

Bovine Spongiform Encephalopathy (BSE)

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INTRODUCTION

Bovine spongiform encephalopathy (BSE – commonly referred to as mad cow disease) is a fatal neurodegenerative disease of cattle (also rarely of goats and potentially sheep) first recognised in the United Kingdom in the mid-1980s. The pandemic that followed, almost entirely confined to Europe, was the direct result of an ‘unnatural’ farming practice that involved the feeding of rendered carcass material derived from cattle to other cattle in the form of meat and bone meal (MBM) – usually referred to as carcass meal in South Africa. The MBM containing the putative causative prion protein was incorporated in animal feeds, particularly feeds for dairy cattle and young calves.

The disease is not conventionally contagious but is so in the sense that it is transmitted when cattle consume feed containing processed proteins derived from infected cattle. Clinical disease usually follows 4-5 years later, i.e. long after consumption of the infected material (incubation period range 2.5 - 8 years). This is an extraordinarily long incubation period for an infectious disease.

The BSE agent (designated PrP^{Sc})¹ is, according to the current prion theory, an aberrantly folded (isomer) of a normal cell-surface protein (designated PrP^C) that is able to induce conformational changes in PrP^C so that PrP^{Sc} is produced in increasing amounts in the central nervous system (CNS) of affected cattle. By the end of the long incubation period this process results in neurological disturbances characteristic of BSE (Griffiths, 1967; Reik et al., 2011). The pathogenesis is similar in all the so-called transmissible spongiform encephalopathies (TSEs) that affect humans and other mammals (Table 1).

Table 1: Transmissible spongiform encephalopathies that affect humans and animals

Disease	Natural host	Other hosts
Scrapie	Sheep and goats	
Transmissible mink encephalopathy	Mink	
Chronic wasting disease	Mule deer, elk & white tailed deer	
Bovine spongiform encephalopathy	Cattle & goats	Domestic cats, captive wild felids (lions, tigers, cheetahs) and bison & antelope
Variante Creutzfeldt-Jakob disease	Humans	

¹ Sc is derived from scrapie – a different disease and therefore a misnomer (Table 1)

Disease	Natural host	Other hosts
Kuru	Humans	
Creutzfeldt-Jakob disease	Humans	
Gerstmann-Staüssler-Scheinker syndrome	Humans	
Fatal familial insomnia	Humans	

BSE's origin is uncertain and has been speculated upon for years, the two most common theories being that it was derived from one of the strains of scrapie (a disease of sheep and goats that has been recognised for more than a century), or that it arose spontaneously in cattle in the UK, and perhaps elsewhere in Europe, and was propagated by the animal feed industry's production and use of MBM. The 'viral hypothesis' is largely discredited because no nucleic acid has so far been detected associated with PrP^{Sc}.

There is compelling evidence that consumption by people of offal (particularly brain and spinal cord) from infected cattle causes a similar neurodegenerative disease in people known as (new) variant-Creutzfeldt-Jakob disease (vCJD), also after a protracted incubation period (Bradley & Verwoerd, 2004a). This makes vCJD a zoonosis, the only one known among the TSEs. Like BSE, vCJD is invariably fatal and affected people usually suffer months of debilitating neurological illness before they die.

The impact that the European BSE pandemic, at its height in the 1990s, had on the psyche of consumers in developed countries was unprecedented. There was confusion and some hysteria at the time resulting largely from the fact that little was understood about the disease. Media speculation added to the fears of consumers and the Veterinary Services and Government of the UK compounded the confusion by premature assurances to the public that BSE was harmless to people, presumably in an attempt to protect the UK's livestock-based industries. Those mistaken assurances were later exposed, escalating public mistrust of government and large agri-businesses. The BSE pandemic provided the initial impetus for present-day insistence upon traceability throughout the human food chain which is now universally espoused.

In the UK alone about half a million cattle suffering from BSE are estimated to have entered the human food chain and the majority of the human population in the UK was consequently exposed (Daily Telegraph, 15 February 2011). However, because up to the end of 2011 only 176 cases of vCJD were recorded in the UK (www.cjd.ed.ac.uk/figures.htm), it would appear that there is a vast difference between exposure- and infection rates in humans.

By 2001 the cost of the BSE epidemic to the UK was estimated to have reached £ 4 billion (approximately R 50.8 billion; Smith & Bradley, 2003). Later estimates were \$ 10-13 billion (R 127–165 billion; Marsh, undated – www.ecoandsocialimpactofemerginginfectiousdisease_111208.pdf).

EPIDEMIOLOGY

Spatial and temporal distribution of BSE

Detailed tables containing information on countries in which BSE has been reported are provided by the World Organisation for Animal Health (OIE) on its website (BSE specific data – www.oie.int). Apart from the 184 169 cases in cattle that were diagnosed in the UK up to the end of 2011, 20 other European countries also recorded the disease, some such as Portugal, Switzerland and Ireland at high prevalence rates. However, only four countries outside Europe reported cases that were not imported, viz. Canada, Israel, Japan and USA. No locations in the southern hemisphere have reported indigenous cases of BSE.

A table reflecting the ‘annual incidence rate²’ of BSE in individual countries is provided on the OIE’s website (www.oie.int). This shows that by the end of 2011 only twelve countries, including UK, still had an annual incidence rate above zero. With the exception of Canada all these countries are in Europe. These data are likely to be reasonably accurate because no other disease enjoys the intensity of surveillance accorded to BSE in Europe. For example, throughout the European Union (EU), all cattle over the age of 30 months slaughtered for human consumption are currently tested for BSE using modern laboratory methods. The likelihood of BSE entering the human food chain in the EU is consequently close to zero.

A comparison of the epidemic curves of BSE and vCJD in the UK is shown in Figure 1. The time differences between the peaks of the BSE and vCJD epidemic curves (1992 & 2000 respectively) are explained by the infection affecting people only once the bovine epidemic had picked up momentum and the incubation period of vCJD being even longer than for BSE. The long ‘tails’ of the epidemic curves have not yet been reliably explained but probably relate to a minority of cases having exceptionally long incubation periods. Nevertheless, it can be predicted with reasonable assurance that BSE and vCJD will become historic in Europe in the next few years.

² The number of indigenous cases per 1 million cattle over the age of 24 months



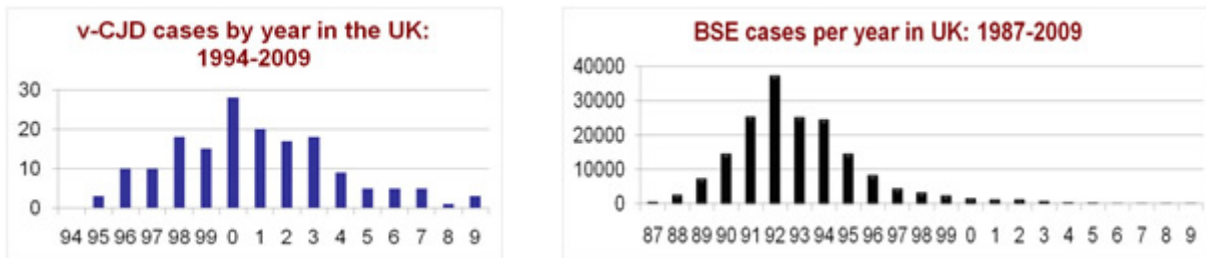


Figure 1: Comparison between BSE & vCJD epidemic curves in the UK: 1987-2009

Species and PrP^{Sc} strain associations

The vast majority of BSE cases that made up the European pandemic were caused by a single strain of PrP^{Sc} (assessed on the basis of mouse biological tests; Bradley & Verwoerd, 2004b). Rare cases of BSE were identified in Europe that were caused by different strains. Recently PrP^{Sc} ‘types’ have been differentiated on the basis of their molecular mass. In addition to the predominant type associated with the European pandemic (designated C), small numbers of cases with a lower (designated L-type) or higher (H-type) molecular mass were identified. In 2011 two BSE cases were found in Switzerland with a novel molecular weight, i.e. different from C-, H- and L-types (<http://escope.prionics.com/issue/2011-decemb>).

Apart from cattle, a few cases of BSE also occurred in antelope and bison in zoos as well as a number of felid species that were fed on rations that contained MBM (Bradley & Verwoerd, 2004c; Table 1). For many years, however, there was no evidence that BSE affected domestic ruminants other than cattle. Recently, however, two cases have also occurred in goats in Europe and sheep have been found to be susceptible experimentally (Spiropoulos *et al.*, 2011). These findings reinforce the need for control measures against BSE to be retained to prevent another epidemic because the potential is that aberrant prion proteins will continue to arise, albeit infrequently, in cattle or small stock. If these prions enter the animal feed chain where an ‘unstable’ BSE situation exists (see below), a new epidemic could potentially arise.

For the above reasons it will likely never be possible to consider BSE ‘eradicated’. This has trade implications that will be discussed below.

Table 1: Transmissible spongiform encephalopathies that affect humans and animals

Disease	Natural host	Other hosts
Scrapie	Sheep and goats	
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encephalopathy		
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Lessons from the European pandemic (1989-2011)

The European pandemic centred on the UK has been described as an extended common source epidemic, the source being MBM containing prion protein fed to cattle (Anderson *et al.*, 1996; Ducrot *et al.*, 2008). The much earlier occurrence of cases and the peak incidence of cases in the UK (1992) in comparison with those of other European countries, indicates that the European pandemic probably spread from the UK to other countries (presumably mainly through export of MBM but also of live cattle in the incubation phase of the disease that subsequently entered the ruminant feed chain).

Circumstantial evidence indicated that procedures at rendering plants in the UK changed in the early 1980s, resulting in waste material from animal carcasses being heated less thoroughly than was the case previously. Additionally, a solvent extraction step was dispensed with (this was originally thought to be an important factor but later research showed the BSE agent to be little affected by the solvent concerned – Bradley & Verwoerd, 2004b). The result was increasing quantities of PrP^{Sc} being recycled with new cases of BSE occurring exponentially, albeit that these cases only became obvious 4-5 years later.

Although other methods of transmission of BSE have been investigated, including horizontal and vertical, none have provided conclusively positive results. It has been concluded therefore that maternal transmission either does not occur or does so at an insignificant rate (Bradley & Verwoerd, 2004b; Ducrot *et al.*, 2008).

All breeds and both sexes of cattle appear to be equally susceptible to BSE (Bradley & Verwoerd, 2004). However, there is evidence of genetic predisposition to vCJD among people (Lewis *et al.*, 2006).

The youngest animal so far identified with BSE was 20 months old – in the UK. Two cases below the age of 30 months were also diagnosed in other European countries but the vast majority of cases have been in cattle 30 months or older with the average age being over 5 years (Decrot *et al.*, 2008).

The following commodities and products derived from cattle are considered by the OIE (based on extensive background research) as safe from the BSE perspective and therefore should not be associated with import restrictions applicable to BSE: blood, milk and milk products, semen, embryos, hides and skins and gelatine and collagen derived from skin, tallow and dicalcium phosphate (there are specific qualifications for some of these – see Article 11.5.1 of the Terrestrial Animal Health Code, www.oie.int).

Ducrot *et al.* (2008) in their review emphasized a number of findings:

- That passive surveillance is inadequate for BSE detection: only after the introduction of mandatory active surveillance in 2001 in most EU countries did the true extent of the BSE problem become apparent. Between 2001-2005 over 50 million cattle were subject to laboratory screening for BSE in European countries which identified about 7 000 cases (i.e. one case per 7 143 cattle tested). In most of these countries active surveillance consisted of a combination of (1) targeted surveillance for suspect clinical cases among downer cows, emergency slaughter animals and animals that died or were killed during transportation and older than 24 months of age, and (2) a sample (typically 3%) of slaughter cattle over 30 months of age.
- Results from extensive surveillance in EU countries identified a number of risk factors:
 - dairy cattle – beef cattle were only about 1/3 as likely to develop BSE as dairy cattle (ascribed to the fact that dairy cattle consume more formulated feeds and less grass than do beef cattle);
 - season of birth – in the UK, dairy cattle born in autumn were found to be at higher risk of developing BSE than those born in spring and in France this applied to beef cattle as well (ascribed to spring calves obtaining feed via grazing in fields while autumn calves are raised for the first few months of life in barns and fed formulated feeds exclusively);
 - dairy cows in highest producing herds had a three-fold higher risk of developing BSE than those in lowest producing herds (ascribed to high producing cows consuming more formulated feed than others);
 - the age of dairy cows at first calving; the earlier the age the greater the likelihood of development of BSE;

- although not a universal finding, BSE appears to have been more common in large herds, possibly related to feeding practices;
- in a number of countries there were also geographical differences between different parts of the same country, probably resulting from specific feed suppliers in different locations selling relatively highly contaminated feed;
- inconclusive evidence was found for milk replacers based on tallow having an association with BSE cases although tallow is considered to be a safe product.

Surveillance for BSE

As indicated in the section above, it has been shown repeatedly in Europe that passive surveillance for BSE is inadequate for detection of the presence of BSE; therefore active surveillance is considered essential. The OIE – which provides an accreditation system for member countries in relation to the adequacy of BSE risk control in countries (i.e. it does not certify ‘disease-freedom’ as is the case for foot and mouth disease, for example) – provides guidance on surveillance approaches and standards (Chapter 11.5 – TAHC, OIE, 2011). These standards present a problem for developing countries because the surveillance requirements for listing as a country or zone with either ‘negligible’ or ‘controlled’ risk BSE risk are logistically and financially demanding. Few African countries, even those dependent on beef exports, are in a position to fulfil the surveillance requirements advocated by the OIE because the cost of compliance far outweighs potential financial benefit. This results in a ‘catch 22’ situation where listing by the OIE as a country with negligible risk is important for market access but the costs involved would make export unprofitable.

This problem is discussed further under control.

BSE and African countries

The issue of whether BSE presents a real risk to African countries continues to be a matter of debate. On one hand, because no indigenous cases of BSE have been identified in the southern hemisphere the risk appears to be non-existent; on the other hand, it is possible that cases were imported into some southern African countries by imports of live cattle and/or feed constituents such as MBM in the period before the extent of the BSE problem in Europe became apparent. This could, in the opinion of the European Commission (EC), be the case for South Africa, although the South African Government disputes the ‘facts’ on which this opinion rests. This disagreement arose as a result of South Africa’s application to the European Food Safety Authority (EFSA) for a GBR (Global BSE Risk) rating in 2001 and the subsequent categorization in 2003 of South Africa’s status as GBR III (i.e. likely but not confirmed that domestic cattle are infected with the BSE agent). South Africa made this application to the EFSA because the OIE at that time did not have a well-developed BSE accreditation system and the EC was providing interim international leadership. According to the South African authorities, the GBR assessment was not properly completed due to failure on the part of South Africa to supply supplementary information to the EFSA on time, i.e. the assessment was based on inaccurate data. However, this assessment is still on

record and the EFSA assessed South Africa's 'external challenge' (i.e. the likelihood that the BSE agent was introduced into the country) as follows:

- 1980-1985 overall – very low; MBM – negligible;
- 1986-1990 overall – high; MBM – moderate;
- 1991-1995 overall – moderate; MBM – very low;
- 1996-2000 overall – high; MBM - high.

On balance it would appear that the rating accorded to South Africa by the EFSA was deficient insofar as MBM imports are concerned. However, there is no doubt that cattle were imported into South Africa from the UK during the early stages of the BSE epidemic in that country and that no assurance is available to show that tissues from these cattle did not enter the animal feed chain as carcass meal. If that did happen the question is whether the infection could have been maintained by carcass meal incorporated into animal feed on a repetitive basis, i.e. resulting from an 'unstable' BSE control system. A study conducted in 2010 on behalf of the Southern African Development Community (SADC) showed that management of risks associated with the manufacture and distribution of carcass meal in South Africa did not accord with international standards (Thomson, 2010). This poses a regional problem because most countries in southern Africa import cattle and feeds from South Africa.

PATHOGENESIS

There is experimental evidence that after oral infection of cattle infectivity is first detectable after about 6 months in the distal ileum (probably associated with the Peyer's patches) which reaches maximum levels about 14 months after infection, i.e. 6 months before similar levels of infectivity arise in the central nervous system (CNS). By 36 months after exposure levels of infectivity in the ileum were found to have declined (Arnold *et al.*, 2009). Traces of infectivity have also been reported in the palatine tonsils of cattle killed 10 months after experimental exposure (Wells *et al.*, 2005).

The route by which infectivity reaches the CNS was shown, also experimentally, to occur by anterograde movement of PrP^{Sc} along two pathways of the autonomic nervous system from the gastro-intestinal tract (GIT), i.e. via: (1) the coeliac and mesenteric ganglion complex, splanchnic nerves and lumbar/caudal thoracic spinal cord (i.e. sympathetic innervation of the GIT) and (2) the vagus nerve (parasympathetic GIT innervation – Hoffmann *et al.*, 2007). Spread of infectivity to the dorsal route ganglia (DRG) appears to occur at about the same time or after infection of the CNS; the levels of infectivity in DRG being in the order of 10-fold lower than in the CNS. In the CNS infectivity levels are variable – $10^{2.4}$ - $10^{5.2}$ mouse i.c. or

i.p. D_{50}/g^3 (Arnold *et al.*, 2009). Spread to the peripheral nervous system and adrenal glands has also been identified in experimentally infected cattle; this occurred at the time or shortly after PrP^{Sc} appeared in the CNS (Masujin *et al.*, 2007).

In cattle in the incubation phase of the disease the doubling-time of PrP^{Sc} in the brain was found to be about 1.2 months and infection of the rostral medulla oblongata preceded infection of the lumbar/thoracic spinal cord while infection of that part of the spinal cord preceded infection of the cervical spinal cord (Arnold *et al.*, 2009). In diseased cattle the brain, followed by the spinal cord contain by far the most infectivity.

In general all TSEs induce similar changes in the CNS consisting of a combination of predominantly extracellular deposition of PrP^{Sc} – the intensity, pattern and distribution of deposition being highly variable – in the form of amyloid (rich in β -sheets) produced by neurons, and spongiform change with neuronal vacuolation and degeneration accompanied by astrocyte and microglial reaction. There is characteristically no inflammatory reaction; consistent with PrP^{Sc} being recognized immunologically as ‘self’. These changes presumably result in disturbances in neurological impulse transmission, the upshot of which is the clinical manifestations associated with TSEs.

The distribution and quantities of infectivity in infected cattle are important in determining the risks that BSE poses to people who consume foods containing bovine tissues. This aspect has therefore been carefully studied. Despite some reports to the contrary, there is little evidence that organs, tissues or secretions other than those mentioned above contain significant amounts of PrP^{Sc} in infected animals or those incubating the disease (Arnold *et al.*, 2009). This includes milk, semen, embryos, pure striated muscle (i.e. beef from which bones and lymph nodes have been removed) and fat (tallow – Terrestrial Animal Health Code, Chapter 11.5; OIE, 2011). Therefore the two major food sources provided by cattle (milk and beef) are safe, or can be made so, for consumers as far as BSE/vCJD are concerned.

DIAGNOSIS AND DIFFERENTIAL DIAGNOSIS

Suspicion of the occurrence of BSE in an animal or herd is almost always first based on observation of clinical signs consistent with BSE. It is most unlikely – because of the low prevalence rate of BSE – even in outbreaks such as in the UK in the 1970-90s, that more than a single animal will show clinical signs in herd of cattle at any given time. Such animals are usually 4 years or older in age.

³ Infectivity measured by intra-cerebral or intra-peritoneal inoculation of mice with dilutions of brain material suspensions – the dose required to induce the disease in 50% of the mice being assessed as representing one infectious dose

The initial signs, which are exclusively behavioral, usually have an insidiously start. The animal may first show signs of anxiety for no obvious reason and/or be hyperaesthetic. Reaction to sudden loud noises or touch elicits exaggerated reaction that does not diminish significantly when repeated. So making a sudden loud noise and watching the reaction of the animal concerned is a useful diagnostic aid. Inco-ordination is also a frequent early sign, especially of the hind limbs. Some animals may adopt a stance where the head is lowered and the neck extended with wide-based hind legs. Hypermetria (over-shooting of intended limb position) is also a common feature of BSE. It should also be remembered that other disease and BSE may be concurrent (Konold *et al.*, 2006). More detailed analyses of the criteria for clinical suspicion are available (Bradley & Verwoerd, 2004b; Konold *et al.*, 2006).

There are no macroscopically observable pathological lesions associated with BSE at any stage of the disease.

In contrast to most other neurological diseases of cattle the course of BSE is often weeks or months long, i.e. before the animal becomes severely incapacitated or dies. This distinguishes BSE from infectious diseases such as rabies, heartwater, cerebral theileriosis and babesiosis, thrombotic meningio-encephalitis (*Haemophilus somnus*), sporadic bovine encephalomyelitis, cerebrocortical necrosis (thiamine deficiency), chemical and biological toxins (e.g. lead, botulism, urea, pesticides, mycotoxicoses, diploidosis & pesticides) and a range of poisonous plants. Non-infectious causes of BSE-like clinical signs include arthritis, lameness, joint trauma, recumbence (downer syndrome – especially after falling on concrete), unsatisfactory milk yield and ear infection (Konold *et al.*, 2006).

There are a number of laboratory-based diagnostic methods that are discussed in detail in Chapter 2.4.6 of the OIE's Manual of Diagnostic Tests and Vaccines for Terrestrial Animals, 2011 (www.oie.int). The information provided below is only intended as a summary and for a complete picture Chapter 2.4.6 of the OIE Manual is highly recommended.

Much effort has been made to develop diagnostic tests for use on live cattle and a number of apparent successes have been reported. However, the consensus seems to be that there is currently no reliable test available for use on live animals. All diagnostic methods are based on histopathology and/or identification of the presence of PrP^{Sc} in the brains of suspect cases.

Histology – which enabled the observation of typical TSE-associated vacuolation in the brainstem, particularly at the level of the obex – was initially the only diagnostic test available. In situations where large numbers of samples have to be examined this approach, even when enhanced by use of immunohistochemistry (IHC) is cumbersome and time consuming, especially if the brain has to be removed from the skull. For that reason sampling methods that retrieve samples of the brainstem through the *medulla oblongata* were developed. These are depicted in Chapter 2.4.6 of the OIE Manual (see above & www.oie.int).

Negative staining of extracts of brain material treated with detergents also enable diagnosis by electron microscopy but this method is now seldom used as a routine. Similarly, biological testing using specific

strains of laboratory mice is also possible but impractical for routine diagnosis for a number of reasons, the main one being the long period of time required to produce a result.

Methods for more rapid diagnosis (available in kit form) and application to large numbers of samples based on ELISAs (enzyme-linked immune-assay) for detection of PrPSc are widely available. Western blots can also be used to test multiple samples simultaneously.

Appropriate laboratory tests and combinations thereof depend on the particular circumstances associated with the planned investigation.

Video link: <http://www.youtube.com/watch?v=pC04eApfAE8&feature=youtu.be>



CONTROL / PREVENTION

The control of BSE should be very simple; all that is needed is to prevent ruminant offal – brain and spinal cord particularly – entering the animal feed chain, i.e. being rendered and incorporated into feed for cattle. If that is done BSE cannot persist in a cattle population and vCJD will likewise not occur.

It turns out this is easier said than done because although most countries in the world today (including southern African countries) have such legislation in place, enforcement is variable and sometimes perfunctory. In Africa the issue is, furthermore, contentious because indigenous cases of BSE have not so far been diagnosed in Africa and there is consequently a belief that it could not occur here. This belief belies the fact that cattle and possibly MBM were imported into some countries of the Region when the BSE epidemic in Europe was at its height. So the BSE agent could have been introduced and perpetuated because the controls in place in some southern African countries are inadequate (Thomson, 2010).

BSE is one of four diseases for which OIE-member countries (or zones or compartments within countries) can apply to the OIE for recognition of official status. Unlike, the other three diseases, application cannot be made for recognition of freedom from BSE; the OIE only lists countries or zones⁴ where BSE surveillance and the risk mitigation system are indicative of two situations (for countries which are in neither category the risk is considered 'undetermined'):

- Negligible BSE risk;
- Controlled BSE risk.

For countries or zones not listed by the OIE as having negligible or controlled BSE risk status, such countries or zones are considered to present 'undetermined BSE risk', i.e. the risk is potentially uncontrolled. In effect, undetermined BSE risk can have serious trade implications. All African countries are currently in this latter category which results in some countries refusing to import beef from African countries.

However, the OIE recognises some commodities and products as being inherently safe irrespective of the disease classification of the country, zone or compartment of origin (because the BSE agent is not present in transmissible quantities in such commodities/products even if derived from infected animals). Among these are milk and milk products and deboned beef, i.e. it is possible to safely export these commodities and products even if the locality of origin is not recognised as having a negligible or controlled BSE risk. There is no doubt, on the other hand, that BSE has in the past been used as a non-tariff barrier to beef imports, i.e. trade protectionism.

The problem with the OIE standards for achieving recognition of negligible or controlled BSE risk is that the financial, technical and logistical requirements recommended by the OIE are exceptionally onerous; this is especially so in respect of the surveillance requirements. So African countries are faced with a dilemma: Is the outlay associated with proving negligible or controlled BSE risk going to justify the potential return on the investment required to achieve it? This can only be decided on a case-by-case basis.

The surveillance system recommended by the OIE to support the risk assessment for BSE risk being either negligible or controlled is described in detail in Articles 11.5.20-11.5.22 of the TAHC – known as Type A and Type B surveillance respectively. Type A surveillance is intended to show that BSE is unlikely (95% confidence) to occur at a rate of greater than one case per 100 000 head in the cattle population concerned. Type B surveillance on the other hand was developed around a design prevalence of one case per 50 000 head in the cattle population. The system is based on accumulation of points accorded for sampling various age and health groups of the cattle population. For, example, surveillance among

⁴ Application for official recognition by the OIE of compartments is not provided for; therefore for compartments the matter needs to be negotiated bilaterally between trading partners

cattle below 30 months of age earns very few points, while surveillance among cattle over 30 months of age and those suffering from neurological disease earns much higher points. The simple fact is, however, that in cattle management systems employed in southern Africa earning sufficient points by either Type A or B surveillance would be logistically and financially very difficult.

An issue associated with the risk assessment for BSE recommended by the OIE (see Articles 11.5.23-11.5.29 of the TAHC) is disposal of so-called specified risk materials (SRMs – tissues/organs with a high risk of containing the BSE agent such as brain and spinal cord) in abattoirs and meat processing plants. Ideally these should be incinerated so that they are removed from the human and animal food/feed chains. However, other than in export abattoirs in Botswana, Namibia and Swaziland this is almost never done in abattoirs in southern Africa. In fact, cattle heads are sold directly out of abattoirs throughout southern Africa on a daily basis. This means that if BSE were present in the region the human population would be exposed to a very high risk situation.

The next-best option for management of SRMs is to render them effectively. It is now recommended that in order to effectively reduce infectivity of the PrP^{Sc} that causes BSE (not necessarily fully inactivate it), material that potentially contains SRMs should be heated to 133 °C at a pressure of 3 bar for 20 minutes (MBM particles should also not have a diameter greater than 50µ – Article 11.5.19). It is important to appreciate, however, that BSE can be adequately managed even when rendering practices are inadequate as was shown in the UK (Ducrot *et al.*, 2008).

MARKETING AND TRADE / SOCIO-ECONOMICS

Perhaps the best illustration of the trade effects BSE can have is what transpired in the USA where, so far, only 4 cases have been identified – the first in late 2003 and the most recent in April 2012.

The beef industry in the US is enormous and until 2003 was the world's largest exporter. Following the occurrence of the first BSE case in late 2003 there was a precipitous fall in beef exports from \$ 3.6 billion in 2003 to \$ 700 million in 2004, i.e. close to an 80% drop. By 2007 only about 2/3 of this loss had been recovered.

Most of the loss of exports was due to the refusal of two countries to continue to import beef from the USA, *viz.* Japan and South Korea which together accounted for about half of the US's exports.

It will be interesting to see whether, following the discovery of another BSE case in the USA in April 2012 to what extent the events of 2004 will be repeated. It is likely the effects will be less dramatic because the hysteria around BSE has declined in recent years but also because the US has lost its dominance of the international beef market. BSE is one of the reasons for that development but there are a number of others as well.

Another reason the most recent case of BSE will probably have a lower impact than in 2004 is that the molecular mass of the PrP^{Sc} of that case was found to be L (i.e. lower than the usual type – see above). There is speculation that this case may have occurred spontaneously and was not occasioned by consumption of rendered carcass material incorporated into animals feed. This issue continues to evolve.

IMPORTANT OUTBREAKS

The number of BSE cases diagnosed in the UK between 1986, when the disease was first formally identified, and the present is available from the OIE website (www.oie.int). At the peak of the outbreak in 1992 there were over 37 thousand cases while in 2011 there were only 11 (Figure 1). At the start of the outbreak the UK exported about \$ 800 million worth of beef but in the first year of the outbreak the losses generated amounted to \$ 980 million and 45 000 jobs were lost apart from many businesses closing. As mentioned in the introduction the total cost to the UK economy resulting from the BSE epidemic may have amounted to as much as \$ 13 billion (about R 1.7 trillion). However, these bare statistics do not reveal the huge psychological impact the disease had on the people of the UK.

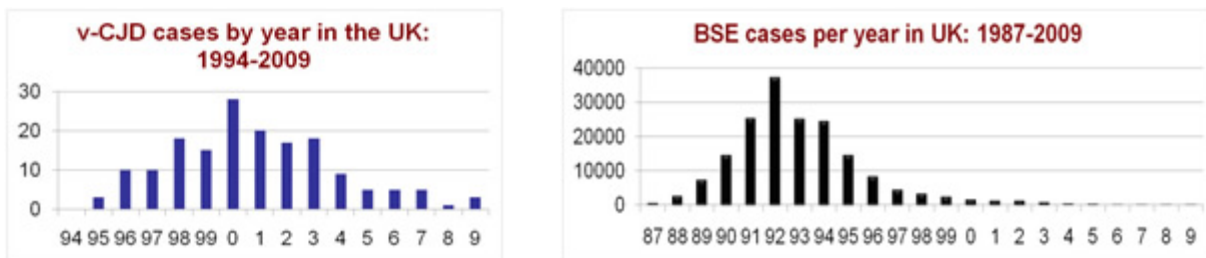


Figure 1: Comparison between BSE & vCJD epidemic curves in the UK: 1987-2009

FAQ

1. What is BSE?

BSE is a neurological disease of adult cattle (very rarely also of goats and potentially sheep) thought to be caused by a transformed normal cell-membrane protein (a prion) spread between cattle by the incorporation of rendered cattle offal containing nervous tissue (usually in the form of carcass meal) that is incorporated into cattle feed (formulated high protein rations).

2. Is BSE a zoonosis?

Yes, a small proportion of people who consume offal derived from cattle infected by eating rendered ruminant protein are likely to develop a fatal neurological disease known as variant Creutzfeldt-Jakob disease (vCJD).

3. Do any of the other transmissible encephalopathies (TSEs) of animals (i.e. mink transmissible encephalopathy or chronic wasting disease of deer) affect people?

Although there has been much speculation that hunters in North America are likely to be exposed to dangerous disease by eating venison from animals they have shot, no such cases have so far been recorded. Mink TSE has likewise not been identified in people.

4. How much of a threat is BSE in southern African countries?

An accurate answer to this question is difficult to provide because although BSE has so far not been diagnosed in Africa, it is probable that infected cattle and/or contaminated carcass meal were imported into some southern African countries in the 1980-90s and perhaps even later. For that reason it is possible, although unlikely, that the prion has been recycled by feeding of carcass meal to cattle in southern Africa because this practice occurred for many years. Although the practice is now banned in all southern African countries, enforcement of the so-called feed ban has been variable. Added to that many people all over southern Africa consume cattle brains daily because cattle heads are sold directly to the public from many abattoirs in the Region. Therefore, if the BSE agent were to be present people would be at high risk.

5. When could the ban on incorporating rendered offal into ruminant feed be safely lifted?

It is likely that BSE will never be eradicated because the normal cell-membrane protein (prion) can arise theoretically spontaneously in all mammals, albeit at an extremely low rate. Therefore, it is essential that feed bans designed to prevent ruminant proteins entering the ruminant feed chain remain in place. So the answer to the question seems to be 'never'.

6. How is it that domestic cats, lions, tigers, cheetahs and various antelope have been diagnosed with a disease that resembles BSE?

Disease in wildlife has only been confirmed in captive animals that have been fed formulated rations produced in essentially the same way as cattle feed, i.e. feedstuffs that contained rendered ruminant proteins.

7. Has BSE been recorded in non-mammals?

There are no confirmed cases although there is a report of a similar disease occurring in red-necked ostriches.

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