revolved around chemical contamination: fertilisers were added to the soil to increase production; herbicides were used to keep down weeds in field crops; and pesticides were used to control pests of every nature. In addition to exposure to natural contaminants in the food supply, antibiotics were routinely fed to animals to maintain their health and prevent illness in high density production situations, such as feedlots and chicken batteries. Veterinary drugs were commonly administered to maintain individual animal health. Furthermore, growth hormones were used to increase production in animals. Measures were taken to control these potential human hazards, both through international standard setting and country specific regulations.

In the 1990s, new hazards of a biological nature became the central focus as regards food safety. The effects of these

pathogens are often immediate and acute, as opposed to the delayed and chronic effects of chemical residues. Furthermore, regulators can ban or modify the use of many potentially hazardous chemicals, but bacteria are more difficult to prohibit.

Given the increasing concerns over microbiological food-borne illness (FBI), standard setting institutions, governments and industry have fully endorsed the hazard analysis critical control points (HACCP) system that was first developed in the 1960s to address the safety of food in the space programme. Through the expansion of this system the food industry has accepted more responsibility for the safety of its products, and quality control and assurance systems have become more sophisticated and efficient. In striving to reduce pathogen loads, the industry has developed biocontrol systems such as carcass steam pasteurisation and various effective carcass rinses and washes.

Successes in lowering the incidence of FBI under mandatory HACCP programmes are being reported (2). This has prompted the design of HACCP-based food safety programmes that reach beyond the food processing area and address on-farm food safety (8), retail and transportation codes of practice, and consumer education programmes, e.g. 'Fight Bac', a programme developed in the United States of America (USA) by the Partnership for Food Safety Education (14), and 'From farm to table with Inocuito', the food safety initiative for children and young people developed by the Pan-American Institute for Food Safety (5). All the programmes emphasise the importance of applying appropriate risk reduction measures across the agri-food continuum and advocate proper food handling behaviours based on the following five keys for safer food, as determined by the WHO (20):

- a) keep food clean
- b) separate raw and cooked food
- c) cook food thoroughly
- d) store food at safe temperatures
- e) use water and raw materials that are safe.

Increasingly, the intervention strategies suggested and made available to reduce risk, call for harmonisation among global food safety standards and systems (3).

There has been a notable change in consumer eating habits and patterns in recent years, particularly in developed countries. For example, pre-cooked meats and fresh-cut produce for salads are now more readily available, thus increasing the potential for FBIs. Traditionally, animal products were identified as the most common vehicles for FBIs and this remains true (3). However, the number of reported outbreaks associated with fresh fruits

and vegetables, such as *Escherichia coli* O157:H7 in leaf lettuce and *Salmonella* spp. in tomatoes and cantaloupe, has increased dramatically over recent years (1). Furthermore, there is increasing consumer demand for information and a higher expectation of a safe food supply.

## Pathogens at the human/animal interface

Over the past few years, the line between human and animal pathogens has become finer. There are an increasing number of diseases that affect both humans and animals, e.g. Hantavirus diseases, Lyme borreliosis, Hendra, Nipah, and West Nile viral diseases, monkeypox (via black tailed prairie dogs [*Cynomys ludovicianus*]), avian influenza, and the coronavirus severe acute respiratory syndrome. Furthermore, even newly discovered prions have shown cross-over capabilities, e.g. the prions associated with both bovine spongiform encephalopathy (BSE) and variant Creutzfeldt-Jakob disease (vCJD) in humans.

Many factors are responsible for this phenomenon and evaluating the importance of the individual contribution of one determinant over another is difficult. Changing climate conditions and the migration of humans to new ecosystems, such as the tropical forest, probably contribute to the development of zoonoses, especially those infections that depend on insect vectors for spread or that need certain environmental conditions to survive temporarily outside a living host. Furthermore, the pathogens themselves are evolving, prompted by natural and man-made pressures, occasionally acquiring in the process a heightened virulence or an increased ability to survive in new environments. Some of these agents have probably been causing problems for many years (e.g. noroviruses and cryptosporidium), but only lately has new technology, such as polymerase chain reaction, pulse field gel electrophoresis and enzyme-linked immunosorbent assay, made their detection, identification and characterisation possible. Improved surveillance tools and systems have broadened the understanding of often complex ecological relationships. Demographic and human health factors also have a role to play in increasing susceptibility to zoonoses, especially in developed countries where the population is aging and a larger number of people who used to die young are living longer, but with weakened immune systems, thus increasing the proportion of individuals with a higher susceptibility to opportunistic infections such as listeriosis. Today, given the swiftness and volume of international travel and global trade, pathogens and/or their vectors may more easily journey in incubating hosts (either human or animal) and survive long enough to infect residents of the receiving country.

Among zoonoses, the rise in food- and water-borne illnesses certainly deserves attention, because recent figures estimating the burden of illness transmitted via these routes have been high (9). The risk of becoming infected with these diseases has been increased as a result of intensive farming practices, which have led to cases of sea lice infestation in aquaculture and an increase in antimicrobial resistance among livestock.

Newly introduced food processing interventions, such as advanced meat recovery systems, may also be contributing to the deteriorating situation, and consumer behaviour is undoubtedly playing a part. Changing lifestyles and gender roles have led to less food preparation at home and more meals being eaten at ready-to-eat outlets, or being bought from street vendors or as pre-packaged ready meals that are then insufficiently warmed in microwave ovens. More culturally diverse human populations have broadened the demand for a wider variety of foods of all kind, especially imported products. Many of these foodstuffs come from developing nations where hygiene controls do not comply with international standards because of a lack of resources or training. The products may infect food-handlers, thereby increasing the probability of a large disease outbreak caused by a virulent pathogen such as hepatitis A virus.

The most common symptoms that occur after consuming food contaminated with microbes are diarrhoea and vomiting, but more serious diseases are sometimes observed, i.e. septic shock, kidney failure, including haemorrhagic uremic syndrome (HUS), meningoencephalitis, or spontaneous abortion.

## Human health surveillance

Epidemiological surveillance of food-borne diseases is a key component of any food safety system and provides essential information on the human/animal pathogen interface. In addition to providing a means of quantifying the actual extent of food-borne zoonoses compared to those travelling along different exposure pathways, a surveillance programme should provide the information required to validate the effectiveness of national food controls and a rapid response to food-borne disease outbreaks. In cases where public health goals are not being met, risk management options should be reviewed and modified food control systems should be implemented.

A number of data sources are available, some of which are useful for implementing a swift response to outbreaks, while others are more useful for the long-range planning and evaluation of health-related programmes and interventions. Some of these sources offer fairly complete and reliable data and others are more timely and emergent

(i.e. provide early warning). Useful data may be obtained from very diverse sources, including notifiable disease reports which come directly from physicians or via laboratories, case and outbreak investigative reports, data from special sentinel networks, one-time or on-going surveys (e.g. FoodNet – <http://www.cdc.gov/foodnet/>) or records of hospital morbidity or mortality.

During the March 2002 WHO consultation on 'Methods for food-borne disease surveillance in selected sites' (19), the need for a global strategy to reduce illness from food-borne disease was recognised, and expressed as follows: 'One of the first steps in the process is to develop guidance for establishing the global burden of food-borne disease by measuring the frequency of FBI in selected countries'. The consultation further divided food-borne disease surveillance into the following four categories:

- a) no formal surveillance
- b) syndrome surveillance
- c) laboratory-based surveillance
- d) integrated food-chain surveillance.

The last developmental stage, i.e. 'integrated food-chain surveillance', should certainly be the goal for any national authority wishing to maximize opportunities to reduce zoonotic disease. The process would require close collaboration and an exchange of information between the agricultural, veterinary and public health sectors. Such close co-operation would be useful, because it would facilitate the comparative analysis of characteristics of microbial isolates found at various stages of food production, processing and distribution, with isolates taken from consumers suspected of suffering from an FBI. In addition to providing the information needed for product tracing and possible food product recall, integrated surveillance would also allow for a better understanding of what type of mitigation strategy is best able to manage risk and where in the food chain it should be implemented in order to maximise its effectiveness. Furthermore, the availability of the data would greatly assist in setting health outcome objectives and reduction targets for FBIs. Moreover, monitoring of the effectiveness of risk mitigation measures implemented at designated points of the food chain would be enhanced. It is obvious, therefore, that a better understanding of the dynamics of zoonotic relationships can only be achieved through the development of integrated human and animal health surveillance systems.

Continuing review of international public health statistics will be a primary factor in the development of international food safety strategies within an overarching risk management framework, as anticipated by the FAO and the Codex Alimentarius Commission.

## Global statistics on food-borne illness

Approximately 70% of cases of acute diarrhoeal disease are caused by the consumption of contaminated water or food, according to WHO estimates. Nevertheless, obtaining an accurate picture of the incidence of FBI on a global level is difficult.

The incidence of food-borne diseases is difficult to compare between countries and even more so between continents on the basis of data collected by their respective surveillance systems. For example, a higher disease rate in one country might not represent a true difference, but rather better surveillance or more sensitive pathogen detection by a laboratory. Generally, the incidence of viral or parasitic diseases appears low because the diagnostic tools used for their detection are inadequate. Most countries, however, are better at reporting bacterial aetiologies for which protocols and methods have been standardised and mastered (e.g. salmonellae). Nevertheless, food-borne viruses (6) are increasingly recognised as the causative agents in outbreaks due to more sophisticated equipment and expertise, whereas they may not be identified when equipment and experience are lacking.

Recent studies have shown that the rate of under-reporting of acute gastro-intestinal illness can be relatively significant, even in developed countries, such as the United Kingdom, where the ratio between the number of cases reported at national level and the actual level of symptomatic illness in the community can approach 1:136. This discrepancy may arise because of the many steps involved in the reporting procedures, i.e. recognition by a physician, specimen testing by a laboratory, and reporting at local, national and international levels (4, 16).

The Centers for Disease Control and Prevention in the USA attempted to estimate the incidence of food-related illness in the country using data from passive and active surveillance systems. About 82% of symptomatic FBIs were of unknown aetiology. Of the food-borne cases caused by known pathogens, 30.2% were due to bacteria (mostly *Campylobacter* and *Salmonella*), 2.6% were attributable to parasites (principally *Giardia* and *Toxoplasma*) and about 67.2% were caused by viruses (mainly noroviruses) (9).

Every Member Country of the Organisation for Economic Cooperation and Development experiences cases of non-typhoid salmonellosis, but the reported incidence varies considerably between countries (from between six and 137 cases per 100,000). However, as mentioned previously, these figures may not be representative of a true difference

in disease rate, but may reflect differences in the sophistication of surveillance systems or laboratory diagnostic capabilities. *Campylobacter* is also often reported in countries that include the microorganism in their regular surveillance. Other pathogens under regular monitoring include *Shigella*, *Yersinia*, Verocytotoxin-producing *E. coli* (VTEC) and *Listeria monocytogenes*. As regards viruses and parasites, only hepatitis A is reported with any constancy. Foods most frequently identified as vehicles in food-borne outbreaks and sporadic cases are meat and meat products, poultry, eggs and egg products, with raw oysters often associated with an infection caused by *Vibrio vulnificus*.

Once statistics on FBI have been collected they can be used to measure the progress of programmes aimed at reducing human mortality and morbidity. A good example of this is 'Healthy People 2010', a set of national health objectives established by the government of the USA to help measure the progress of publicly funded programmes, including those implemented to reduce the incidence and impact of FBI in the population. These national objectives help rally various sectors such as agriculture and public health, who then co-operate in defining integrated strategies, allowing consensus to be reached on annual targets (15).

## A regional case study

Since 1989, the Pan-American Health Organization (PAHO) has been working with its Member States to build national capacity for FBI surveillance. Weaknesses still persist in many countries in epidemiological surveillance, illness reporting, detection and investigation of outbreaks, and data analysis for policy and programme decision-making. It is, therefore, difficult to adequately evaluate the FBI situation in the Latin American region. A similar situation exists in many countries of Africa and Asia.

Keeping in mind the geographical differences of countries in Latin America and the limitations in the coverage and quality of the different epidemiological surveillance systems, a summary of the information reported to the PAHO-based information system for surveillance of FBIs (SIRVETA: Sistema de Información para la Vigilancia de las Enfermedades Transmitidas por los Alimentos) over the past nine years is provided here, giving an indication of the food-borne morbidity in that region of the world. Since 1995, SIRVETA has received 6,511 reports of FBI outbreaks from 22 countries in the region, with one country in the Caribbean contributing more than 54% of the total reports. About 250,000 people fell ill in these outbreaks and 317 died. Thirty-seven percent of all clusters of food-borne illness occurred in private dwellings. In 29% of known outbreaks, no laboratory analyses were performed to identify the aetiological agents.

Among the cases with confirmed aetiology, 57% were attributed to bacteria, 12% to viruses and 21% to marine toxins. The remaining 10% were caused by parasites, chemical contaminants, or plant toxins. Food items most commonly associated with the reported outbreaks were fish (22%), water (20%) and red meats (14%).

Based on the available data of laboratory-confirmed aetiological agents, salmonellae were undoubtedly the bacteria most frequently reported by the surveillance systems in the Americas, corresponding to 20% of the total food-borne outbreaks. Another toxin increasing dangerously in the Americas is Shiga-toxin producing *E. coli* (STEC), and Argentina has one of the highest incidences of HUS, a known complication of STEC infection, especially in the paediatric age group (10).

## International agencies

Recently, the international agencies responsible for human health (WHO), food production (FAO) and animal health (OIE) have come to realise that there is a need to co-ordinate their efforts and integrate their activities at the human/animal interface. The BSE/vCJD connection clearly demonstrated that what is fed to animals raised for food can have a significant impact on human health. The mandate of the OIE is currently being broadened to include food safety considerations relating to food-borne risks to human health that are due to hazards that arise from animals (11), be they biological, chemical or physical agents in food. This includes consideration of pathogens not known to cause clinical signs in animals themselves, such as VTEC. The OIE recognises that veterinarians involved in food production 'have an essential role to play in the prevention and control of food-borne zoonoses, even when animals are not clinically affected' (12).

In the opening statements of a WHO workshop held in 2001, the Director of the Department of Communicable Disease Surveillance and Response and the Director of the Food Safety Programme (part of the Department of the Protection of the Human Environment), stressed the need to strengthen the abilities of the WHO to assess the magnitude of food-borne diseases and to improve the capacity to determine the sources and aetiologies of FBIs. They recognised the complexity of the problem and that a multi-disciplinary and inter-sectorial approach (human and veterinary medicine and food science) should be devised to develop the necessary prevention and control strategies. They also mentioned the need to improve our ability to link pathogens in food to disease in humans, and stated that this could be achieved by improving human disease surveillance, developing better methods of controlling food-borne pathogens throughout the food production chain, and systematically assessing

microbiological risk. One of the subjects discussed at the meeting was the establishment of a 'global association of networks', an international network comprised of FBI surveillance systems from different countries. The value of such a network would depend partly on the strength of each individual national component, hence the importance of improving the capability and reliability of these systems (17).

Many countries are now developing research plans that will allow a greater understanding of the dynamics of food-borne zoonoses. For example, one of the recently established research goals of the Netherlands is 'to develop a risk-management system in the meat production chain that covers the most important public health risks' (13). Thus, in addition to the establishment of an international network of surveillance systems, international agencies also face the challenge of setting up an international network to co-ordinate research needs.

In May 2004, the WHO hosted a consultation to discuss collaboration between animal health and public health professionals in addressing emerging zoonoses. The consultation, which was co-sponsored by the FAO and the OIE, concluded that:

'Emerging zoonotic diseases are a global and regional issue of increasing importance and their current upward trend is likely to continue. Human activities and behaviour often drive the emergence of zoonotic diseases; these include food and agriculture practices, deforestation and urbanisation of virgin areas, globalisation of trade of live animals including wildlife and animal products and climate changes' (21).

The experts further stated that 'for WHO, together with FAO and OIE, the next step forward is to mobilise political awareness and support for the implementation of a public and animal health infrastructure' (21).

## Recommendations

- 1) International organisations that are responsible for public health surveillance systems should be encouraged to develop a reporting category for food-borne zoonoses.
- 2) The OIE should consider developing international animal health standards and technical advice for food-borne zoonotic organisms that do not cause clinical disease in animals.

- 3) Further research needs to be undertaken on the ecology of food-borne pathogens at farm level, i.e. factors influencing survival, multiplication and spread in the environment and factors favouring the colonisation of food animals.

- 4) Surveillance of FBI at national and international level should be strengthened so that the scale of the problem can be genuinely quantified and strategic plans for improved food controls can be prioritised according to risk. This should include integration of national and international surveillance databases, harmonisation of food-borne disease investigation methodology, standardisation and quality control of laboratory diagnostic methods and allocation of appropriate resources.

- 5) International attempts should be made to answer the question as to whether 'emerging' food-borne zoonotic diseases are a proportionately significant public health issue in the developing world compared to the developed world.

- 6) All international agencies and national competent authorities engaged in food safety should apply a risk-based farm-to-table approach when developing food safety controls.

## Conclusion

Today, to counteract the complex combination of detrimental factors that may compromise the safety of food, including growing concern that food production may be a vehicle for the increase in antimicrobial resistance, preventive strategies and mitigating actions need to be taken at every step of the food chain, from the farm to the consumer's plate. The considerable burden of morbidity and mortality transmitted via food and water deserves the combined attention of international agencies created to safeguard public health. All stakeholders in the food chain, including governments, industry and consumers, must contribute to this global effort. Strengthening public health surveillance systems at both national and international level will be an essential step in the implementation of an effective risk management approach.



## Systemes alimentaires et évolution des types de toxi-infections alimentaires à caractère zoonotique

A.A. MacKenzie, D.G. Allard, E. Perez & S. Hathaway

### Résumé

Les auteurs passent en revue les toxi-infections alimentaires de caractère zoonotique à la lumière des facteurs qui, à l'heure actuelle, influent sur la protection sanitaire des aliments, et des agents pathogènes au niveau de l'interface entre l'homme et l'animal. Ils examinent également l'épidémiologie des toxi-infections alimentaires et les facteurs expliquant les différences de statistiques entre pays. Avant de conclure par plusieurs recommandations, les auteurs soulignent l'importance d'une approche collaborative pour le contrôle et la prévention des toxi-infections alimentaires, et la nécessité d'efforts concertés entre les organisations internationales de santé publique, de santé animale et de production alimentaire. Ils présentent une étude de cas régionale en Amérique latine, à partir des rapports émanant des systèmes de surveillance de cette région.

### Mots-clés

Émergence – Épidémiologie – Industrie alimentaire – Santé animale – Santé publique – Sécurité sanitaire des aliments – Toxi-infection alimentaire – Zoonose.



## Los sistemas de alimentación y las lábiles características de las zoonosis transmitidas por vía alimentaria

A.A. MacKenzie, D.G. Allard, E. Perez & S. Hathaway

### Resumen

Los autores examinan las enfermedades zoonóticas que se transmiten por vía alimentaria, considerando los factores que influyen hoy en día en la salubridad de los alimentos y los patógenos presentes en la interfaz entre el hombre y los animales. También discuten sobre la vigilancia epidemiológica y sobre las diferencias de estadísticas entre países para esta clases de enfermedades. Antes de concluir con varias recomendaciones, los autores reflexionan sobre la importancia de un enfoque colaborativo para la prevención y el control de las enfermedades transmitidas por vía alimentaria, y discuten de la necesidades de coordinar los esfuerzos de las agencias internacionales que trabajan en salud humana, sanidad animal y la producción de alimentos. Asimismo presentan un ejemplo de América Latina, en que describen la situación de las enfermedades transmitidas por vía alimentaria según la información presentada por los sistemas de vigilancia de esta región.

### Palabras clave

Emergencia – Industria alimentaria – Salubridad de los alimentos – Salud humana – Sanidad animal – Transmisión alimentaria – Vigilancia – Zoonosis.



## References

1. Blaine K.A. & Powell D.A. (2004). – Microbial food safety considerations for organic produce production: an analysis of Canadian organic production standards compared with US FDA guidelines for microbial food safety. *Food Protect.*, **24** (4), 246-252.
2. Centers for Disease Control and Prevention (CDC) (2003). – Preliminary FoodNet data on the incidence of food-borne illnesses – selected sites, United States. *MMWR*, **53** (16), 338-343.
3. Council for Agricultural Science and Technology (CAST) (2004). – Intervention strategies for the microbiological safety of foods of animal origin. CAST Issue Paper #25, 24 January. CAST, Ames, 19-20.
4. Handysides S. (1999). – Editorial. Underascertainment of infectious intestinal disease. *Communic. Dis. public Hlth*, **2** (2), 78-79.
5. Instituto Panamericano de Protección de Alimentos (PANALIMENTOS) (2004). – De la granja a la mesa por Inocuito. Website: <http://www.panalimentos.org/InfoPanalimentos2.0.20040225/infoPanalimentos/esp2003librito.pdf> (accessed on 29 October 2004).
6. Koopmans M. & Duizer E. (2004). – Foodborne viruses: an emerging problem. *Int. J. Food Microbiol.*, **90** (1), 23-41.
7. Krauss H., Schiefer H.G., Weber A., Slenczka W., Appel M., von Graevenitz A., Enders B., Zahner H. & Isenberg H.D. (2003). – Zoonoses: infectious diseases transmissible from animals to humans, 3rd Ed. ASM Press, Washington, DC, 456 pp.
8. MacKenzie A. (1999). – Changing aspects of food safety and on-farm practices. In Proc. 136th Annual Convention of the American Veterinary Medical Association (AVMA), 10-14 July, New Orleans, 537-543.
9. Mead P.S., Slutsker L., Dietz V., McCaig L.F., Bresee J.S., Shapiro C., Griffin P.M. & Tauxe R.V. (1999). – Food-related illness and death in the United States. *Emerg. infect. Dis.*, **5** (5), 607-625.
10. Ministerio de Salud y Ambiente (2004). – Website of the Ministry of Health and the Environment (Argentina) (in Spanish): [http://www.msal.gov.ar/htm/site/sala\\_situacion/index.asp](http://www.msal.gov.ar/htm/site/sala_situacion/index.asp) (accessed on 3 June 2004).
11. OIE (World Organisation for Animal Health) (2002). – Editorial from the Director General. The new mandates of the OIE. Website: [http://www.oie.int/eng/Edito/en\\_edito\\_nov02.htm](http://www.oie.int/eng/Edito/en_edito_nov02.htm) (accessed on 27 January 2004).
12. OIE (World Organisation for Animal Health) (2003). – Editorial from the Director General. The role of the veterinarian at the abattoir. Website: [http://www.oie.int/eng/Edito/en\\_edito\\_nov03.htm](http://www.oie.int/eng/Edito/en_edito_nov03.htm) (accessed on 27 January 2004).
13. Ottevanger A. & Albesque A.I.V. (2004). – Risk management in the meat production chain – a Dutch approach. In Proc. World Meat Hygiene and Inspection Congress, 6-8 July, Downing College, Cambridge. (Proceedings were sent to all delegates on a CD-rom produced by the United Kingdom Food Standards Agency.) Website: <http://www.food.gov.uk/foodindustry/meat/wmhcongress2004>.
14. Partnership for Food Safety Education (2004). – FightBAC! Campaign. Website: <http://fightbac.org/main.cfm> (accessed on 3 June 2004).
15. United States Department of Health and Human Services (2000). – Food Safety. Part A, Focus Area 10. In Healthy People 2010, Vol. I., 2nd Ed. United States Government Printing Office, Washington, DC, 10/9-10/17.
16. Wheeler J.G., Sethi D., Cowden J.M., Wall P.G., Rodrigues L.C., Tompkins D.S., Hudson M.J. & Roderick P.H. (1999). – Study of infectious intestinal disease in England: rates in the community, presenting to general practice, and reported to national surveillance. *BMJ*, **318**, 1046-1050.
17. World Health Organization (WHO) (2001). – Global surveillance of food-borne disease: developing a strategy and its interaction with risk analysis. Report of a WHO consultation, 26-29 November, Geneva, 37 pp. Website: [http://www.who.int/foodsafety/publications/food-borne\\_disease/en/surveillance\\_strategy.pdf](http://www.who.int/foodsafety/publications/food-borne_disease/en/surveillance_strategy.pdf) (accessed on 31 May 2004).
18. World Health Organization (WHO) (2001). – Protocol for the assessment of national communicable disease surveillance and response systems. Annexe 1.0 – Surveillance Definitions. WHO, Department of Communicable Disease, Surveillance and Response, Geneva, 23 pp.
19. World Health Organization (WHO) (2002). – Methods for food-borne disease surveillance in selected sites. Report of a WHO consultation, 18-21 March, Leipzig. WHO, Geneva, 29 pp.
20. World Health Organization (WHO) (2004). – Five keys to safer food. Website: <http://www.who.int/foodsafety/publications/consumer/5keys/en/> (accessed on 3 June 2004).
21. World Health Organization (WHO) (2004). – Recommendations from WHO's consultation on zoonoses. Website: <http://www.who.int/mediacentre/briefings/2004/m3/en/print.html> (accessed on 27 May 2004).