SURVEILLANCE FOR BSE

The two major objectives for BSE surveillance are to determine whether BSE is present in a country, and, if present, to monitor the extent and evolution of the outbreak over time. In this way, the effectiveness of control measures in place can be monitored and evaluated. However, the reported number of BSE cases in a country can only be evaluated within the context of the quality of the national surveillance system.

Governments must allocate and expend funds to develop and implement a national surveillance programme. These costs include personnel, testing and compensation for farmers, as well as disease awareness activities. The decision to implement such a system has both positive and negative economic and political effects. Therefore, governments must have scientific justification in order to make these decisions, normally available in the form of a risk assessment.

The *Terrestrial Animal Health* Code OIE (considered the international standard), provides general guidelines for disease surveillance (OIE, 2005a) and specific guidelines for an appropriate level of BSE surveillance (OIE, 2005b). The OIE code standards for BSE are updated frequently, often on a yearly basis, thus the most recent OIE guidelines, available at http://www.oie.int/eng/normes/mcode/en_sommaire.htm, should always be used.

However, BSE risk can still exist in a country even if no cases are found with surveillance. Surveillance aims to supplement the more comprehensive data that are provided by a risk assessment (Heim and Mumford, 2005).

1. PASSIVE SURVEILLANCE

In most countries, BSE is listed as a notifiable disease, which is a basic requirement for a functioning passive (as well as active) surveillance system. However, some countries have no national passive surveillance system for BSE, or only a weak system.

Until 1999, BSE surveillance in all countries was limited to the notification of clinically suspected cases by farmers and veterinarians (and others involved in handling animals) to the veterinary authorities (passive surveillance), and it was assumed that this would allow early detection of an outbreak (Heim and Wilesmith, 2000). However, because passive surveillance relies solely on the reporting of clinical suspects and is dependent on many factors, including perceived consequences on the farm and diagnostic competence, it is not necessarily consistent or reliable. Underreporting is the most important constraint of a passive surveillance system for BSE. To improve reporting and allow the overall functioning of the passive system, the following minimum factors must be in place (Doherr *et al.*, 2001):

Notification: The disease must be notifiable, meaning that there is a legal requirement to report the disease to an official authority when it is suspected. The procedure for notification should be simple, and it should be clear who is responsible for what. Veterinarians, farmers and others involved in handling animals should know what they have to do if they identify a suspect case.

Definition of BSE: In order to optimize identification of all clinical cases, the legal definition of a BSE suspect should be broad. In several countries the legal definition for a BSE suspect refers only to cattle with neurological signs, which is too narrow a description. The OIE describes BSE suspects as cattle over 30 months:

- affected by illnesses that are refractory to treatment;
- displaying progressive behavioural changes such as excitability, persistent kicking when milked, changes in herd hierarchical status, hesitation at doors, gates and barriers; or
- displaying progressive neurological signs without signs of infectious illness.

Often farmers and veterinarians know about BSE only from pictures of extreme, late stage clinical disease as portrayed by the media. They must be informed that these extreme BSE signs are often not seen and signs are usually very subtle. It should be recognized that cattle may display only some of the possible signs, and that signs may vary in severity. Since BSE causes no pathognomonic clinical signs, some individual animals with signs compatible with BSE will be seen in all countries with cattle populations. Such animals should always be investigated as BSE suspect animals.

Disease awareness: All individuals handling cattle (farmers, veterinarians, personnel at the slaughterhouse and others) must be able to recognize clinical signs of the disease. This requires extensive, long-term information campaigns and education programmes to improve disease awareness, targeted to every level and every sector.

When designing a disease awareness programme for improving passive surveillance, the following considerations should be taken into account

- Message to be conveyed
- Media to be used
- Groups to be targeted
- Cultural aspects
- Motivation factors
- Format used

Developing education programmes is especially difficult in countries with BSE risk but no cases, as administrations and individuals first must be willing to consider that the disease might be present.

Willingness to report: There must be minimal negative consequences to the identification of a positive case at the farm level. The motivation of a farmer to notify a suspect case if their whole herd, i.e. "life-work", could be destroyed without reasonable justification is minimal. Therefore, possible consequences should be understood and accepted as "reasonable" by the farmers.

Compensation scheme: The value of culled animals must be reasonably compensated. In many countries an animal confirmed to have BSE is compensated, but not a negative suspect animal. Because most animals notified will probably be negative, it is crucial to also compensate farmers for the negative suspects.

Diagnostic capacity: There must be adequate laboratory competence to ensure appropriate handling and examination of brain tissue collected within the framework of a surveillance system. The appropriate people should be trained by experienced laborato-

ries, and they should be up to date with all sampling, handling, shipping and diagnostic methods used.

Because all the factors described above vary greatly, both among countries and within countries over time, the results of passive BSE surveillance systems are subjective and evaluation and comparison of reported case numbers should be made carefully. Experience clearly shows that mandatory reporting of clinically suspect cases alone is not sufficient to derive a true picture of the BSE situation in a country, because such reporting is too dependent on these subjective factors.

2. ACTIVE SURVEILLANCE

To optimize identification of positive animals and improve the surveillance data, those populations of cattle that are at increased risk of having BSE can and should be actively targeted within a national surveillance system. Cattle with signs of disease non-specific to BSE and cattle that died or were killed for unknown reasons may be defined differently in different countries (e.g. sick slaughter, emergency slaughter, killed cattle, fallen stock, downer cows; Table 1). The probability of detecting BSE-infected cattle is higher in this population, as it may have been BSE that led to the debilitation, death, cull or slaughter of these animals (SSC, 2001). Many of these cattle may have exhibited some of the clinical signs compatible with BSE, which were not recognized. The experience of many countries in the last years has shown that, after clinical suspects, this is the second most appropriate population to target in order to detect BSE.

The age of the population tested is also important, as the epidemiological data show that cattle younger than 30 months rarely test positive for BSE. Therefore, targeted surveillance in most countries aims to sample cattle over 30 months of age selectively in the risk populations, which may be identified on the farm, at transport or at the slaughterhouse. Testing of these risk populations is now mandatory in most European countries.

Ideally, BSE suspect cattle should be separately identified and reported, and not leave the population through other possible exit routes (such as burial). In practice, however, these suspect cases are often not identified and are considered (in the best case) as fallen stock, and sometimes as emergency slaughter cattle. In the worst case, they go into the regular slaughter chain. This is not totally avoidable, but with good disease awareness and a good ante mortem inspection at the slaughterhouse, most cases can be excluded from the slaughter chain.

TABLE 1. Populations of cattle to consider when planning a national BSE surveillance system.

Population of cattle	Category	
Healthy cattle	Regular slaughter	
Cattle with non-specific signs (e.g. weight loss, loss of production) Cattle that died/were culled for unknown reasons (e.g. on the farm, during transport)	Sick slaughter Emergency slaughter Fallen stock Downer cows	RISK GROUPS
Cattle with specific signs of BSE	BSE suspects	

TABLE 2. Efficiency of testing risk and the regular slaughter populations in the European Union

	Regular slaughter cattle		Risk cattle	
Year	2003	2004	2003	2004
Number of cattle tested	8 716 481	9 551 469	1 295 770	1 478 650
Number of BSE positive cattle	265	166	783	520
Rate of positives : number tested	32 892	57 539	1 655	2 844
Cost to find one positive BSE case (using €70/ sample)	€ 2.3 million	€ 4 million	€ 115 841	€ 199 094

However, despite the fact that correctly implemented sampling of risk populations and BSE suspects would hypothetically be sufficient to meet the goals of BSE surveillance, testing a subsample of cattle at regular slaughter should be considered in order to minimize diversion of questionable animals to slaughter, i.e. to improve compliance. If farmers are aware that random sampling is occurring in the slaughterhouse, and if the probability of being tested is large enough, they are less likely to try to send suspect animals directly to slaughter.

Targeted surveillance systems are both effective and efficient. After they gained more widespread use in 2001, many countries in Europe and also the first countries outside Europe detected their first BSE cases. From the experiences gained in Europe, it is also clear that it is most cost effective to promote the effective implementation of passive and targeted surveillance in risk populations rather than to focus on testing of the entire regular slaughter population (Table 2).

3. SURVEILLANCE SYSTEMS IN DIFFERENT COUNTRIES

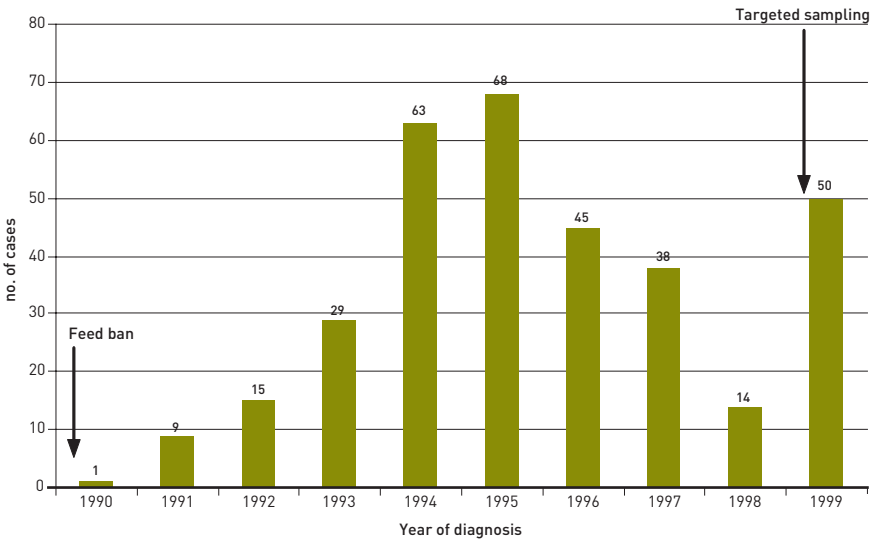
BSE surveillance and testing programme approaches vary among countries. Some countries have no system in place, some test only a few animals, some test certain subpopulations but not others, some test according to OIE guidelines, and some test many more animals than the OIE requirements (but in some cases from inappropriate populations or age groups). Therefore, conclusions regarding the extent of the BSE problem in a country cannot be made by simply examining the number of reported cases, and comparisons cannot be made between countries without considering implementation of the surveillance system in place.

More intensive, targeted surveillance increases the probability of finding any disease in any country (Calavas *et al.*, 2001; Doherr *et al.*, 2001). Therefore, when examining a country's reported BSE tests and reported BSE cases, the following issues must be considered

- Compliance and capacity (i.e. in identifying suspects, in collecting samples). The legislation in place, the infrastructure available and the ability to identify and diagnose cases vary substantially among countries.
- The proportion of the total cattle population that is tested (or is positive). Because actual numbers do not provide an adequate relative picture, the proportion tested (or positive) must be given.
- The age of the population sampled. Animals under 30 months of age are much less likely to test positive, so including them in testing systems artificially raises the proportion of negative tests.

FIGURE 1

Number of BSE cases identified in Switzerland from 1990 through 1999



- The total number of clinical suspects sampled. This reflects the disease awareness and willingness to report in the country.
- The subpopulations sampled. Regular slaughter cattle have a much lower risk than the "risk populations" described above.

The examples of Switzerland and the EU are presented below.

3.1. Switzerland

After implementation of targeted sampling in Switzerland in 1999 (Doherr *et al.*, 1999; Doherr *et al.*, 2001), the number of identified cases increased (Figure 1). The targeted surveillance programme in Switzerland currently includes:

- passive surveillance (clinical suspects);
- all died or killed on farm or during transport, but not cattle over 30 months of age slaughtered for human consumption (fallen stock);
- all emergency slaughter cattle over 30 months of age;
- random sample of regular slaughter cattle over 30 months of age.

3.2. European Union

The number of identified cases also increased in the original 15 EU member states (EU15) after implementation of targeted sampling in 2001 (EC, 2002). In the EU, the official targeted sampling system is the same for all 25 current Members. The surveillance system includes testing all cattle:

- of any age and showing clinical signs consistent with BSE;
- over 24 months of age and subject to emergency slaughter (accident or serious physiological and functional problems);
- over 24 months of age and died or killed on farm or during transport, but not slaughtered for human consumption (fallen stock);

- over 24 months of age and found at ante mortem inspection to be suspected or suffering from a disease or a disorder;
- over 30 months of age and subject to regular slaughter for human consumption (only Sweden is allowed to take a random sample).

The numbers of tested and positive cattle in each category in each EU Member State are published and updated regularly. Although the number of cases in the EU was increasing in 2001 and 2002, since 2003 the number of cases in the EU altogether is decreasing (EC, 2003; 2004). A total of over 10 million cattle were tested in the EU in 2004. Of these, 686 cattle were positive. Spain and Portugal were the only countries in the EU 15 Member States with an increase of cases in 2003, and Germany in 2004.

However, as described above, these numbers must be examined in the context of the quality of the surveillance programme implemented in each Member State. Although all EU Members have the same legal requirements for surveillance (except the UK and Sweden, which have special regulations), the numbers tested are very different. Some of the countries reporting very few BSE cases have also performed fewer examinations. The risk population tested in 2004 ranged between 0.81 and 4.78%, and the population of regular slaughter cattle between 7% and 38.2% (except the UK and Sweden) of the live adult cattle population. Also, the number of suspects tested varied enormously among countries. Although some variations in the number of tests performed could be explained by different production systems, the deviation is so significant that it can only be explained by variable implementation of the surveillance.

His means the numbers may not be reliable in some countries of the EU (and other countries worldwide), even those with few cases. The reported numbers from some countries may overrepresent the overall numbers tested (and therefore underrepresent the number of positives), because many cattle younger than 30 months – even younger than 24 months – are tested and the reported numbers are then not adjusted for age. Therefore, country-to-country comparisons need to be treated cautiously. This situation also emphasizes that legal requirements alone are not sufficient, and the surveillance system must also be effectively implemented and controlled.

4. PLANNING A SURVEILLANCE SYSTEM FOR BSE

If a country decides to initiate a surveillance programme for BSE, enough time for preparation must be allowed and sufficient funds allocated. First, a scientific national BSE risk assessment must be completed. For this, countries must evaluate what specific information they have, what they need, and where to obtain it (see the "Risk assessment" chapter in this course manual). Then they must decide what infrastructure is required (and what is available in the country) to implement the system effectively.

For many years, the OIE has recommended that the level of BSE surveillance should be commensurate with the risk. However, prior to 2005, guidelines for the numbers of samples to test had been given only for passive surveillance. Since 2005, detailed guidelines for countries with negligible and higher BSE risk are available (OIE 2005b), such that:

- When the risk assessment demonstrates non-negligible risk, the country should conduct surveillance that will allow the detection of BSE around a prevalence of at least one case per 100 000 animals in the adult cattle population (i.e. a higher level of surveillance).

- When the risk assessment demonstrates negligible risk, the country should conduct surveillance that will allow the detection of BSE around a prevalence of at least one case per 50 000 animals in the adult cattle population (i.e. a lower level of surveillance).

The guidelines assign a value to every test based on the risk population and age of the animal sampled, i.e. the lowest value is given for normal slaughtered cattle of an age below two or above nine years; the highest value is given for clinical suspects between four and seven years. The values of all the samples tested are then added. Depending on risk and cattle population size, a specific number of points must to be reached within seven years.

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RISK ASSESSMENT

1. BASIC CONCEPTS OF RISK ANALYSIS AND IMPORT RISK

Risk has two components:

- the likelihood of an event occurring (e.g. a disease outbreak);
- the likely magnitude of the consequences (e.g. scale of an outbreak, costs of control/eradication, trade losses);

Risk analysis is a structured process designed to determine:

- what can go wrong;
- how likely it is to go wrong;
- how serious it would be if it went wrong;
- what can be done to reduce the likelihood and/or seriousness of it going wrong.

Risk analysis is a tool that uses data, information and opinions from various disciplines such as epidemiology, pathology, microbiology, virology and economics. It blends inductive and deductive reasoning and judgement, and it must be able to incorporate incomplete information. It can be qualitative or quantitative, and can address a wide variety of questions, both generally and specifically.

All risk analyses, by definition, are made up of four components: hazard identification, risk assessment, risk management and risk communication. These components will be described in detail in section 1.4 of this chapter.

Because transmissible spongiform encephalopathies (TSEs) can be spread through movement of animals and animal products, risk analysis can be used to evaluate the risks involved in international trade. This becomes important in:

- identifying and examining the risks of transferring the TSE agent between countries;
- developing conditions that allow trade to proceed "safely".
- fulfilling domestic responsibilities (e.g. biosecurity and quarantine legislation);
- fulfilling international responsibilities (e.g. the Sanitary and Phytosanitary Agreement of the World Trade Organization (WTO) and code standards of the World Organisation for Animal Health (OIE); detailed in section 1.4 of this chapter)

Risk analyses can also be used by countries initially to assess their own national risk of having a TSE. In addition, the assessments can be used to develop, compare and evaluate domestic strategies for control, eradication, surveillance and monitoring of TSEs.

Results can be used to guide TSE-related policy decisions through assessment of the significance of risks. Policy makers must consider many factors, including the assumptions made in the analysis and the perception of the risks, and then evaluate what risk will be considered acceptable and what policies to implement.

The principles of risk analysis are described generally in this section on import risk analysis. In sections 2 and 3 of this chapter, the concepts will be applied to assessment of BSE risk.

1.1. International trade concepts

The WTO Sanitary and Phytosanitary (SPS) Agreement defines the concept of free trade in animal and animal products. It specifies that, for WTO member countries, no sanitary measures (i.e. trade restrictions) should be in place unless there is a likelihood that a disease may enter and lead to unacceptable biological or economic consequences (WTO, 1994).

According to the SPS Agreement sanitary measures are implemented to protect human and/or animal health from the risks arising from diseases entering, establishing or spreading. They may include testing, inspection and/or certification programmes, and must only be applied to the extent necessary to protect human or animal health. They may not be applied arbitrarily, may not allow trade discrimination among countries where similar disease conditions exist, and may not be used to disguise trade restrictions. Although the measures of countries may differ, they may be accepted as equivalent if they achieve the same objective.

Because WTO recognizes the OIE as the relevant international organization responsible for developing international standards on animal health and zoonoses, sanitary measures should be based on OIE standards when they exist. Any measures exceeding OIE standards, however, must be supported by a risk assessment.

If scientific evidence is insufficient to conduct such a risk assessment (e.g. for a newly emerging disease), countries may adopt interim measures, which are based on the amount of information available. However, additional information needs to be sought and assessed in a reasonable amount of time.

1.2. Principles of import risk analysis

Import risk analyses are used to evaluate disease risks objectively and transparently, so that spread of human and animal disease agents can be avoided and import restrictions (sanitary measures) can be justified. The basic SPS risk assessment process includes the following steps:

- identify diseases to be prevented from entering, establishing, or spreading, and their associated potential biological and economic consequences;
- evaluate the likelihood of disease entry, establishment or spread, and the associated potential biological and economic consequences;
- evaluate the likelihood of disease entry, establishment or spread according to the measures that might be applied.

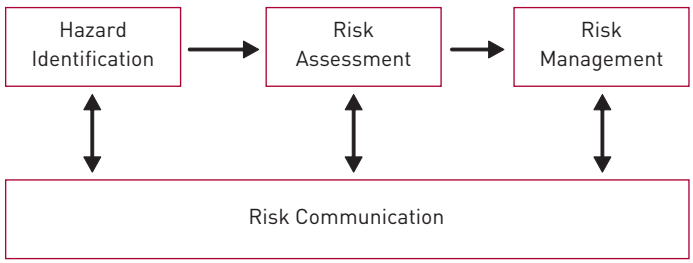
The analysis should:

- be based on the OIE framework (Figure 1) (OIE, 2005 a,b);
- fulfil the obligations of the SPS Agreement;
- be based on the best available scientific information;
- only consider disease-associated effects;
- only evaluate the likelihood of disease entry, establishment or spread and its potential consequences, not the possibility of these events;
- evaluate the risks according to the measures that might be applied;
- be transparent.

To conduct a risk analysis comprehensively, a team is generally required. The team should be made up of individuals skilled in epidemiology, critical thinking, domestic quarantine law, the SPS Agreement, statistics, probability modelling and economics. This likely includes epidemiologists (animal and human), government regulators, stat-

FIGURE 1

OIE risk analysis framework



Source: OIE (2005a)

isticians, mathematical modellers, economists, etc. Although all these individuals may not be available in many smaller countries, there are often opportunities for collaboration among countries with common concerns and risks.

An important concept in the risk analysis process is transparency. Transparency means comprehensive documentation of data, information, assumptions and uncertainties, methods, results, discussion and conclusions, and should be supported by a reasoned and logical discussion. All conclusions should be fully referenced. These requirements help to ensure:

- fairness and rationality;
- consistency in decision making;
- ease of understanding by all the interested parties;
- that assumptions are documented;
- that uncertainties are dealt with appropriately;
- that reasons for conclusions and recommendations are obvious;
- that interested parties are provided with clear reasons for the imposition of sanitary measures or refusal to import.

A risk analysis inevitably includes a degree of subjectivity due to personal opinions and perceptions of analysts, experts and decision makers. One way to promote objectivity is to ensure transparency. Another way is to have the analysis undergo a peer review. It must be recognized, however, that the peer review process requires a significant time commitment. As well, reviewers should be chosen strictly on the basis of their status as acknowledged authorities in their field, and given specific terms of reference for the review.

Finally, it is important to remember that even the best and most complete risk analysis does not provide definitive answers, but only provides information for those individuals who must then make decisions (e.g. quarantine officers, chief veterinary officers, politicians). The information often strongly suggests certain recommendations. However, decisions must often also consider other factors.

1.3. Defining the scope of the risk analysis

The first step in any risk analysis is specifically defining the scope in terms of the following variables:

- Commodity: a particular commodity (e.g. beef meat) or a category of commodities (e.g. live viral vaccines)
- Animal: a single animal species (e.g. cattle) or a group of similar species (e.g. ruminants)
- Disease: a particular disease (e.g. BSE) or a group of diseases with similar epidemiological characteristics (e.g. TSEs)
- Exporting country: a single country/bilateral (e.g. USA) or a group of countries/multilateral (e.g. European Union) or any country (generic)

Scientific names should be used to describe animal species and disease agents, e.g. domestic cow = *Bovis bovis*, porcine reproductive and respiratory syndrome (PRRS) virus = Order *Nidovirales* Family *Ateriviridae* Genus *Aterivirus*.

The nature, source and intended use of the commodity must be fully described (e.g. "chilled or frozen boneless beef meat from the UK for human consumption"). Also, the relevant methods of production, manufacturing, processing or testing that are normally applied (e.g. chilling, freezing, cooking, curing, irradiating) and any quality assurance programmes that may apply (e.g. HACCP programmes for the production of beef meat) and how they are verified should be described. The likely annual volume of trade may not be readily available, but should be at least estimated.

Finally, the purpose must be clearly stated, e.g. "to assess the likelihood of PRRS virus spreading or becoming established in New Zealand and its likely consequences as a result of importing chilled or frozen pig meat for human consumption from the USA". It should also be stated if recommendations are to be included.

1.4. OIE risk analysis framework

Because import risk analyses should be based on the OIE framework (Figure 1) (OIE, 2005 a,b), they must therefore include the aspects of risk communication, hazard identification, risk assessment and risk management, as described below (Figure 2).

Risk communication

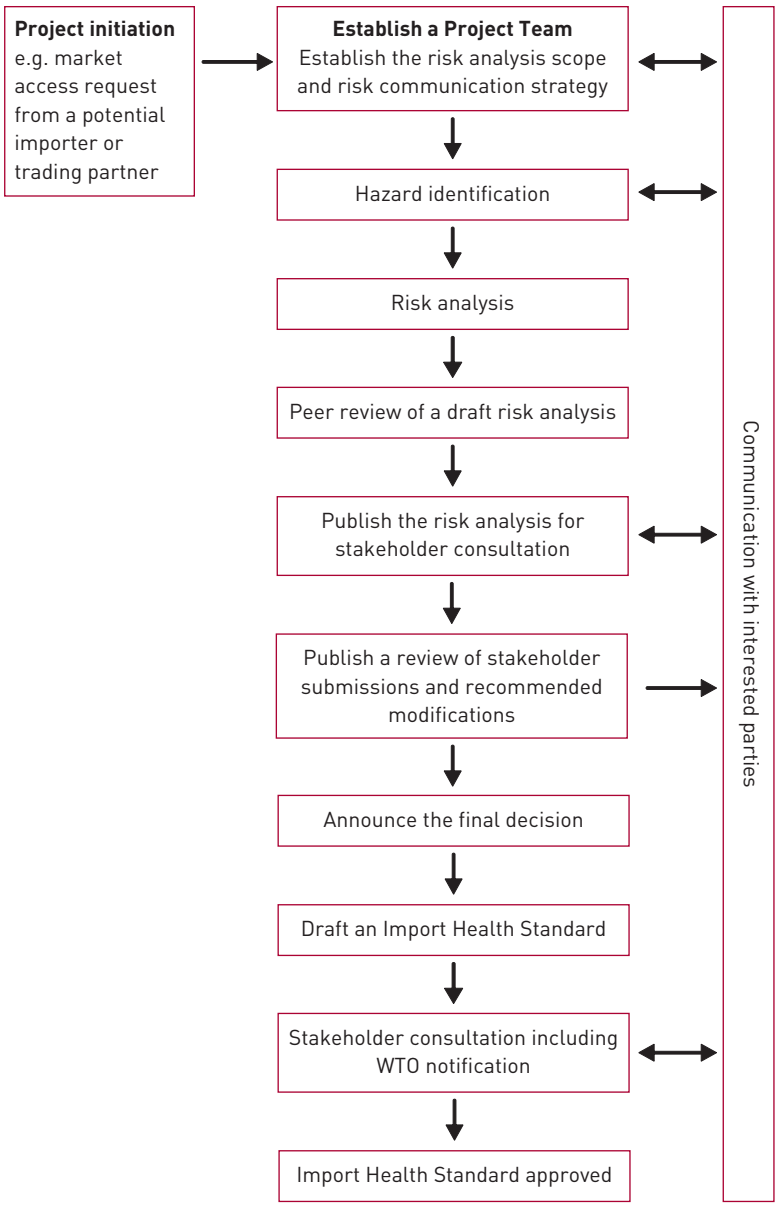
Risk communication is the process by which information and opinions regarding hazards and risks are gathered from potentially affected and interested parties (the stakeholders) during a risk analysis, and by which the results of the risk assessment and proposed risk management measures are communicated to the decision makers and all other interested parties in both the importing and exporting countries. Risk communication should be open, interactive, iterative, transparent and timely, and be targeted to the audience that will be receiving the information. Effective risk communication will lead to a better understanding of the rationale for a particular decision even if all differences and conflicts among stakeholders are not resolved.

A risk communication strategy to identify interested parties and determine the most appropriate means of communicating with them should be established at the beginning of each risk analysis. Communication should continue throughout the analysis.

Risk communicators describe an important component of risk, termed "outrage", which affects differences in perception of risk (Sandman, 2006). The public estimates a risk as high when outrage is high even though the actual hazard may be low (whereas

FIGURE 2

Flowchart of the import risk analysis process



Source: adapted from Murray (2001)

risk assessors, ignoring outrage, present the risk as low when the hazard is estimated to be low). "Outrage" is affected by the perception of risks, for example as being voluntary vs coerced, fairly vs unfairly distributed, natural vs artificial, non-memorable vs memorable, chronic vs catastrophic, knowable vs unknowable, individually controlled vs controlled by others, morally irrelevant vs morally relevant, and given less vs more media attention.

Hazard identification

Potential hazards must be clearly identified before they can be assessed or managed. Hazard identification is used first to identify pathogens that could potentially produce adverse biological, environmental or economic consequences.

As a first step, a comprehensive list of all the pathogens associated with the imported animal or commodity should be made, starting with the diseases notifiable to the OIE (OIE, 2005c) and including others as appropriate.

In order to be classified as a hazard and be subject to further consideration in a risk assessment, these pathogens must meet specific criteria. First, the pathogens must be known to affect the animals being imported. For imported commodities, the pathogen must affect the animals from which the commodity is derived and the commodity must be a potential vehicle for the pathogen.

It must be determined whether the pathogen is likely to be present in the exporting country. For this, the relevant zoning/regionalization parameters, surveillance and monitoring systems, and veterinary services in the exporting country must be evaluated. The pathogen must also be considered exotic to the importing country or region. Finally, the pathogen must either be under official control in the importing country or be shown to be less virulent than strains present in the exporting country.

Sources of information about the pathogens and the countries include the OIE, ProMED (ProMED Mail, 2006), direct liaison with the veterinary service in a particular country, veterinary literature or animal health status information published by individual countries.

A risk analysis may not be required either if hazards are not identified (i.e. the pathogens do not meet the above criteria, in which cases restrictions are not justified) or if measures recommended in the OIE Code (OIE, 2005d) are applied to each hazard.

Risk assessment

Risk assessment evaluates the likelihood of entry, establishment or spread of a potential hazard as well as its potential biological, environmental and economic consequences. Assessments should be based on the best available scientific information, be transparent and be reviewed as new information becomes available (e.g. as the volume of trade increases, if the disease status of a trading partner changes).

Risk can be evaluated by either qualitative and quantitative methods, or both. Qualitative risk assessment is a reasoned and logical discussion where likelihood is expressed in subjective terms (e.g. high, medium, low, negligible). A qualitative assessment is the most common type of risk assessment, particularly for routine decision making, and is appropriate in most situations. A quantitative risk assessment should always be preceded by a qualitative assessment.

Quantitative risk assessment requires computers, data spreadsheets, risk analysis software, and mathematical modelling skills and training. It involves developing a mathematical model to link various aspects of the epidemiology of a disease, where both the inputs and outputs (results) are expressed numerically. Quantitative assessments may be useful adjuncts to qualitative assessments in order to gain further insights, identify critical steps, assess the impact of uncertainty and compare management strategies. However, it is very important to recognize that although quantitative assessments generate a numerical result, this does not mean a quantitative assessment is more objective or that the results are more precise. In some cases, data are lacking and expert

opinion must be incorporated, adding subjectivity. However, a quantitative assessment may allow expert opinion to be modelled transparently.

Both qualitative and quantitative risk assessments inevitably include a degree of subjectivity. Two sources of subjectivity are the personal perceptions of risk analysts, experts and decision makers and the selection of an appropriate model structure (e.g. which pathways to include or exclude and the type of distributions chosen to represent a variable). Transparency and peer review help to ensure a reasonable level of objectivity.

Semi-quantitative methods are not necessarily more objective than strictly qualitative techniques because the quantitative aspects are not as critically applied and there may be a considerable lack of transparency. In semi-quantitative assessments, numbers may be arbitrarily applied to qualitative estimates and then may be arbitrarily combined, often giving a misleading impression of objectivity and perhaps leading to inconsistent outcomes. Semi-quantitative methods may be useful to prioritize risks in a non-contentious environment; however, they offer no advantages over a well researched, transparent and peer reviewed qualitative assessment.

Uncertainty and variability (this section excerpted from Murray, 2001) The way uncertainty has been described by risk analysts from various disciplines has led to a degree of confusion. Risk analysis is essentially a tool aimed at predicting the future. For example, we might want to predict the weight of a weaner pig chosen at random. We know from our own observations that there is a great deal of natural variation between individual pigs of this age. Such variability is a biological reality. While we might have a good "feel" for the range and what an average might be, it is only by weighing several pigs that we can begin to make some accurate predictions. As more data are collected, more knowledge is acquired, and we can describe the variation in the weights of weaner pigs with increasing certainty, enabling us to be increasingly confident of our predictions. If we weighed all pigs in the population we would have a perfect understanding of the average weight and how much variation exists and there would be no uncertainty. Obviously, this is impractical and we need to achieve a balance between acquiring perfect knowledge and obtaining reasonable estimates upon which we can base our predictions with a reasonable level of confidence. Uncertainty, then, may be thought of as a measure of the incompleteness of one's knowledge or information about an unknown quantity. It is important to remember that even with complete knowledge (that is, no uncertainty) variability still exists.

These ideas can be extended to import risk analysis where, for example, we want to predict the likelihood of an outbreak of foot-and-mouth disease (FMD) in "Country A" following the importation of goat cheese from "Country B". For an outbreak to occur, a complex chain of events needs to take place beginning with:

i) an outbreak of FMD in "Country B" that results in at least one infected goat shedding FMD virus in its milk;
ii) the virus surviving pasteurization, the cheese manufacturing process, storage and transportation to "Country A";
iii) a susceptible animal ingesting discarded cheese in "Country A", becoming infected and transmitting the virus to other animals

There may be some very good information on the survival of FMD virus in pasteurized milk, some limited information on the occurrence of FMD in "Country B" and virtually no information on the likelihood of susceptible animals ingesting cheese scraps in "Country A". A prediction in these circumstances will be based on information ranging from

poor to excellent. As a result, we could conclude that there is significant uncertainty in the estimates for the occurrence of FMD in "Country B" and the exposure of susceptible animals in "Country A". The impact of these uncertainties on the overall estimate of risk needs to be carefully considered. For instance, the impact is likely to be insignificant if pasteurization is predicted to kill FMD virus effectively. On the other hand, if pasteurization cannot be relied upon because the FMD virus is either heat tolerant or there is significant variability in its effectiveness, the impact of these uncertainties becomes much more important.

Where there is significant uncertainty in the estimated risk, a precautionary approach to managing risk may be adopted. However, the measures selected must nevertheless be based on a risk assessment that takes account of the available scientific information. In these circumstances the measures should be reviewed as soon as additional information becomes available and be consistent with other measures where equivalent uncertainties exist. It is not acceptable to conclude simply that, because there is significant uncertainty, measures will be based on a precautionary approach. The rationale for selecting measures must be made apparent.

Scenario trees Development of scenario trees can assist in identifying and describing biological pathways, which help to ensure a logical chain of events is assessed, as well as to facilitate effective risk communication. They assist in identifying data required and in communicating the model structure. Scenario trees are an essential component of quantitative risk analyses.

To develop a scenario tree (Figure 3), first the initiating event and the end point (outcome of interest) must be defined. The steps in the middle are then identified, and likelihood statements are assigned to each step.

Components of a risk assessment A risk assessment has four components: release assessment, exposure assessment, consequence assessment and risk estimation (Figure 4).

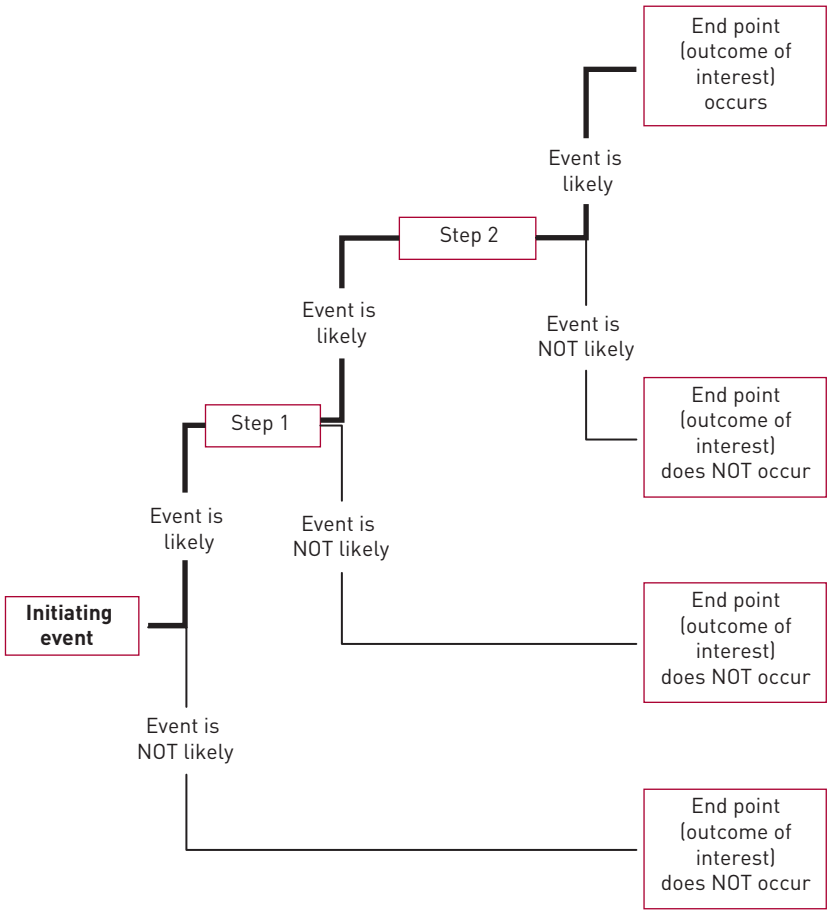
A release assessment describes the biological pathway(s) necessary for a commodity to become infected or contaminated in the exporting country, and estimates the likelihood of the commodity already being infected or contaminated when imported. It considers biological, country and commodity factors. A risk assessment may be concluded if the results of the release assessment show the likelihood of introducing the hazard is negligible.

An exposure assessment describes the biological pathway(s) necessary for animals and humans to be exposed to the hazard in the importing country, and estimates the likelihood of these exposure(s) occurring. As in the release assessment, the exposure assessment considers biological, country and commodity factors. The risk assessment may be concluded if the results of the exposure assessment show the likelihood of every exposure pathway is negligible.

A consequence assessment identifies what might happen, i.e. the potential biological, environmental and economic consequences associated with the hazard, and estimates the likelihood of these consequences occurring. It considers direct consequences (such as production and public health impacts) and indirect consequences (such as costs of control and trade losses), but should not consider non-disease associated consequences (such as the impact of the imported commodity on domestic industries through increased competition).

FIGURE 3

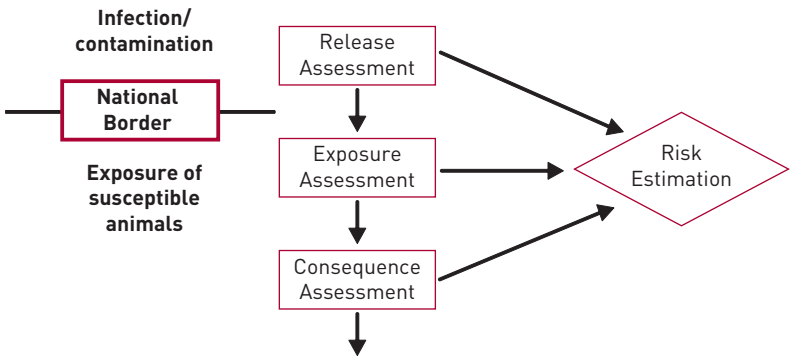
Scenario tree



Source: Murray, 2001.

FIGURE 4

Components of a risk assessment



A consequence assessment identifies potential "outbreak" scenarios, e.g. the disease either:

- does not spread within the exposed population;
- spreads within the exposed population, but is quickly identified and eradicated;
- establishes within the exposed population and spreads to other populations before eventually being eradicated;
- establishes within the exposed population, spreads to other populations and becomes endemic.

Then the likelihood of each "outbreak" scenario is estimated, and the likely magnitude of the consequences of each "outbreak" scenario at the farm/village, district, regional and national levels is also estimated. The risk assessment may be concluded if potential consequences are not identified, or the likelihood of every potential consequence is negligible.

The risk estimation summarizes the results from the release, exposure and consequence assessments to estimate the likelihood of the hazard entering, spreading or becoming established and leading to adverse consequences. It is not sufficient to conclude that there is a **possibility** of these events, but an evaluation of the **likelihood** of each of these must be undertaken, as given in the following scheme:

Release assessment (likelihood of entry)
Is the likelihood negligible that the commodity is carrying the hazard when it is imported?

- If the answer is YES, the risk estimate is classified as negligible.
- If the answer is NO, then conduct an exposure assessment.

Exposure assessment (likelihood of susceptible animals and/or humans becoming exposed)
Is the likelihood negligible of susceptible animals and/or humans being exposed via each and every exposure pathway?

- If the answer is YES, the risk estimate is classified as negligible.
- If the answer is NO, then conduct a consequence assessment.

Consequence assessment
Is the likelihood of each and every significant biological, environmental or economic consequence negligible?

- If the answer is YES, the risk is estimated to be negligible.
- If the answer is NO, then proceed to risk management.

Risk management

Risk management is the process of identifying, selecting and implementing sanitary measures to manage effectively the risks posed by the hazard(s) associated with the commodity under consideration. It is not acceptable to simply identify the range of measures that might reduce the risks; there must be a reasoned relationship between the measures chosen and the risk assessment so that the results of the risk assessment support the measure(s). Measures recommended in the OIE code (OIE, 2005d) are the international standard, but where OIE recommendations do not exist or the

proposed measures are more stringent than the OIE, measures must be supported by a risk analysis in order to fulfil WTO SPS obligations (WTO, 1994).

Risk management is comprised of four steps: risk evaluation, option evaluation, implementation, and monitoring and review.

Risk evaluation refers to the assessment process, and implementation of sanitary measures can only be justified if the risk estimate is greater than negligible. In option evaluation, different sanitary measures are identified, evaluated and selected to manage the risks effectively. All measures considered must be related to the outcome of the risk assessment, because the WTO SPS Agreement requires that the likelihood of the entry, establishment or spread of a hazard must be evaluated according to the measures that might be applied. The following guidelines must be ensured when selecting option(s):

- the option(s) are based on scientific principles;
- that the OIE Code's sanitary measures are considered. If there is a scientific justification that these measures do not effectively manage the risks, measures that result in a higher level of protection may be applied. Alternatively, measures less stringent than those recommended may be applied where there is sufficient justification that the risks can be effectively managed using those measures;
- the options are applied only to the extent necessary to protect human or animal life or health;
- negative trade effects are minimized;
- the options are not applied arbitrarily;
- the options do not result in discrimination between exporting countries where similar conditions exist;
- the options are feasible by considering the technical, operational and economic factors affecting their implementation.

Measures must then be effectively implemented, as well as audited (monitored) and reviewed through inspections and /or random checks to ensure that they are achieving the intended results.

2. RISK ASSESSMENT FOR BSE IN COUNTRIES

For many years, BSE was considered a problem exclusively of the UK. Even after the detection of BSE cases in countries outside the UK, the risk of having BSE was categorically denied by many other countries in Europe and throughout the world.

An unfortunate pattern can be seen in most countries, relative to BSE. Measures are often only implemented after the first BSE case is detected or, if measures are already in place, only then are they appropriately implemented and controlled and additional measures taken. This often significantly improves the situation but it does not eliminate the risk immediately, as cases will continue to be reported until all animals born before the national system became stable (i.e. able to avoid recycling and amplification of the BSE agent) have passed through their lifespan. The concept of stability is further described in section 2.3 of this chapter.

In a joint WHO/FAO/OIE Technical Consultation on BSE in June 2001, it was stated that materials potentially infected with BSE have been distributed throughout the world (OIE, 2001). At this consultation, the OIE recommendation on BSE risk was supported through the conclusion that all countries should evaluate their potential exposure through a systematic assessment of risk.

2.1. BSE status of countries according to the OIE (excerpted in part from OIE, 2005d)

Before 2005, the OIE categorized countries into the following five groups:

BSE free country or zone
BSE provisionally free country or zone
Country or zone with a minimal BSE risk
Country or zone with a moderate BSE risk
Country or zone with a high BSE risk

In May 2005, a new BSE chapter was adopted reducing the number of categories to three:

Country, zone or compartment with a negligible BSE risk
Country, zone or compartment with a controlled BSE risk
Country, zone or compartment with an undetermined BSE risk

In addition to an assessment of BSE risk, the OIE status categorization for BSE includes evaluation of some of the measures in place in the country. According to the OIE Code, factors evaluated in the establishment of BSE status should include:

- the outcome of a risk assessment identifying all potential factors for BSE occurrence and their historic perspective;
- ongoing awareness programmes for veterinarians, farmers and workers involved in transportation, marketing and slaughter of cattle to encourage reporting of all cattle showing clinical signs consistent with BSE in target subpopulations as defined in the OIE Code Appendix on BSE surveillance (OIE, 2005 e,f);
- compulsory notification and investigation of all cattle showing clinical signs consistent with BSE;
- examination in an approved laboratory of brain or other tissues collected within the framework of the surveillance and monitoring system.

When the risk assessment (which takes into account the surveillance referred to in the release and exposure assessments above) demonstrates non-negligible risk, the country should conduct "Type A" surveillance in accordance with the OIE Code (OIE, 2005e). When the risk assessment demonstrates negligible risk, the country should conduct "Type B" surveillance (see the "Surveillance for BSE" chapter in this course manual).

For example, the cattle population of a country, zone or compartment may be considered at negligible risk when a risk assessment has been conducted and it has been demonstrated that appropriate generic measures have been taken for a relevant period of time to manage all risk identified.

Currently, Australia, Argentina, New Zealand and Uruguay are classified according to the pre-2005 system as "BSE free" and Chile, Iceland, Paraguay and Singapore are categorized as "BSE provisionally free". Countries applying to the OIE for designation after the end of 2006 will be re-assessed based on the 2006 categorization system (OIE, 2005g).

It is clear that, according to the above definitions, the BSE status of a country (or zone or compartment, as defined by OIE) can only be determined on the basis of the outcome of a national BSE risk assessment. The OIE Code lists the following potential factors that must considered in such an assessment:

Release assessment:

- the presence or absence of animal TSE[1] agents in the country;
- MBM or greaves manufactured from the indigenous ruminant population;
- imported MBM or greaves, live animals, animal feed and feed ingredients;
- imported products of ruminant origin for human consumption (which may have contained SRM and may have been fed to cattle) or for *in vivo* use in cattle.

Relevant surveillance and other epidemiological investigations should be taken into account in carrying out the assessment.

Exposure assessment:

- domestic recycling and amplification of the BSE agent through consumption by cattle of MBM or greaves of ruminant origin, or other feed or feed ingredients contaminated with these;
- the use of ruminant carcasses (including from fallen stock), by-products and slaughterhouse waste, the parameters of the rendering processes and the methods of animal feed manufacture;
- the feeding of ruminants with MBM and greaves derived from ruminants, including measures to prevent cross contamination of animal feed;
- the level of surveillance for BSE conducted on the cattle population to that time and the results of that surveillance.

2.2. Geographical BSE risk assessment (text summarized and adapted from SSC references, 2000-2003)

On the basis of the risk assessment criteria set by the OIE, the Scientific Steering Committee of the European Commission (SSC) has carried out a geographical BSE risk assessment (GBR) in a number of countries. The GBR is a qualitative indicator of the likelihood of the presence of one or more cattle being infected with BSE, at a given point in time, in a country. Where presence of BSE is confirmed, the GBR gives an indication of the level of infection. The risk of human exposure within the country is not an output of the GBR, nor are other TSEs considered.

The GBR is based on qualitative risk assessment methodology, which uses information on risk factors that contribute either to the potential for introduction of BSE into a country or region or the opportunity for recycling of the BSE agent in a country or region. The following questions are answered through the GBR:

- Was the agent introduced into the country by import of potentially infected cattle or feed (MBM), and if so to what extent?
- What would happen if the agent were introduced into the animal production system, i.e. would it be amplified or eliminated?

Assumptions made

In the GBR, contaminated feed is considered as the only possible route of infection because epidemiological research has clearly shown that the origin and maintenance of the BSE epidemic in the UK were directly linked to the consumption of infected MBM

[1] In 2006, the OIE BSE chapter was modified to include only BSE (and not all TSEs) in the release assessment.

by cattle. Similarly, for all countries other than the UK, the only possible initial source of BSE considered is the import of contaminated feed or infected animals. Other assumptions and considerations include:

- Potential domestic initial sources of BSE (e.g. spontaneous occurrence of BSE or other TSEs in the country) are not considered, because these sources have not been scientifically confirmed and no basis exists for assessing their risk potential.
- The possible impact of maternal transmission is not considered because of the qualitative nature of the method, the relatively lesser importance of this factor in comparison to feed, and the lack of scientific confirmation of its existence.
- No other route of transmission is considered. While the existence of a third mode of transmission (after feed and vertical transmission) of BSE has been postulated and cannot be excluded, to date there is no scientific evidence to establish its significance.
- Blood, semen and embryos are not seen to be effective transmission vectors. Accordingly, blood meal is also not considered to be a risk.

BSE risk concept of the GBR

Basic knowledge regarding the epidemiology and amplification of BSE must therefore be known prior to the initiation of the GBR (or any risk assessment) in a country. Also, the risk of BSE in other countries becomes important when the risks within the country are evaluated.

As stated above, the GBR considers that the BSE agent is introduced into a country via infected cattle or MBM ("external challenge"). The outbreak may then be propagated due to amplification of the agent through domestic recycling of the products. Figure 5 shows the amplification cycle and external challenges, and forms the basic framework for understanding the GBR.

In some countries, when animals are slaughtered, up to 50% of their tissues are not eaten by humans and so enter the rendering system. At the rendering plant, these tissues are processed into many different by-products, primarily MBM. Other by-products may include tallow, greaves, meat meal and bone meal.

Depending on the amount of infectivity present in the tissues to be rendered as well as the rendering processing parameters, the resultant by-products may contain infective BSE agent. When these tissues are fed to cattle, the disease is transmitted and the cycle starts again. The ability of the measures in place to prevent this amplification is called the stability of the internal system. The more stable the internal system, the smaller the "internal challenge", and the lower the risk of domestic exposure.

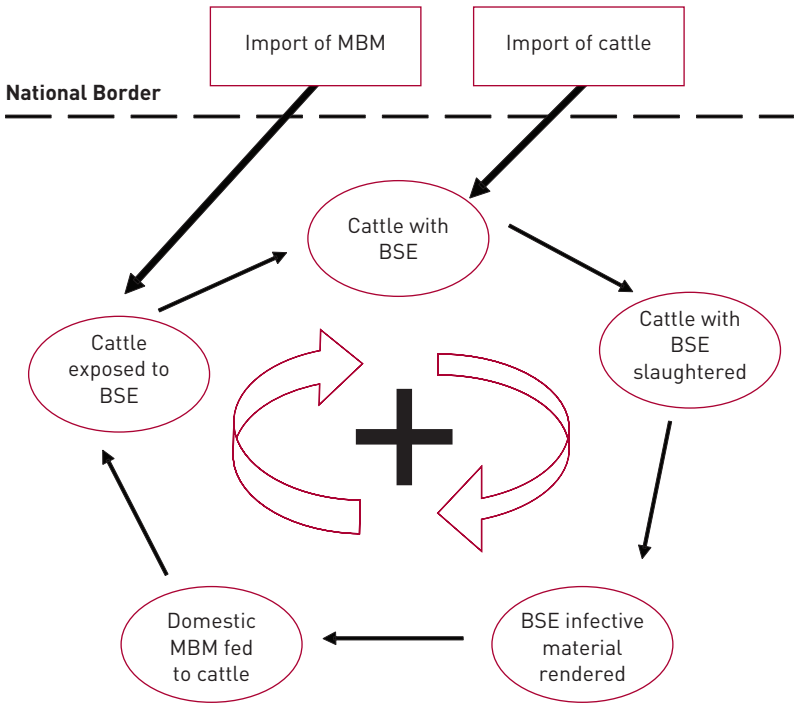
This amplification may remain silent with no reports of clinical BSE cases for many years. By the time a first case is reported, the agent is likely widespread in the cattle population and many animals are likely incubating the disease.

Data used

The GBR assessment is mainly based on comprehensive national information provided by the competent authorities within the assessed countries, and it is assumed that the information provided is correct. So far, the available data have generally been adequate to carry out a qualitative assessment of the GBR, but considerable differences in the availability and quality of data remain of concern.

FIGURE 5

External challenge and domestic amplification cycle of BSE



Source: SSC (2000b)

Limitations in data quality and completeness are still observed despite the use of all available additional sources of information, such as reports from the missions of the Veterinary Inspection Services of the Food and Veterinary Office of the European Commission and international trade statistics. To complement insufficient information, worst case assumptions are generally used as long as they are regarded as reasonable. These "reasonable worst case assumptions" are used whenever extrapolation, interpolation or similar approaches are not possible. For example, when conflicting data from equally reliable sources are available, the worse of the two is used. In another example, a shortcoming in many GBR dossiers is insufficient information on compliance with the preventive measures put in place by the competent national authorities. Compliance, therefore, is often assumed to be weak.

Another problem with regard to data comes from the slow development of the BSE epidemic due the long incubation period of the disease. This implies that exports could already have posed external challenges to importing countries, even when the materials were exported many years before the first BSE case was recognized in the exporting country. It also implies that data for up to the past 20 years must be included in these risk assessments.

Risk of introduction of the BSE agent into a country

Imports are first examined because, as stated above, the GBR assumes that the BSE

agent could only be introduced into a country by imports of BSE-infected cattle and the import of BSE-contaminated MBM. Also, the GBR assumes that the spread of BSE was initially through the export of live cattle or MBM from the UK.

As cattle born in the mid-1970s in the UK were potentially affected, imports dating back to this period are included in the risk assessment investigation if data are available. Also, since 1990, other countries in addition to the UK have reported BSE; therefore imports from these countries must also be considered as risky, unless adequate safeguards had been implemented. The risk of introduction of the BSE agent into a country is evaluated with reference not only to a country's own import statistics but also to the export statistics of the UK and other at-risk countries. This procedure allows an initial analysis to be performed to determine whether any potentially infectious material ("challenge") might have entered a country at any time.

The following points must be considered:

- The assumed external challenge resulting from imports from the UK during the peak of the BSE epidemic in the UK is taken as the point of reference.
- The challenge resulting from imports during other periods and from other BSE risk countries is assessed in relation to this baseline.
- BSE risk countries are all countries that are already assessed as GBR III or IV (i.e. cases are present or likely to be present in the country; GRB risk categories are defined below) or which have notified at least one domestic BSE case.
- Challenge levels are defined as a function of imports from the UK at the time when the risk of BSE contamination was regarded to be the highest.
- These points are used for live cattle imports from the UK:
  - The period from 1988 to 1993 was chosen as the highest risk period for live cattle imports because it covers roughly one incubation period before the peak in BSE incidence (1992/93), and because data on case incidence in UK birth cohorts show that risk was already high in 1985/86 and 1986/87. Breeding cattle that normally reach an age of five or more years in the importing country are normally exported at an age of around 24 months (e.g. as pregnant heifers). Keeping this range, therefore, appeared to be justified. Additionally, though it might be possible that the risk carried by imports in 1987 was slightly underestimated by using this range, it is maintained to ensure comparability of GBR results.
  - It is assumed that during this period the average BSE prevalence of infected animals in exported cattle was around 5%, i.e. of 20 animals, one could have been infected. The value of 5% is used because at normal survival probabilities only one in five calves reaches an age of five years. As the case incidence in the critical birth cohorts was probably about 1%, at least 5% of the calves in that birth cohort must have been infected.
  - A moderate external challenge is then defined as a challenge resulting from import of between 20 and 100 live cattle from the UK in the period 1988-1993. A moderate external challenge would therefore have made it likely that at least one infected animal was imported. The other levels of external challenge were established with the intention of indicating significant differences in the external challenge. The resulting scale mainly serves as a tool to ensure consistent judgment of the risk resulting from imports, rather than providing an objective measure of the level of risk.

TABLE 1. Definition of external BSE challenge levels according to the geographical BSE risk assessment

	Level of external challenge resulting from import of live cattle or MBM from the UK or other BSE-risk countries					
Level of external challenge	**Live cattle from the UK 1988-1993 (no. of heads) imports**	**UK**	**Other countries**	**MBM* (tons) import from the UK 1986-1990**	**UK**	**Other countries**
Extremely high	≥10 000	UK-imports before 88 and 94-97: *10; after 97: *100	Imports from other countries with a BSE risk: R1*1 000, R2* 100	≥10 000	UK-imports before 86 and 91-93: *10; after 93 *100	Imports from other countries with a BSE risk: R1*100, R2* 10
Very high	1 000 – <10 000			1 000 – <10 000		
High	100 – <1 000			100 – <1 000		
Moderate	20 – <100			20 – <100		
Low	10 – <20			10 – <20		
Very low	5 – <10			5 – <10		
Negligible	0 – <5			0 – <5		

*MBM refers to MBM, MMBM, BM or Greaves but not to composite feed that colud contain it.
Source: SSC (2003a)

- These points are used for import of MBM from the UK:
  - The period of highest risk that MBM imported from the UK was contaminated with BSE was set to 1986-1990. The risk peaked in 1988 when "specified bovine offal" (SBO, more or less synonymous to SRM) was excluded from the human food chain but was still included in rendering and feed production in the UK. The risk was later reduced with the exclusion of SBO from rendering, and therefore feed, at the end of 1989. However, as the effective implementation of that ban was delayed for some time, the risk of MBM imports is considered to only have declined since 1990, and then further in 1993, when the SBO ban had been more effectively implemented.

Table 1 indicates that the import of one ton of MBM is considered to pose the same challenge as the import of one live animal. It is unlikely to be higher because the probability that more than one infected animal was included in the processing of each ton of MBM is very low, even during the epidemic in the UK. It is unlikely to be lower because rendering can only reduce BSE infectivity not eliminate it.

Given the much lower incidences in BSE risk countries other than the UK, or in the UK in other periods, it is assumed that the risk carried by live cattle exported from other BSE risk countries or from the UK in other periods is much lower. To reach the same level of risk, therefore, either 100 times (R2) or 1 000 times (R1) more live cattle must be imported than from the UK between 1988 and 1993. For MBM, 10 (R2) or 100 (R1) times more MBM must be imported than from the UK between 1986 and 1990 to represent a similar external challenge.

Available import/export statistics do not allow clear differentiation of the various

forms of processed animal proteins that are imported. They also do not differentiate between the types of products or between species from which products are produced. The term "MBM" is therefore used in the context of the GBR as a term referring to meat and bone meal as such, as well as meat meal, bone meal or greaves made from meat and offal. It is also synonymous to "flours, meal, pellets made from meat or offal not fit for human consumption; greaves" (EUROSTAT, custom code 230110) in the import/export context. As long as no evidence is provided to the contrary, in the GBR it is assumed that "MBM" is at least partly made from ruminant material.

The external challenge that enters the BSE/cattle system in the importing country associated with imported cattle or MBM also depends on what is done with the cattle after import. The key question is whether the BSE infectivity that could have been carried by these imports did enter the internal BSE/cattle amplification system, as described in Figure 5, or not.

Infectivity imported via live cattle only enters the BSE/cattle system of the importing country if these animals die or are slaughtered and rendered into MBM that could reach cattle via the feed chain. If rendering of imported cattle is avoided, the external challenge is effectively managed and there is no risk that domestic infections could result from imported infected cattle. Another related factor is age at slaughter; imported animals slaughtered young (e.g. < 24 months of age) may only carry a fraction of the infectivity found in a clinical case. Imported calves that are immediately slaughtered or fattened and slaughtered before two years of age therefore represent a negligible or very low external challenge.

Infectivity imported via MBM enters the BSE/cattle system when it is integrated into feed that could reach cattle, be it intentionally or via cross contamination. The latter is possible during transport, in feed mills and on farms, and is difficult to control although the ability to avoid cross contamination is essential for the stability of a BSE/cattle system (see below). If imported MBM is reliably only used for non-ruminants, e.g. in pet food, it would not represent an external challenge.

In principle, it cannot be excluded that, under certain circumstances, even an importation of infectious material entering an unstable BSE/cattle system may have no impact. This may happen if it is unintentionally eliminated, e.g. if contaminated imported MBM is all fed to pigs or poultry and does not reach cattle, even if during that period feeding MBM to cattle was legally possible and generally done. However, the principles of risk assessments require that reasonable worst case scenarios are used whenever the contrary cannot be demonstrated. In the GBR, therefore, it is assumed that any BSE exposure within an unstable system would result in domestic cattle being infected with BSE.

Risk of propagating the BSE agent in a country

When risky imports are found to have occurred, the stability of the system in the country, i.e. the system's ability to minimize the exposure of cattle, is then investigated. This primarily relates to the use made of MBM, the use made of SRM, the rendering conditions and the feeding systems. The factors assumed to be able to prevent the amplification of BSE infectivity in the system are the following:

SRM: What happens with SRM after slaughter is evaluated. Some material, such as brain and spinal cord, may contain particularly high concentrations of the BSE agent. In BSE-infected cattle that approach the end of the incubation period, between 95 and

99% of the infectivity is concentrated in the SRM. Removing these from the feed cycle reduces the amount of infectivity by up to two logs. However, small breaches of this measure may affect this reduction significantly. If these materials are used for further processing to animal feed, there is a high risk of amplification of the BSE agent.

The definition of SRM in a country should not only include slaughterhouse waste (by-products) but also fallen stock or cattle dead on arrival or condemned in ante mortem inspection. If BSE is present in a cattle population, the prevalence of infected cattle approaching the end of the BSE incubation period is significantly higher in the subpopulation of fallen stock and emergency slaughter than in regular slaughter (see the "Surveillance for BSE" chapter of this course manual). Hence, considering these carcasses to be SRM and excluding them from the feed chain reduces the risk of recycling the BSE agent. As with other SRM, however, even occasional rendering of fallen stock could pose a risk because, in this case, the animal could have been approaching the end of the incubation period and a high concentration of BSE infectivity would then enter the rendering process and later the feed chain.

Therefore, if an SRM ban, including risk carcasses, is put in place at an early stage, this increases the stability of the system. The impact of SRM removal is assessed by the GBR as follows:

- SRM removal is considered to be "OK" if SRM are reliably removed from imported and domestic cattle and fallen stock is also reliably excluded from rendering into feed.
- SRM removal is considered to be "reasonably OK" if SRM from imported and domestic cattle and fallen stock is normally not rendered but the efficiency and/or implementation of this is not well documented.
- SRM removal is considered to be "not OK" if it has to be assumed that SRM and/or fallen stock are normally rendered into feed.

Rendering: what happens with animal by-products and cadavers is evaluated. "Rendering" refers to the processing of animal remains or entire animals into processed animal proteins and related by-products such as MBM, bone meal, meat meal, greaves, and tallow.

The BSE agent is extremely resistant to most physical and chemical inactivation methods. It has been scientifically proven that even treatment of infected material at 133 °C with 3 bars of pressure (of steam in the airless system) for 20 minutes does not completely inactivate the agent if the initial infective load was high, although this process is able to reduce BSE infectivity significantly (OIE, 2005h). It is also crucial that the material to be rendered has a maximum particle size of 5 cm and a moisture content of about 60%. Recent experiments have shown that residual infectivity can be present also when very high temperatures were used.

Therefore, if the rendering process is appropriate, or there is no rendering industry and the animal by-products and cadavers are buried or incinerated, this increases the stability of the system. The impact of rendering is assessed by the GBR as follows:

- If all rendering plants that process ruminant materials reliably operate at the 133 °C/20 min/3 bar standard, the GBR assumes, for all practical purposes, that any infectivity would be reduced by a factor of at least 1 000. Under this condition rendering is considered as "OK". Also, if no rendering takes place, rendering is considered to be "OK".

- If only rendering plants that process high-risk material (i.e. SRM, fallen stock, condemned materials and animals condemned in ante mortem inspection) reliably operate at the above standard, rendering is considered to be "reasonably OK".
- If high and low risk material is rendered under substandard conditions, or if the evidence provided for the reliable application of the standard conditions is insufficient, rendering is considered to be "not OK", even if individual rendering plants might comply with the standard.

Feeding: whether feeding of MBM to ruminants occurs is evaluated. In many countries, animals have traditionally never been fed MBM. But assumptions on this subject have to be looked at critically, as BSE cases have been diagnosed in many countries where it was not a customary practice to feed MBM to cattle.

It has to be considered that, even when no MBM has been fed to ruminants, the exposure risk may still remain because of cross contamination and cross feeding. If MBM is banned for ruminant feed but allowed in feed for pigs and poultry, and these feeds were manufactured in the same mills and transported by the same vehicles as ruminant feeds, and if inappropriate feeding practices cannot be ruled out on farms, the risk still remains. The risk is lower than in countries that have not prohibited feeding MBM to ruminants but it is still significant. This is demonstrated by the large numbers of reported BSE cases that were born after the implementation of feed bans (BAB cases) and other measures.

If no contamination occurred and feeding MBM to cattle would be completely avoided, the only efficient BSE transmission route known would be blocked and no more cases should be seen. The impact of MBM bans and feeding is assessed by the GBR as follows:

- Feeding is considered to be "OK" if it is highly unlikely that any cattle received mammalian MBM (MMBM) at any time in their lives. This assessment has to take into account deliberate feeding of mammalian MBM to cattle as well as accidental administration, e.g. due to cross contamination of MBM-free cattle feed with (traces of) MMBM. Feeding is considered to be "OK" if, for example, a total feed ban together with controls by feed sampling are implemented.
- If deliberate feeding of MMBM to cattle is unlikely, e.g. because of a feed ban, but cross contamination cannot be excluded (e.g. no controls by sampling in place), feeding is considered to be "reasonably OK".
- If deliberate feeding is likely to occur, even only at certain periods of the year or of the life of certain cattle, or if cross contamination of cattle feed with MMBM is likely, feeding is then considered to be "not OK".

Therefore, the BSE/cattle system in a country is considered to be "optimally stable" if recycling of the agent is practically excluded. This requires that all three main stability factors (SRM removal, rendering and feeding) are in place, well controlled, implemented and audited, i.e. are assessed as "OK". Ideally such a system would also integrate a highly effective BSE surveillance system, and control of all imported live cattle and feeds would help to prevent a potential external challenge, i.e. imported BSE-infected cattle or BSE-contaminated MBM from entering the BSE/cattle system.

The different combinations of the three main stability factors result in different levels of stability, as shown in Table 2. In a neutrally-stable system, the recycling rate of the BSE agent would just be high enough to maintain the total level of infectivity once intro-

TABLE 2. BSE stability levels, according to the GBR assessment

Stability	Level	Effect on BSE infectivity	Most important stability factors (SRM removal, rendering, feeding)
Stable The system will reduce BSE infectivity	Optimally stable[1]	Very fast	All 3 "OK".
	Very stable	Fast	2 "OK", one "reasonably OK".
	Stable	Slow	2 "OK" and 1 "not OK" or 1 "OK" and 2 "reasonably OK".
Neutrally stable		Constant	3 "reasonably OK" or 1 "OK" and 1 "reasonably OK" and 1 or 2 "not OK".
Unstable The system will amplify BSE infectivity	Unstable	Slow	2 "reasonably OK", 1 "not OK".
	Very unstable	Fast	1 "reasonably OK", 2 "not OK".
	Extremely unstable	Very fast	All three "not OK".

[1] "Optimally" should be understood as "as stable as possible according to current knowledge".
Source: SSC (2003a).

duced into the system, i.e. the number of new infections in the cattle population is more or less equal to the number of incubating cattle leaving the system.

It should be understood that Table 2 is not meant to provide a semi-quantitative assessment of stability but is rather meant to be guidance for ensuring consistent interpretation of comparable data. This should ensure that similar situations are judged similarly.

GBR results and status of countries

On the basis of this evaluation, countries assessed are categorized into four GBR levels:

- GBR I: highly unlikely that any BSE infected cattle are present.
- GBR II: the presence of any BSE infected cattle is unlikely, but it cannot be excluded.
- GBR III: the presence of BSE infected cattle is likely or, if cases were already discovered, the number of BSE cases identified during the last 12 months is below 100 per million adult cattle.
- GBR IV: more than 100 BSE cases per million adult cattle were discovered in the last 12 months.

As of June 2006, 68 countries have been assessed (Table 3). In some cases, the countries have conducted internal BSE risk assessments and submitted them to the SSC for review according to GBR guidelines.

Some countries have already been assessed for a second time. In certain cases the result of the second assessment has deviated from the first one. In some countries initially assessed as GBR II, a BSE domestic case was detected due to enhanced surveillance (e.g. Austria, Canada, Finland, Slovenia). The reason for this deviation was how the external challenge was assessed. Before 2002, only imports from countries with reported cases were taken into account. Since 2002, also imports from GBR III countries with no reported cases are taken into account.

Often, before the detection of the first cases in many "BSE-free" countries, the GBR showed that a risk could be present. Since 2000, 11 countries have detected a first BSE case. Of these, six had previously been classified as GBR III (Czech Republic, Ger-

TABLE 3. Results of the GBR assessments through 2005

GBR I: Highly unlikely	Argentina (I), Australia (I), Iceland, New Caledonia, New Zealand (I), Panama (I), Paraguay (I), Singapore, Uruguay (I), Vanuatu
GBR II: Unlikely but not excluded	Botswana (I), Brazil (I), Colombia, Costa Rica (II), El Salvador (I), India, Kenya, Mauritius, Namibia (I), Nicaragua (I), Nigeria, Norway (I), Pakistan, Sweden (II). Swaziland (I)
GBR III: Likely but not confirmed or confirmed at a lower level	Albania, Andorra, Austria, Belarus, Belgium, Bulgaria, Chile (I), Croatia, Denmark, Canada (II), Cyprus, Czech Republic, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Latvia, Lithuania, Luxembourg, Malta, Mexico, Poland, The Netherlands, Romania, San Marino, Slovak Republic, Slovenia, South Africa, Spain, Switzerland, Turkey, USA (II)
GBR IV: Confirmed at a higher level	Portugal, United Kingdom

Note: Countries re-assessed as of 2004 have former GBR level in brackets

many, Italy, Poland, Slovakia, Spain). Moreover, Israel detected a first case before the assessment was finalized, while the draft report already indicated GBR III. Similarly, in Denmark, the first BSE case was detected shortly before the finalization of the SSC Opinion of 6 July 2000, which already indicated the classification of Denmark into GBR level III.

The success of the GBR shows that a scientifically-based, comprehensive risk assessment must be carried out to estimate the extent of the BSE problem in countries. Decisions on preventive measures should be based on a detailed risk assessment and countries should not wait until the first case occurs before taking preventive measures. There remain many countries with an unknown BSE risk. In order to minimize import risks from these countries, further risk assessments are needed to evaluate the real BSE distribution worldwide.

New research findings and experiences made have been followed by modifications of the GBR method (SSC, 2002 a,b,c). Especially after detecting BSE cases outside Europe, a further revision of the method is now necessary and will be carried out in the near future.

3. IMPORT RISK ASSESSMENT FOR BSE

It is clear that the most efficient way to prevent the introduction of BSE, or any new disease, into a country is to control the import of certain products from countries at risk. As stated in section 1.1 of this chapter, the SPS Agreement encourages WTO Members to base their measures on international standards, guidelines and recommendations, i.e. the *Terrestrial Animal Health Code* of the OIE in the case of animal health and zoonoses.

Import risk assessment for BSE follows the same basic steps as all other types of import assessments, as described in section 2 of this chapter.

3.1. OIE recommendations regarding import of BSE risk products

The aim of the OIE *Terrestrial Animal Health Code* is to assure the sanitary safety of international trade in terrestrial animals and animal products. This is achieved through the detailing of health measures to be used by the veterinary authorities of importing and exporting countries to avoid the transfer of agents pathogenic for animals or humans, while avoiding unjustified sanitary barriers.

As new or updated BSE information becomes available, the BSE chapter in the OIE Code may be amended. To obtain the most current recommendations, the online version of the code should always be consulted (http://www.oie.int/eng/normes/mcode/en_sommaire.htm). In the following paragraphs, some of the main TSE import recommendations of the 2005 Code are summarized (OIE 2005d):

- Regardless of the BSE status of the exporting country, the trade of some commodities, such as milk and milk products, semen and embryos, hides, skins, protein free tallow, and dicalcium phosphate, as well as gelatine or collagen prepared exclusively from hides and skins, should be authorized without restriction. Since May 2005, also deboned skeletal meat from cattle of 30 months or less and certain blood and blood products are included in this list (with some additional conditions such as the ban of certain stunning techniques, ante mortem and post mortem inspection and no contamination with SRM and/or MRM).
- Ruminant-derived MBM or commodities containing such products from countries with controlled or undetermined BSE risk should not be traded.
- For the inactivation of TSE agents during the production of MBM containing ruminant proteins, the following procedure should be used: the raw material should be reduced to a maximum particle size of 50 mm before heating; the raw material should be heated under saturated steam conditions to a temperature of not less than 133 °C for a minimum of 20 minutes at an absolute pressure of 3 bar (OIE, 2005b).
- The recommendations concerning imports of cattle are adapted according to the risk status of the exporting country. The main recommendations for cattle selected for export from countries with BSE risk are that they are sufficiently identified and are not the offspring of suspected cases. In addition, they have to be born after the date on which the ban on the feeding of ruminants with MBM derived from ruminants was effectively enforced. For exporting countries with negligible risk there are no conditions recommended.
- For the import of meat and meat products from cattle over 30 months it is recommended that, for exporting countries with BSE risk, the feeding of ruminants with MBM derived from ruminants has been banned and the ban has been effectively enforced. Furthermore, an ante mortem inspection is recommended. Products including or contaminated with SRM and/or MRM must be excluded from importation, except from countries with negligible BSE risk. The list of SRM varies according to the BSE status.

3.2. Import risk assessment considerations

If a country wishes to implement measures that are stricter than those of the OIE, they must prove on scientific grounds that there is a reason for doing so, i.e. stricter measures must be based on an import risk assessment.

Thus the principal aim of import risk assessment is to provide importing countries

with an objective and defensible assessment of the BSE risks associated with the importation of cattle and cattle products. The assessments can be qualitative or quantitative and may address individual risk or societal risk. The assessment should be based on the following criteria:

- The assessment should be transparent, so that the exporting country is provided with clear reasons for the imposition of any import conditions or refusal to import.
- There should be a reasoned relationship between the measures chosen and the risk assessment, so that the results of the risk assessment support the measures.
- Where there is significant uncertainty, a precautionary approach may be adopted. However, the measures selected must nevertheless be based on risk assessment that takes account of the available scientific information. In these circumstances the measures should be reviewed as soon as additional information becomes available. It is not acceptable simply to conclude that, because there is significant uncertainty, measures will be selected on the basis of a precautionary approach. The rationale for selecting measures must be made apparent.

Frequently, in practice, BSE-related import measures imposed by countries without reported BSE cases have been extremely harsh and in most cases not based on scientific findings. Often, they were defined as a being a "precautionary approach". Subsequently, unjustified import measures were often stopped after the occurrence of the first BSE case in the importing country.

In these BSE import risk assessments, not only the exposure risk for cattle (as in the GBR), but also the exposure risk for humans must be addressed. Therefore, all ways by which people can be exposed to infectivity should be considered. For example, from the farm, possible BSE exposure may occur via slaughtered cattle, bovine-derived products and by-products. From the incinerator, possible exposure may occur via air, sewage, other raw products and ground contamination.

After all the pathways have been considered, information on each pathway must be gathered. For quantitative assessments, these data should be quantitative if possible. For example, when BSE exposure risk from ingestion of food is assessed, it must be considered that whether BSE exposure results in infection depends on the exposed species as well as the type and amount of exposure. In general, BSE risk assessments only consider the infectivity of tissues from cattle potentially infected with BSE, as this is the only zoonotic TSE known to date. In this example, in order to estimate the amount of possible exposure, four parameters are evaluated:

- *The infectivity of CNS tissues from an animal with clinical BSE to another bovine*. Experiments to date (primarily conducted at the Veterinary laboratory Agency/in the UK) have evaluated the infectivity from brains of clinically affected bovines. Results range from 10^1 to 10^3 bovine oral ID_{50}/g, but ongoing experiments may allow further precision of this range in the future (SSC, 2002d).
- *The relative infectivity of non-CNS tissues in an animal with BSE*. The infectivity of non-CNS tissues, evaluated through pathogenesis studies, is presented in the "Introduction to TSEs" chapter of this course manual.
- *The development of infectivity through the incubation period of the disease*. The development of infectivity in CNS tissues has been evaluated through pathogenesis studies. The first infectivity was found at 32 months post oral infection and not at 26 months. In an attack rate study using similar doses, a mean incubation

time of 48 months was determined. Using these numbers, an exponential growth curve can be estimated for the development of infectivity throughout the incubation period (SSC, 2002d).

- *The cattle–human species barrier*. When human exposure is being evaluated, the species barrier must be considered, though because not much information is available here, the cattle exposure dose (bovine oral ID_{50}) is often used. However, it is probable that the BSE infectivity is lower for humans, and may range from 10 to 10 000 times less than the infectivity for cattle (Raymond *et al.*, 1997; SSC, 1999; 2000c).

In summary, when import risk assessments for BSE are undertaken, a wide variety of comprehensive information needs to be gathered. A good level of current scientific knowledge is required and accurate data on all possible exposure pathways in the country must be known (i.e. slaughter techniques, rendering industry parameters, what is eaten in the country, etc). Therefore, it is clear that in order to ensure such a risk assessment is valid, adequate time must be allowed for a careful and comprehensive understanding of all the parameters.

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SSC. 2000b. Final opinion of the Scientific Steering Committee on the geographical risk of bovine spongiform encephalopathy (GBR). http://europa.eu.int/comm/food/fs/sc/ssc/out113_en.pdf)

SSC. 2000c. Opinion on oral exposure of humans to the BSE agent: infective dose and species barrier (adopted by the Scientific Steering Committee at its meeting of 13-14 April 2000, following a public consultation via Internet between 6 and 27 March 2000). http://europa.eu.int/comm/food/fs/sc/ssc/out79_en.pdf

SSC. 2002a. Updated opinion on the geographical risk of bovine spongiform encephalopathy (GBR). http://europa.eu.int/comm/food/fs/sc/ssc/out243_en.pdf

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APPENDIX 1

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Participants from the partner countries have also contributed significantly to the production and translation of the course manuals, and to many other aspects of the courses.

APPENDIX 2

Related background reading and Web links*

* These references and Web links refer to all four *Capacity Building for Surveillance and Prevention of BSE and Other Zoonotic Diseases* project course manuals. Therefore, all documents and links may not be applicable to the topics covered in this manual.

RELATED BACKGROUND READING AND WEB LINKS

TSE pages of selected ministries and other general data sources

Department of Environment Food and Rural Affairs. United Kingdom, BSE homepage: http://www.defra.gov.uk/animalh/bse/index.html

FAO. BSE pages: http://www.fao.org/ag/AGAinfo/subjects/en/health/bse/default.html

Ministry of Agriculture of New Zealand. BSE homepage: http://www.biosecurity.govt.nz/node/7650

Swiss Federal Veterinary Office. BSE homepage: http://www.bvet.admin.ch/gesundheit_tiere/01752/01804/02075/index.html?lang=de

TAFS. Position papers: http://www.tseandfoodsafety.org/startseite.htm

United States Department of Agriculture. Animal and Plant Health Inspection Service, BSE homepage: http://www.aphis.usda.gov/lpa/issues/bse/bse.html

WHO. BSE pages: http://www.who.int/zoonoses/diseases/bse/en/

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BSE cases and risk

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European Union Guidance Document for Regulation 1774/2002. http://europa.eu.int/comm/food/fs/bse/bse48_en.pdf

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Human prion diseases

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APPENDIX 3

Glossary of technical terms and acronyms*

* This glossary refers to all four *Capacity Building for Surveillance and Prevention of BSE and Other Zoonotic Diseases* project course manuals. Therefore, all documents and links may not be applicable to the topics covered in this manual.

GLOSSARY OF TECHNICAL TERMS AND ACRONYMS

AAFCO	Association of American Feed Control Officials
Ab	Antibody
AFIA	American Feed Industry Association
Animal by-products	Tissues and other materials (including fallen stock) discarded at the slaughterhouse, which generally go to incineration, burial or rendering (depending on the country)
Animal waste	Animal by-products
Ante mortem	Before death (generally refers to the period immediately before slaughter)
AP	Apparent prevalence
BAB	Born after the ban; animals with BSE that were born after implementation of a feed ban
BARB	Born after the real ban; animals with BSE that were born after implementation of a comprehensive and effectively-enforced feed ban
BSC	Biosafety cabinet
BSE	Bovine spongiform encephalopathy
BL	Biosafety level
By-pass proteins	Proteins that are not degraded in the rumen but are digested in the small intestine to provide additional amino acids
CCP	Critical Control Point: a step in a production chain that is essential to prevent or eliminate a food safety hazard or reduce it to an acceptable level and at which a control can be applied
CEN	Europan Committee for Standardization
CJD	Creutzfeldt-Jakob Disease
CNS	Central nervous system
Combinable crops	Those able to be harvested with a combine
Contaminants	Materials that should not be present in a given product; e.g. rodents, birds, rodent droppings, toxins and mould are contaminants that should not be present in any livestock feed
Control (noun)	The state wherein correct procedures are being followed and criteria are being met (HACCP context)
Control (verb)	To take all necessary actions to ensure and maintain compliance with criteria established in a HACCP (or other control) plan (HACCP context)

Core fragment	The part of PrP^{Sc} that is not digested by proteinase K (also called PrP^{Res})
Critical limit	A criterion that separates acceptability from unacceptability (e.g. during audits)
Cross contaminants	Substances carried from areas or materials where they are not prohibited to areas or materials where they are prohibited
Cross feeding	The feeding of a livestock group with prohibited feeds intended for another livestock group
CP	Crude protein
CWD	Chronic wasting disease.
DNA	Deoxyribonucleic acid; the genetic material for all living organisms except bacteria
Downer cattle	Cattle too sick to walk to slaughter (definition differs among countries)
EC	European Commission
EFSA	European Food Safety Authority
ELISA	Enzyme-linked immunosorbent assay
Emergency slaughter	Slaughter cattle with clinical signs non-specific for BSE (definition differs among countries)
Epitope	Structural part of an antigen that reacts with antibodies
Epitope demasking	Process in which the epitope becomes available for antibody binding (for example, by denaturation)
Essential amino acids	Those that cannot be synthesized and therefore must be provided by the feed/food
EU	European Union
Fallen stock	Cattle that died or were killed for unknown reasons (definition differs among countries)
FAO	Food and Agriculture Organization of the United Nations
FDA	Food and Drug Administration (United States of America)
FEFAC	European Feed Manufacturers' Federation
FIFO	First in first out; a production concept to optimize quality
Flushing batches	Batches of feed processed or transported in-between feed batches containing prohibited and non-prohibited materials, and intended to remove traces of prohibited materials from the equipment
FMD	Foot-and-mouth disease
FN	False negatives; truly-diseased animals that test negative on a diagnostic test
FP	False positives; truly non diseased animals that test positive on a diagnostic test
FSE	Feline spongiform encephalopathy; TSE in cats, believed to be caused by ingestion of the BSE agent.

GAFTA	Grain and Feed Trade Association
GAP	Good agricultural practices
GBR	Geographical BSE risk assessment
GHP	Good hygiene practices
GMP	Good Manufacturing Practices
GMT	Good microbiological technique
Greaves	A proteinaceous by-product of the rendering process
GTM	GAFTA Traders Manual
H & E	Haematoxylin and eosin stain
HACCP	Hazard Analysis and Critical Control Points: a method to identify process steps where a loss or significant deviance from the required product quality and safety could occur if no targeted control is applied
HACCP plan	A document prepared in accordance with the principles of HACCP to ensure control of hazards that are significant for the segment of the production under consideration
Hazard	A biological, chemical or physical agent with the potential to cause an adverse health effect
Hazard analysis	The process of collecting and evaluating information on hazards and conditions leading to their presence to decide which are significant for the segment of the production under consideration and therefore which should be addressed in the control (or HACCP) plan
High quality protein	Protein sources that match the requirements of a particular species or production class well
HPLC	High performance liquid chromatography
IAG	European Feed Microscopists working group
IFIF	International Feed Industry Federation
IHC	Immunohistochemistry
Indigenous BSE case	Domestic BSE case; non-imported BSE case
M+C	Methionine plus cysteine; amino acids generally considered together, because cysteine can be derived from methionine in animals
ISO	International Organization for Standardization
Mammal	An animal that lactates; in this context, livestock excluding aquatic species and poultry
MBM	Meat and bone meal; the solid protein product of the rendering process
Medulla oblongata	Caudal portion of the brainstem
MMBM	Mammalian meat and bone meal
Monitoring	An ongoing process of specific animal health data collection over a defined period of time

Monogastric species	Animals with simple stomachs (e.g. swine, poultry, horses, humans)
MOSS	Monitoring and surveillance system
MRM	Mechanically recovered meat
NIRC	Near infrared camera
NIRM	Near infrared microscopy
NIRS	Near infrared spectrography
Notifiable disease	A disease for which there is a national legal requirement to report cases and suspects to an official authority
Obex	The point on the midline of the dorsal surface of the medulla oblongata that marks the caudal angle of the fourth brain ventricle; a marker for the region of the brain stem where some of the predilection areas for histological lesions and PrP^{Sc} deposition in BSE are located (such as the dorsal nucleus of the vagus)
OD	Optical density
OIE	World Organization for Animal Health
OR	Odds ratio
Pathogenicity	Ability of an organism to invade a host organism and to cause disease
PCR	Polymerase chain reaction
Pithing	The laceration of central nervous tissue by means of an elongated rod-shaped instrument introduced into the cranial cavity of slaughter cattle after stunning.
PK	Proteinase K; a serine proteinase that digests PrP^{C} completely but PrP^{Sc} only partially under certain conditions
Post mortem	After death
Prion	Infectious agent causing TSE
Proteolysis	Cleavage of a protein by proteases; also referred to as "digestion"
PrP	Prion protein, encoded by the gene *PRNP*, expressed by many cell types and many organisms
PrP^{BSE}	Resistant prion protein associated with bovine spongiform encephalopathy; also called PrP^{Sc}
PrP^{C}	Normal prion protein found in eukaryotic cells
PrP^{Res}	Resistant prion protein core remaining after proteolysis of PrP^{Sc} using proteinase K
PrP^{Sc}	Resistant prion protein associated with transmissible spongiform encephalopathies, including BSE
PrP^{Sens}	Normal prion protein found in eukaryotic cells; also called PrP^{C}
PV	Predictive value

Rapid test	Test systems using immunological assays that detect the presence of infectious agents in animal tissues or other materials within hours
RR	Relative risk
Ruminant species	Animals with multichambered stomachs that allow bacterial fermentation of feeds prior to intestinal digestion (e.g. cattle, sheep, goats, camellids)
Scrapie	A TSE of sheep and goats
SE	Sensitivity of a diagnostic test
Segregation	Undesirable separation of raw ingredients in a compound feed after processing
SFT	Swiss Institute of Feed Technology
Sick slaughter	Cattle with non-specific signs (definition differs among countries)
SP	Specificity of a diagnostic test
SPS Agreement	Agreement on the Application of Sanitary and Phytosanitary Measures
SRM	Specified risk materials; those animal tissues most likely to contain TSE infective material
SSC	Scientific Steering Committee of the European Commission
Strip test	Lateral flow immunochromatographic test for rapid detection of proteins in feed samples
Surveillance	Extension of monitoring in which control or eradication action is taken once a predefined level of the health-related event has been reached
TAFS	International Forum for TSE and Food Safety
TBT Agreement	Agreement on Technical Barriers to Trade
Terrestrial animal	In this context all livestock excluding aquatic species (e.g. poultry, ruminants, pigs, horses)
TME	Transmissible mink encephalopathy
TP	True prevalence
Tracing	Determining where an animal or product originated or has been
Tracking	Following an animal or product forward through the system
TSE	Transmissible spongiform encephalopathy
UK	United Kingdom of Great Britain and Northern Ireland
USA	United States of America
vCJD	Variant (or new variant) Creutzfeldt-Jakob disease of humans; believed to be caused by ingestion of the BSE agent

WB	Western blot
WHO	World Health Organization
WTO	World Trade Organization

Additional definitions can be found in

- the OIE *Terrestrial Animal Code*, Chapter 1.1.1. http://www.oie.int/eng/normes/MCode/en_chapitre_1.1.1.htm
- the FAO/WHO Codex Alimentarius "Current official standards". http://www.codexalimentarius.net/web/standard_list.do?lang=en

APPENDIX 4

Project summary

PROJECT SUMMARY

This course is a part of the project *Capacity Building for Surveillance and Prevention of BSE and Other Zoonotic Diseases*. The aim of the project is to build capacity, establish preventive measures and analyse risks for bovine spongiform encephalopathy (BSE), so that, ultimately, partner countries are able either to prove themselves to be BSE-free or are able to decrease their BSE risk to an acceptable level. Governmental and private veterinary services, diagnostic laboratories, and the livestock, food and animal feed industries will be strengthened and supported, and technical capacity built at every step along the food production chain. In the future, the knowledge gained during this project could be used by the countries to establish similar programmes for control of other zoonotic food-borne pathogens.

The project is funded by Swiss governmental agencies and utilizes expertise available in Switzerland and worldwide and infrastructure available from the Food and Agriculture Organization of the United Nations (FAO) to assist the governments of the partner countries to achieve the project's aim. The executing agency is Safe Food Solutions Inc. (SAFOSO) of Berne, Switzerland.

The direct project partner in each country is the National Veterinary Office. The countries commit and pay a salary to at least one individual, situated in the National Veterinary Office, to act as a National Project Coordinator (NPC), commit three trainees per course and provide the necessary infrastructure for implementation of the project in the country. The NPC is responsible for coordinating the activities of the project within the country, including offering training courses, identifying and organizing trainees, and promoting communication between the project, the government, the scientific community in the country, the livestock and food industries, and the public. Other commitments by the countries include providing paid leave time for employees to attend courses, providing infrastructure and facilities for in-country courses, providing historical and current data (surveillance data, animal movement data, import/export records) and the staff required to identify those data, and providing adequate staff for and facilitating the initial needs assessment and final comprehensive risk assessment.

A National Project Board in each of the participating countries regularly evaluates the operational progress and needs of the project, and provides a regular venue for communication among the project team, national partners and stakeholders. This Board is comprised of the NPC, representatives of the national government, a project representative, the local FAO representative, and local stakeholders from private industry and the veterinary community.

ACTIVITIES OF THE PROJECT

1. The specific needs of each participating country are assessed.
2. Comprehensive courses to "train the trainers" are provided in Switzerland (or elsewhere) to selected participants to improve understanding of the epidemiology of and relevant risk factors for BSE and to develop specific knowledge and skills for implementing appropriate controls.

Three trainees from each country, as well as the NPC, travel to Switzerland (or elsewhere) to participate in each course.

The courses are:

- Diagnostic Techniques for transmissible spongiform encephalopathies
- Epidemiology, Surveillance and Risk Assessment for transmissible spongiform encephalopathies
- Transmissible spongiform encephalopathies management in livestock feeds and Feeding
- Transmissible spongiform encephalopathies Management in Meat Production

Each course is preceded by an introduction to BSE covering the background of transmissible spongiform encephalopathies (TSE), BSE, biosafety, general concepts of epidemiology and risk assessment, and risk communication. Each course also includes discussion of aspects of risk communication that are relevant to the topic being presented.

Only those motivated individuals who will be implementing the relevant information into the national BSE programme, who have some experience (e.g. ability to use a microscope, veterinary training) and have adequate English skills, are accepted.

After each course, the relative success of the course is evaluated focusing on the success of the training methods and effectiveness of the knowledge transfer rather than on the learning of the individual trainees. Therefore, no written test is given, but close contact is maintained with the trainees after they return to their countries, and their progress and success in implementation of their training into the national BSE programme is followed and evaluated in the field.

3. Each of the TSE-specific courses is then offered as an in-country course in the native language, and is organized by the trainees and the National Veterinary Offices with technical support from the project. In-country courses use the same curriculum and expected outcomes as the original courses, and are provided with support, technical assistance and materials (translated into their own language). The introductory TSE and biosafety course curriculum is also presented. At least one expert trainer assists in presenting these courses. Participants are chosen according to strict selection criteria, but the number of participants and the frequency and location of courses given depends on the needs of the country and the type of course.
4. The knowledge gained through the courses should then be integrated by the partner country through development and implementation of a national BSE control programme. The programme is promoted and supported by the countries to ensure the sustainability of the system. Contact, technical support and follow-up with the countries is ongoing throughout the project.
5. Information campaigns to improve BSE awareness are targeted to national governments, producers and consumers.
6. Partner countries are supported in the submission of a comprehensive national BSE risk assessment to the World Organisation for Animal Health (OIE) in order to document their BSE status to the international community.

To support countries with economies in transition and developing countries in the control and prevention of bovine spongiform encephalopathy (BSE), the project Capacity Building for Surveillance and Prevention of BSE and Other Zoonotic Diseases, involves collaboration between FAO, SAFOSO and National Veterinary Offices in partner countries, and is funded by the Government of Switzerland. The aim of the project is to build capacity, establish preventive measures and analyse risks for BSE. Partner countries are thus enabled to decrease their BSE risk to an acceptable level or demonstrate that their risk is negligible, and thereby facilitate regional and international trade under the SPS agreement of the WTO. The project includes comprehensive training courses to improve understanding of the > epidemiology of and relevant risk factors for BSE and TSE and to develop specific knowledge and skills for implementing appropriate controls.

This manual is a supplement to the training course on Epidemiology, surveillance and risk assessment for transmissible spongiform encephalopathies and it is targeted at governmental epidemiologists who will contribute to the development and implementation of the national BSE surveillance and control programme and to the BSE risk assessment for the partner countries.