Rev. sci. tech. Off. int. Epiz., 2010, **29** (3), 523-535

Animal production food safety: priority pathogens for standard setting by the World Organisation for Animal Health

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Submitted for publication: 18 February 2010
Accepted for publication 26 August 2010

Summary

In this short study, expert opinion and a literature review were used to identify the pathogens that should be prioritised by the World Organisation for Animal Health (OIE) for the development of future standards for animal production food safety. Prioritisation was based on a pathogen's impact on human health and amenability to control using on-farm measures. As the OIE mandate includes alleviation of global poverty, the study focused on developing countries and those with 'in-transition' economies. The regions considered were Eastern Europe, Asia, the Middle East, Africa and South America.

Salmonella (from species other than poultry) and pathogenic *Escherichia coli* were considered to be top priorities. *Brucella* spp., *Echinococcus granulosus* and *Staphylococcus aureus* were also mentioned by experts. As *Salmonella*, and to a lesser extent pathogenic *E. coli*, can be controlled by on-farm measures, these pathogens should be considered for prioritisation in future standard setting. On-farm control measures for *Brucella* spp. will be addressed in 2010-2011 in a review of the OIE *Terrestrial Animal Health Code* chapter on brucellosis. In Africa, *E. granulosus*, the causative agent of hydatidosis, was estimated to have the greatest impact of all pathogens that could potentially be transmitted by food (i.e. via contamination). It was also listed for the Middle East and thought to be of importance by both South American experts consulted. *Taenia saginata* was thought to be of importance in South America and Africa and by one expert in the Middle East.

Keywords

Developing countries – *Escherichia coli* – Expert opinion – Foodborne – Priority – *Salmonella* – Standards – World Organisation for Animal Health – Zoonosis.

Introduction

Foodborne disease (FBD) is of great global importance. Diarrhoeal disease, much of which is foodborne, kills an estimated 2.2 million people each year (53). Although mortality is particularly high in developing countries, FBD also has a massive impact in developed countries. Mead *et al.*(33) estimated that foodborne diseases cause 76 million illnesses, 325,000 hospitalisations, and 5,000 deaths in the United States each year.

Many cases of FBD exhibit relatively mild clinical signs but still require medical treatment or affect the patient's ability

to work. Hence mortality represents the 'tip of the iceberg' when considering the true cost of FBD to society. Estimation of the global burden of FBD is a major initiative currently being undertaken by the World Health Organization (WHO) Foodborne Disease Burden Epidemiology Reference Group (FERG) (45).

Animals play a particularly important role in FBD. They can be a source of pathogens in food products of animal origin and also through faecal contamination of plant-derived foods and water (11). To minimise the risk of FBD, control measures should be implemented at both the pre-harvest level and subsequent stages of the production-to-consumption chain, i.e. 'from farm to fork'. In many situations, on-farm control may be more cost-effective (42, 47) and have a greater impact than control measures applied elsewhere (13).

One of the objectives of the World Organisation for Animal Health (OIE) is to provide a better guarantee of the safety of food of animal origin. To this end, the OIE established the Animal Production Food Safety Working Group (APFSWG) in 2002. This Group's role is to work with other relevant organisations, especially the Codex Alimentarius Commission (CAC) and its parent bodies (the WHO and the Food and Agriculture Organization of the United Nations [FAO]), in reducing foodborne risks to human health due to hazards arising from animals (44). The APFSWG has a programme for the development of animal production food safety standards covering the level of primary production to the first transformation of animal products, with a principle focus on on-farm measures. Many of the pathogens responsible for FBD do not normally cause disease in animals.

Several horizontal standards addressing animal production food safety and a specific chapter on *Salmonella* in poultry are already in the Veterinary Public Health section of the OIE *Terrestrial Animal Health Code* (*Terrestrial Code*) (59). Food safety aspects of certain pathogens that also cause animal disease have also been addressed in specific disease chapters, e.g. that on bovine tuberculosis.

However, there are many pathogens for which measures at the on-farm level to prevent FBD are not currently covered in the *Terrestrial Code*, and for the most part CAC standards include only general references to primary production at the farm level (10). Historically, the role of veterinarians (and the OIE) has been primarily to control diseases of animals (14); the focus on the development of international standards for on-farm measures to prevent FBD is fairly recent. By including animal production food safety in its mandate, at the request of Member Countries, the OIE has already taken important steps to address any gaps in standards for the food production-to-consumption continuum. The necessary action, including coordination with the CAC, is being addressed through the APFSWG.

Aims

This paper provides details of a study that was carried out in 2009, the aim of which was to identify the pathogens (viruses, bacteria, parasites and prions) that should be given priority in future OIE standard setting for animal production food safety. Clearly, developed and developing countries may have different concerns and priorities in regard to food safety in foods of animal origin. As more than two-thirds of OIE Member Countries are developing countries and countries with 'in-transition' economies, and the OIE's mandate includes helping to alleviate global poverty, the needs of these countries were the primary consideration.

The assessment was carried out in a qualitative, discursive manner, with the focus on identifying important pathogens and issues. Within the limits of the study it was not possible to undertake an in-depth assessment of the relative importance of each pathogen. The pathogens identified as most important and their amenability to control using on-farm measures are discussed.

The recommendations contained in this paper were given to the APFSWG in November 2009 and the Terrestrial Animal Health Standards Commission in February 2010 and they will be provided to OIE Member Countries to inform their views on the priorities for future OIE standards in animal production food safety.

Materials and methods

Prioritisation of pathogens was based on the burden of human FBD they cause; the extent to which they are amenable to control at the farm level; their coverage by current OIE and CAC standards; and, as appropriate, the significance of the pathogens to international trade and any other concerns of OIE Member Countries.

Pathogens causing OIE listed diseases, those that are not OIE listed, and pathogens that do not cause disease in animals were considered. Pathogens were not prioritised for consideration by the OIE if control at the farm level is not currently feasible or cannot be achieved in a practical cost-effective manner. Non-infectious disease agents were not considered.

Expert opinion

Experts were identified for each of the following regions: Eastern Europe, Asia (excluding the Middle East), the Middle East, Africa, and South America. In May 2009, opinions from one or two experts for each region were obtained.

Selection of experts

OIE associates from each region were asked to recommend appropriate experts in FBD. Expert opinions were obtained from two private consultants, four academics, one state Veterinary Service employee and one OIE employee. All had regional experience in FBD.

Questionnaire

Experts were asked to complete a brief postal questionnaire. The questionnaire asked experts to list the foodborne pathogens with the greatest impact on human health in their region and the most important food source by which people are exposed to each pathogen. Experts were asked to identify at least three pathogens. They were also asked if the pathogens would be amenable to on-farm control and to suggest what control measures were appropriate. Finally, experts were asked if there were foodborne pathogens and zoonotic pathogens, other than those already mentioned, that should be a higher priority for future OIE standard setting; for example, zoonoses that are not foodborne or diseases that have significant implications for issues other than human health.

Salmonellosis in poultry, anthrax (*Bacillus anthracis*) and bovine spongiform encephalopathy were not considered, as relevant standards have already been developed by the OIE.

Wider consultation

A range of other people with knowledge and interest in the area of FBD were contacted (more than 40 individuals), 20 of whom responded. Their input was informal, they did not complete the questionnaire. These people represented government agencies, intergovernmental organisations and academic institutions.

The results of the questionnaire were considered in conjunction with relevant literature and work done by other organisations concerned with FBD. As mentioned, the findings were considered by the APFSWG and the Terrestrial Animal Health Standards Commission and will be provided to OIE Member Countries.

Results

Expert opinion

The responses from the five regions are shown in Table I.

The pathogens considered to be of priority although not foodborne and those considered to be of priority for reasons not linked to human health are shown in the lower part of the Table.

Table I

Foodborne pathogens that have the greatest impact on human health in different regions, based on expert opinion

Pathogens considered to be of priority although not foodborne and those considered to be of priority for reasons not linked to human health are shown in the lower part of the table ('Other pathogens'). Experts indicated whether the priority of these pathogens should be lower, higher or equal to that of the foodborne pathogens

Impact	South America		Africa	Asia		Eastern Europe	Middle East	
	Expert A	Expert B	Expert A	Expert A	Expert B	Expert A	Expert A	Expert B
Biggest impact	*Escherichia coli* O157:H7	*E. coli* O157:H7	*E. granulosus*	*Salmonella* spp.	*S.* Enteritidis and *S.* Typhimurium	*Salmonella* spp.	*Salmonella* spp.	*E. coli* O157:H7
	Salmonella spp.	*Salmonella* spp.	*B. melitensis* and *B. abortus*	*T. spiralis*	*Vibrio parahaemolyticus*	Pathogenic *E. coli* strains	*Campylobacter* spp.	*S. aureus*
	Listeria monocytogenes [a]	*L. monocytogenes* [a]		*T. solium*	*Streptococcus suis* type 2	Viruses	*B. melitensis*	*Shigella* spp.[a]
	Staphylococcus aureus	*Brucella* spp.		*Mycobacterium bovis*	Norovirus [a] (hepatitis A virus [a][b])	*Toxoplasma gondii*	*E. granulosus*	*Campylobacter jejuni*
Least impact					*S. aureus*	*Campylobacter* spp. *L. monocytogenes* [a]		
	Lower priority	**Higher priority**	**Equal priority**	**Higher priority**			**Lower priority**	
Other pathogens	*Echinococcus granulosus*	*Coxiella burnetii*	*T. saginata*	HPAI H5N1			*T. saginata*	
	Trichinella spiralis	*E. granulosus*		Nipah virus			*M. bovis*	
	Taenia saginata and *T. solium*	*T. saginata*					*T. gondii*	

(a) foodborne but not a true zoonotic agent
(b) uncertain opinion

Important food sources

The most important food sources of each pathogen were inconsistently provided, but included the following:

– *Salmonella* spp: fresh meat from different sources (pork specified for Asia)

– pathogenic *Escherichia coli* (including O157:H7): beef and other meat

– *Listeria monocytogenes*: fresh meats, ready-to-eat products and milk products

– *Staphylococcus aureus*: meat products, dairy products (fermented pork specified for Asia)

– *Brucella* spp.: milk and milk products (goat products specified for Asia)

– *Echinococcus granulosus*: contaminated vegetables (Middle East); dust inhalation was mentioned as an important exposure route by one region (Africa).

Control measures

Control measures were identified in varying degrees of detail as listed below:

– general: sanitary control measures; implementation of good agricultural practices; biosecurity and control of wildlife

– *Salmonella* spp.: on-farm surveillance and hygiene; application of relevant control measures (as defined by European Union [EU] legislation)

– *Trichinella spiralis* and *Taenia solium*: confining livestock; using concrete floors and ensuring that feed is obtained from safe sources

– *Mycobacterium bovis* and *Brucella* spp.: disease surveillance; pasteurisation of dairy products; use of vaccination against *Brucella* spp.

– *B. anthracis*: vaccination; surveillance; identification of high risk areas

– *E. granulosus*: treatment of dogs; meat inspection; destruction of hydatid cysts in meat

– *Taenia saginata*: meat inspection; treatment of carcasses; human hygiene

– pathogenic *E. coli*: test and cull appears ineffective, preventing *E. coli* growth in wet feeds and sanitation of water troughs may be effective

– *Listeria monocytogenes*: hygiene and sanitation in milk harvesting

– *Toxoplasma gondii*: preventing contamination of feed, water and the environment; preventing consumption of dead pigs and rodents by other animals; serological tests at slaughter; pig confinement systems

– for aquaculture: water quality and non-specified management factors.

Current OIE coverage of foodborne disease pathogens

The standards in the *Terrestrial Code* and the recommendations found in other relevant publications for pathogens that cause FBD are summarised in Table II.

Wider consultation

Wider consultation and literature review helped to put the issue in context and to provide supporting information. The APFSWG concurred with the main findings of the report and agreed that the opinions of the Member Countries should be sought, especially on the importance of parasitic diseases. This was accepted by the Terrestrial Animal Health Standards Commission.

Discussion

Justification of methodology

Attempts to transparently and objectively prioritise foodborne pathogens for attention have been undertaken by many organisations (6, 8, 39, 46). These attempts frequently use a scoring system, whereby each disease is scored on several relevant criteria, the scores then being combined to give an overall semi-quantitative measure of importance.

In this study, several relevant criteria were considered for each pathogen, but as the study relied on a small number of experts combined with an assessment of the literature, scoring methods were not necessary. This allowed explicit consideration of the underlying complexities and uncertainties.

Published data on FBD and the control of relevant pathogens are scarce, particularly for most developing countries. The true incidence of FBD is likely to be underestimated in routine disease surveillance data and causative agents may not be definitively identified. Attributing a case to a foodborne source adds another level of uncertainty. Furthermore, the identification of effective and appropriate on-farm measures requires evidence that is often lacking.

For the above-mentioned reasons, the lack of a need for precise quantitative measures and the request from the APFSWG for the rapid provision of guidance on future standard-setting needs, expert opinion was seen as an

Table II
Current coverage of farm-level control of foodborne disease agents in the OIE *Terrestrial Animal Health Code* (59) or other OIE published guidelines (assessed December 2009)

Pathogen	Coverage	Details
Salmonella in poultry	*Terrestrial Code*	Aimed at poultry breeding flocks and hatcheries
Brucella abortus and *B. melitensis*	*Terrestrial Code* (OIE listed diseases)	Details on-farm disease freedom measures, not specifically public health measures (*ad hoc* group has been scheduled)
Trichinella spiralis	*Terrestrial Code* (OIE listed disease)	Covers proof of disease freedom and importation of fresh meat (need more consideration of on-farm measures)
	FAO/WHO/OIE Guidelines (23)	Prevention of infection in domestic pigs
BSE	*Terrestrial Code* (OIE listed disease)	Farm-level control covered
Mycobacterium bovis	*Terrestrial Code* (OIE listed disease)	Details on proof of disease freedom but not on recommended farm biosecurity measures
Taenia saginata	*Terrestrial Code* (not an OIE listed disease)	Few details included
Taenia solium	*Terrestrial Code* (OIE listed disease)	No details included
	FAO/WHO/OIE Guidelines (54)	On-farm control discussed
Echinococcus spp.	*Terrestrial Code* (OIE listed disease)	Few details included
	WHO/OIE Guidelines (55)	Animal control discussed
Coxiella burnetii	*Terrestrial Code* (OIE listed disease)	No details included
Bacillus anthracis	*Terrestrial Code* (OIE listed disease)	Some animal-level measures mentioned but not in detail (currently under review)

BSE: bovine spongiform encephalopathy
FAO: Food and Agriculture Organization of the United Nations
WHO: World Health Organization

appropriate and timely way to address this issue. An open questionnaire was used so that experts would be free to highlight issues that may have otherwise been overlooked.

Limitations and biases

The method of selection of experts was non-systematic and the questionnaire and the accompanying instructions were kept brief to maximize the response rate. This variety of professional backgrounds and interests and the brevity of the wording meant that questions could have been interpreted variably. By way of example, an expert may have evaluated 'impact on human health' by considering mortality, morbidity, cost to health services or some other measure or combination of measures. The fact that experts from the same region often gave different answers is partly due to this scope for interpretation and partly due to uncertainty as to which pathogens are of relatively greater importance.

A lengthier study with a panel of experts that confer and work together to provide a single, collective response to each question (as used in Delphi studies) was not performed. This was due to lack of time and resources and based on the fact that the most important step in validating the report is requesting input from OIE Member Countries, to obtain not only factual information but also the considered views of official veterinarians with responsibility for the management of animal health and the prevention of FBD. The approach taken in this study puts greater dependency on the selection of the regional experts and the particular experiences and knowledge of each expert selected (48).

Some pathogens are frequently under-reported and the cases that are reported tend to be the more severe ones. How this and other complexities were accounted for by experts was not explicitly considered in the questionnaire.

Using a standard measure of impact of disease (e.g. Disability-Adjusted Life Years [4]) is a valid method of assessing the impact of a disease but could not be undertaken in the time available for this study.

Another issue relevant to prioritisation is how to assess the relative importance of regions when identifying the pathogen(s) of most significance globally. Considering population size or number of countries present in the region would be two possible methods. This study did not attempt to deal with such precise comparisons and merely highlighted pathogens considered to be of significant regional and global importance.

Pathogens prioritised by experts

Non-poultry *Salmonella* spp. were identified by experts as priority pathogens for OIE standard setting in the animal production food safety domain by all regions except Africa. Various fresh meats were suggested as the main food source responsible for these *Salmonella* infections. Pathogenic strains of *E. coli* (specifically *E. coli* O157:H7) were thought to be a top FBD priority for South America, the Middle East and Eastern Europe, with meat, and beef in particular, considered to be the main source. These two pathogens are considered in more detail elsewhere in this report. Support for other pathogens was less consistent. Three regions mentioned *Brucella* spp. and *S. aureus* as priority pathogens but these pathogens were never mentioned by more than one expert in the same region. This may reflect uncertainty over their relative importance as a cause of FBD compared to other pathogens.

Staphylococcus aureus of human origin is more important than strains of animal origin in FBD (31). However, the role animals play in the development of antibiotic resistance in pathogens such as methicillin-resistant *S. aureus* (MRSA) is of great concern (30). Recommendations for on-farm measures to avoid the development of antimicrobial resistance are included in the *Terrestrial Code* (59).

Brucellosis is one of the most widespread zoonoses (52) and causes both human disease as well as reduced productivity in livestock (61). Methods of controlling *Brucella* spp. are well known and have been successfully applied in many countries. Although *Brucella* spp. are extensively covered by OIE publications (58, 59), official recommendations for on-farm control measures are not. The FAO has produced guidance on surveillance (38) and FAO and OIE regional activities have addressed this topic (21).

Some pathogens appear to have a marked regional variation in their impact, the most notable examples being in Africa where *Salmonella* spp., *E. coli* and *S. aureus* were not mentioned as priority pathogens. This may reflect the lack of detailed studies on FBD in this region.

Echinococcus granulosus, the causative agent of hydatidosis, was estimated to have the greatest impact of all foodborne pathogens in Africa; it was also listed for the Middle East and thought to be of importance by both South American experts consulted. Hydatidosis was inconsistently considered an FBD by experts. Dogs are the usual definitive host of *E. granulosus*, with ungulates such as sheep acting as the intermediate hosts: humans become infected through contact with dogs and food contaminated with parasite eggs (32), dust inhalation is another possible route of transmission (43).

Taenia saginata was thought to be of importance in South America, Africa and by one expert in the Middle East. This FBD causes relatively mild clinical signs (27). Its major impact is through production losses in the beef industry, condemnation of beef and loss of export trade due to restrictions imposed upon countries that fail to control it (27). The limited impact of *Taenia saginata* in causing FBD could be a reason for the APFSWG not to consider it of high priority.

Echinococcosis, trichinellosis and porcine cysticercosis are OIE listed diseases. There are chapters in the *Terrestrial Code* on hydatidosis and trichinellosis but they focus on the international movement of live animals, rather than control on-farm or prevention of FBD. In 2001 the WHO/FAO/OIE jointly published recommendations on the control of echinococcosis and, in 2005, on control of taeniosis and cysticercosis (23, 54, 55, 59). However, these publications do not have the status of standards.

Non-poultry *Salmonella* spp.

Salmonellosis is possibly the most common FBD in the world (36). Based on the human isolates reported to the WHO Global *Salmonella*-Surveillance in the period 2000-2002, *Salmonella enterica* serovar Enteritidis and *Salmonella enterica* serovar Typhimurium were the most frequently reported isolates for all regions. Apart from contaminated eggs, contamination of carcasses with animal faeces is considered to be the principal source of human exposure. Contamination of vegetables by animal faeces is another source of infection (36).

Although hen eggs and broiler meat play a major role in human salmonellosis (22), other sources of *Salmonella* are also of importance. In an international study of 4,093 reported foodborne outbreaks, eggs accounted for 43.4% of *Salmonella* Enteritidis outbreaks, and chicken meat 9.9%. The remaining 46.7% of outbreaks were attributed to a range of other animal-derived and non-animal derived foods (24). In the same study, 18.2% of *Salmonella* Typhimurium outbreaks were attributed to eggs and 10.4% were attributed to chicken meat. Again, the remaining 71.4% of outbreaks were attributed to other animal and non-animal derived products. However, the exact relevance of this study is uncertain as outbreaks only represent part of the burden of disease and developing countries were poorly represented. This highlights the imperfect knowledge on which assessments of pathogen importance must be made. In a review of invasive non-Typhi *Salmonella* disease in Africa, Morpeth *et al.* stated that non-Typhi *Salmonella* is a leading cause of bloodstream infection, with *Salmonella* Enteritidis and *Salmonella* Typhimurium being the most commonly isolated serotypes in sub-Saharan Africa (34). The appearance of antimicrobial resistance in certain strains of *Salmonella* (42) is an additional concern.

Effective on-farm control of *Salmonella* in pigs has been successfully implemented in some countries, such as Finland and the Scandinavian countries (16, 49). The EU has a programme to reduce *Salmonella* contamination of pigs at slaughter with interventions (including on-farm measures) to be implemented by Member States (18). Feeding, management and hygiene practices have all been used as on-farm measures to control *Salmonella*. As no single measure can sufficiently control disease, several measures must be implemented for effective results. Although a Scandinavian style *Salmonella* surveillance and control programme would not be feasible for many countries, some of the control measures that have been successfully used may form an appropriate basis for providing recommendations on on-farm measures.

There is no specific reference to on-farm control of *Salmonella* in non-poultry species with respect to food safety in the *Terrestrial Code* (59) or CAC publications.

Pathogenic *Escherichia coli*

Escherichia coli is a common and normally harmless member of the gut micro-flora of most warm-blooded species. However, enteric disease may result if humans are infected with certain pathogenic *E. coli* strains (35).

Certain shiga toxin-producing *E. coli* (STEC), also known as verotoxigenic *E. coli* are of particular concern. In wild and domestic animals, infection with STEC strains seems to be fairly common yet it causes little disease (7). In humans, STEC infection is rare but these organisms are known to cause disease with signs including watery diarrhoea, haemorrhagic colitis and haemolytic uraemic syndrome (HUS), particularly in children and the elderly. Most human cases are due to food contaminated with zoonotic STEC of animal origin (19).

Enterohaemorrhagic *E. coli* (EHEC) comprise a subset of STEC serotypes that are commonly associated with bloody diarrhoea and HUS. Although several EHEC serotypes can cause human disease, O157:H7 is most frequently implicated (7). Cattle are the major reservoir for all zoonotic STEC, including EHEC O157:H7 (19). Contaminated foods derived from cattle (particularly ground beef) are the most common source of infection, due to contamination during food preparation. Animal faecal contamination of growing fruit and vegetables is another important source of this pathogen. Various foods are associated with disease outbreaks, including undercooked hamburgers, milk, unpasteurised apple cider, sprouts and salad (24, 42).

In 1999 Mead *et al.* (33) estimated that *E. coli* O157:H7 caused more than 60,000 illnesses in the United States annually, 0.5% of all cases of FBD and 2.9% of deaths due to FBD. Greig *et al.* (24) found *E. coli* to be responsible for 9.5% of FBD outbreaks in an international study. Up to 10% of EHEC patients are thought to develop HUS and the case-fatality rate for this is estimated to range from 2% to 7%, although for some outbreaks involving the elderly the figure is as high as 50% (51). Outbreaks can be very large. One EHEC O157 outbreak in Japan involved approximately 9,000 school children (51). As well as being a problem in Europe, Japan and North America, EHEC is an important pathogen in Australia, Chile, Argentina and South Africa (35), although the non-O157 serotypes may be more important than the O157 serotype in these countries. In the developing world, foodborne pathogenic *E. coli* other than EHEC seem to be more important (35). Many cases of disease due to non-EHEC *E. coli*, although foodborne, are due to poor sanitation and are not associated with an animal reservoir (37). Although zoonotic-STEC are often responsible for disease in developing countries (19), limitations in surveillance make it difficult to know how important they are in FBD (42).

Some countries have adopted a policy of considering raw ground beef 'adulterated' if it contains any *E. coli* O157:H7. This has led to very large recalls of ground beef at enormous cost (9). This policy poses a potential barrier to international trade and is of great concern to beef exporting countries.

Control of pathogenic *E. coli* of animal origin requires the application of measures at all stages of the food chain, including on-farm. On-farm measures should be aimed at reducing intestinal colonisation and shedding of the relevant bacteria as well as reducing their persistence in the farm environment (19). These measures would also reduce human infection due to direct contact with the animals (50).

Vaccination and the use of probiotics and bacteriophages have been investigated as possible methods of reducing EHEC O157:H7 excretion in cattle. The probiotic *Lactobacillus acidophilus* culture appears to be effective and is widely used in the United States. However, the benefits of other specific measures are at present unclear (29, 40). It was thought by one expert that testing and culling carriers of EHEC O157:H7, although a logical approach (19), may be ineffective, although there is a lack of published data on the matter. It must be remembered that pathogen-specific measures may be inefficient as they allow the emergence of other pathogens.

Among non-specific measures, the management of manure and slurry is important. Good management practices, including maintaining hygienic troughs and pens, managing silage correctly, and avoiding overcrowding of animals are relevant (15). As faecal contamination of hides is the main source of *E. coli* contamination of meat (28), it is important to ensure that cattle are clean when sent to

slaughter and that faecal contamination of carcasses during slaughter/dressing is avoided or removed.

Control measures for EHEC O157:H7 applied throughout the food chain have had a positive effect in the United States (28). Although some argue that control of EHEC O157:H7 should focus on harvest and post-harvest (28) for both meat and leafy vegetables, this does not mean that pre-harvest control is unimportant. However, the potential for cross-contamination during transport and processing highlights the need for good post-harvest control in addition to measures applied on-farm.

Measures for the control of pathogenic *E. coli* are not provided in the *Terrestrial Code* (59), although the OIE and FAO have produced guidelines on good farming practices (10, 56).

Developed countries

A significant amount of work has been done on the burden of FBD in developed countries (1, 2, 5, 17, 20, 33). *Campylobacter* spp. and *Salmonella* spp. are often considered to have the biggest impact. However, developing countries have a different view on the relative importance of specific pathogens. Developed countries are generally less concerned about parasitic diseases and other diseases that have been successfully controlled through national programmes, whether the measures are applied on-farm (e.g. bovine brucellosis and tuberculosis) or subsequently (e.g. pasteurisation) (41, 52).

Potentially important pathogens that were not prioritised by experts

Campylobacter spp. are a major cause of FBD globally (1, 5, 12, 17). Campylobacteriosis presents as diarrhoea with fever and malaise. Complications may arise, rarely, but very few deaths occur. Poultry meat is regarded as a key source of infection. CAC guidelines for the control of *Camplylobacter* in chicken meat (currently under development) include on-farm control measures that complement the text on hygiene and biosecurity procedures in poultry production in the *Terrestrial Code* (59). As this pathogen is being addressed by the CAC and, in relation to general biosecurity measures in poultry production, by the OIE, there may be little need to prioritise it for the development of OIE standards. Perhaps more importantly, there is little evidence that the on-farm control of *Campylobacter* spp. can be effectively managed. Poor biosecurity practices allow the carriage of the pathogen into farm sheds by wildlife and by humans. Introduction of external personnel and packaging during reduction of poultry density by 'thinning' flocks during production has also been found to increase contamination (3, 25). Restricting access of flies and other insects may help to avoid contamination of flocks (26).

How do OIE standards and guidelines make a positive contribution to public health?

The standards and guidelines of the OIE help to protect public health in two ways. The standards formally adopted by OIE Member Countries (57, 58, 59, 60) are legal references for the World Trade Organization (WTO) Agreement on the Application of Sanitary and Phytosanitary Measures. These standards should be used by WTO Members to determine the measures applied to animals and animal products for international (and regional) trade. Moreover, these standards are valuable to Member Countries because they represent expert scientific opinion, on a global basis, for defining on-farm measures to help avoid food safety risks and to safely trade animals and animal products internationally. In addition, OIE recommendations can be used by Member Countries to guide the development and implementation of national or regional programmes that aim to improve animal health and animal production food safety nationally.

It is clear that FBD has an important impact on poor communities, even though the specific contribution and relative importance of different pathogens may not be well defined. In the absence of strong Veterinary Services and good governance, the adoption of official control programmes based on OIE standards may have little effect, for example, where livestock slaughtering and trade in animal products is largely informal and takes place outside any official health or safety framework. In these situations, community level interventions may be more effective than legislation in reducing the impact of FBD in the short term. In the longer term, strengthening of Veterinary Services and their infrastructure through interventions of international donors working in collaboration with the OIE is perhaps the most reliable and effective approach and this work, through the application of the OIE Tool for Evaluating the Performance of Veterinary Services, is an ongoing global priority of the OIE.

Conclusions

The data required for prioritisation of pathogens for OIE standard setting in relation to FBD are lacking, particularly for developing countries. Consulting regional experts is a suitable method to provide a snapshot review of the situation, but the recommendations should be the subject of consultation with OIE Member Countries, consistent with the OIE democratic procedure for standard setting.

Based on the opinion of the experts consulted, non-poultry *Salmonella* spp. and pathogenic *E. coli* (especially

E. coli O157:H7) should be considered for prioritisation. This was supported by the literature and other factors, including the feasibility of on-farm control and the lack of coverage in current OIE and CAC standards. More is known about effective on-farm control of non-poultry *Salmonella* spp. than *E. coli* O157:H7, which suggests that non-poultry *Salmonella* spp. should be rated as a higher priority for standard setting.

Proven on-farm methods for the control of *Brucella* spp. exist. As work is currently under way to review the *Terrestrial Code* chapter on brucellosis, no specific recommendations are warranted.

Echinococcus granulosus was estimated to have the greatest impact of all foodborne pathogens in Africa; it was listed for the Middle East and thought to be of importance by both South American experts consulted. Hydatidosis is not an FBD in the classical sense. However, humans may acquire infection via contamination of food and the disease is amenable to control measures, therefore it is worthy of consideration in the context of this review. *Taenia saginata* was considered important in South America, Africa and by one expert in the Middle East. It causes relatively mild disease in humans but can have a major impact on the beef industry.

Although WHO/FAO/OIE have published recommendations on the control of echinococcosis, taeniosis and cysticercosis, these publications do not have the status of standards.

Consistent with the OIE democratic procedures for the development of standards, the future priorities for standards in relation to agents of FBD rest with OIE Member Countries.

Acknowledgements

Thanks go to contributing experts including Dr Héctor J. Lazaneo, Dr Cristina López, Dr Peter Roeder, Dr Ronello Abila, Dr Suphachai Nuanualsuwan, Prof. Dr Jacek Szczawiński, Dr Pavlos Economides and Prof. Hassan Aidaros. Thanks also go to all members of the International Trade Department of the OIE and the WHO Food Safety, Zoonoses and Foodborne Diseases Department.

La sécurité sanitaire des aliments d'origine animale pendant la phase de production : les agents pathogènes à examiner en priorité dans le cadre des travaux normatifs de l'Organisation mondiale de la santé animale

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Résumé

Une enquête basée sur des avis d'experts et sur une étude documentaire a été conduite dans le but de déterminer quels sont les agents pathogènes à traiter en priorité dans le cadre des futurs travaux normatifs de l'Organisation mondiale de la santé animale (OIE) relatifs à la sécurité sanitaire des aliments d'origine animale en phase de production. Les priorités ont été établies en tenant compte de l'impact des agents pathogènes sur la santé publique et des possibilités de contrôle au niveau des exploitations. La réduction de la pauvreté au niveau mondial étant l'un des objectifs du mandat de l'OIE, l'étude a surtout porté sur les pays en développement et en transition. Les régions couvertes étaient l'Europe centrale, l'Asie, le Moyen-Orient, l'Afrique et l'Amérique du Sud.

Salmonella (chez les espèces autres que les volailles) et *Escherichia coli* pathogène ont été désignés comme deux priorités absolues. Les experts ont également cité *Brucella* spp., *Echinococcus granulosus* et *Staphylococcus aureus* parmi les agents prioritaires. En raison de la possibilité de contrôler *Salmonella* et, dans une moindre mesure, *E. coli* au niveau des élevages, ces

deux agents devraient figurer parmi les priorités des futures normes. Les mesures visant à maîtriser la présence de *Brucella* spp. dans les élevages seront examinées en 2010-2011, lors de la révision du chapitre du *Code sanitaire pour les animaux terrestres* de l'OIE consacré à la brucellose.
En Afrique, parmi tous les agents responsables de toxi-infections alimentaires (notamment ceux transmis par des aliments contaminés), c'est *E. granulosus*, l'agent responsable de l'hydatidose qui a été cité comme le plus important en termes de santé publique. *Echinococcus granulosus* figurait également sur la liste des agents pathogènes prioritaires au Moyen-Orient ; de même, les deux experts sud-américains interrogés l'ont jugé important. *Taenia saginata* a été cité comme étant important en Amérique du Sud et en Afrique, ainsi que par l'un des experts du Moyen-Orient.

Mots-clés
Avis d'expert – *Escherichia coli* – Norme – Organisation mondiale de la santé animale – Pays en développement – Priorité – *Salmonella* – Toxi-infection alimentaire – Zoonose.

Inocuidad de los alimentos en producción animal. Patógenos prioritarios en la actividad normativa de la Organización Mundial de Sanidad Animal

T.J.D. Knight-Jones, G.E. Mylrea & S. Kahn

Resumen
Los autores describen un breve estudio que tenía por objeto determinar los patógenos a los que la Organización Mundial de Sanidad Animal (OIE) debería conceder prioridad en el futuro al elaborar normas relativas a la inocuidad de los alimentos en la producción animal, atendiendo a la opinión de expertos y a un análisis bibliográfico. Para definir un orden de prioridad se tuvieron en cuenta las consecuencias sanitarias de los patógenos para el hombre y la posibilidad de controlarlos mediante la adopción de medidas en cada explotación. Toda vez que el mandato de la OIE incluye la lucha contra la pobreza en el mundo, el estudio se centró en los países en desarrollo y los países con una economía 'en transición'. Las regiones consideradas fueron: Europa Oriental, Asia, Oriente Medio, África y Sudamérica.
Se consideró que la máxima prioridad residía en las salmonelas (que afectan a especies distintas de las aves de corral) y las *Escherichia coli* patogénicas. Los expertos mencionaron también *Brucella* spp., *Echinococcus granulosus* y *Staphylococcus aureus*. Dado que es posible luchar contra *Salmonella*, y también en menor medida contra las *E. coli* patogénicas, adoptando medidas en cada explotación, en los futuros procesos normativos convendría otorgar la máxima prioridad a esos microorganismos patógenos. Las medidas apropiadas que cabe adoptar en las explotaciones para luchar contra las brucelas serán objeto en 2010-2011 de una revisión del capítulo dedicado a la brucelosis del *Código sanitario para los animales terrestres* de la OIE.

Se concluyó asimismo que en África *E. granulosus*, agente causal de la hidatidosis, era, de todos los patógenos que podían transmitirse por vía alimentaria (esto es, contaminando un alimento), el que tenía consecuencias más dañinas. Ese parásito también fue incluido en la lista relativa a Oriente Medio, y los dos expertos sudamericanos consultados lo mencionaron como uno de los patógenos importantes. En Sudamérica y África se consideró importante *Taenia saginata*, que también citó un experto de Oriente Medio.

Palabras clave
Escherichia coli – Normas – Opinión de expertos – Organizaión Mundial de Sanidad Animal – Países en desarrollo – Prioridad – *Salmonella* – Transmisión por vía alimentaria – Zoonosis.

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