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Assessment of Risk from Possible BSE Infectivity in Dorsal Root Ganglia

for

The Food Safety Authority of Ireland

DNV CONSULTING

Management & Technology Solutions

Palace House,
3 Cathedral Street,
London SE1 9DE,
United Kingdom
Tel. +44 (0) 20 7357 6080
Fax. +44 (0) 20 7357 0475
http://www.dnv.com
Det Norske Veritas Limited
Org. No. 1503799

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Approved by .....
Philip Comer
Business Leader, DNV Consulting

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Management Summary

The risk of exposure to the BSE infective agent due to any infectivity present in dorsal root ganglia of beef sold for domestic consumption has been assessed for the population of the Republic of Ireland for the year 2000 and the risk reduction due to removing meat from the bone estimated.

Dorsal root ganglia (DRG) are part of the peripheral nervous system and are located within the vertebral column. DRG connect to the spinal cord but would not normally be removed with the spinal cord when that is removed as SRM at the time of slaughter. Some cuts of beef, notably T-bone steaks and some cuts of rib of beef, are sold to the consumer with the vertebral column and there is therefore the possibility that people could be exposed to potentially infectious material.

In 2000 some 1.9 million cattle were slaughtered in Ireland, but of these only 205,700 (11%) were for domestic consumption. Of the cattle slaughtered for domestic consumption 5% were older than 3 years whilst the percentage of all cattle slaughtered is 30%. A statistical model of the BSE epidemic in Ireland has been used to estimate that 79 cattle were slaughtered in the calendar year before clinical onset of BSE in 2000. Of these 79 only 0.9 would have been slaughtered for the domestic market. Animals slaughtered in the calendar year before clinical onset of BSE are assumed to have a significant level of BSE infectivity, although this would be less than that in a clinical case. Animals slaughtered more than a calendar year before onset are assumed to have no significant infectivity. The model predicts that none of the animals slaughtered in the calendar year before clinical onset of BSE were less than 3 years of age.[1] The model also predicts that the numbers slaughtered in the calendar year before clinical onset will reduce from 79 to 38 in 2001 and 20 in 2002. The predicted risk level would reduce in proportion to these numbers. The actual position should be monitored to check that these predictions remain valid.

The risk has been estimated using an event tree method that can be evaluated using a probabilistic risk assessment approach. This allows the range and uncertainty in the input data to be assessed. Two key assumptions in the assessment relate i) to the fraction of DRG that would remain in the meat when bone is removed from the meat in a butchers shop, and ii) to the fraction of DRG present in a bone in cut such as a T-bone steak that would be consumed. For the former two alternative assumptions are considered; in Case 1 it is assumed that 1% of the DRG are cut away with the meat, and in Case 2 that only 0.1% of the DRG are cut away with the meat. For the latter, a distribution of values with a normal distribution having a 95 percentile range from 5% to 95% has been used.

The DRG Task Force initiated a survey of abattoirs and butchers and a consumer survey to obtain information on the amount of beef sold on the bone in Ireland. The abattoir survey indicated that T-bone steaks would be produced from almost half (44%) of the animals slaughtered for domestic consumption.

The total infectivity ingested for Case 1.1 (where products such as T-bone steaks and rib of beef may be sold) is estimated to be 0.6 human oral ID_{50} units, with a 95 percentile range from 0.003 to 110. This infectivity would be distributed over all the beef eating population of Ireland, and the average individual risk for those that eat beef regularly (the 67% of the population who eat beef weekly) is estimated to be 2×10^{-7} human oral ID_{50} units per person

[1] In the probabilistic assessment, zero animals slaughtered in the calendar year before onset is assumed to have a 95 percentile range from 0 to 3.

per year, with a 95 percentile range of 1×10^{-9} to 4×10^{-5}. The maximum individual risk for those eating T-bone steaks frequently (once a week) is estimated to be 7×10^{-6} human oral ID_{50} units per person per year, with a 95 percentile range of 4×10^{-8} to 1×10^{-3}.

The distribution of the individual risk results is shown in Figure 1 a) on a risk perspective scale. This is a logarithmic scale and includes the risk acceptance criteria in use by the UK Health and Safety Executive for comparison. From the figure it can be seen that the median value for the average individual risk is within the level of what would normally be considered acceptable. However, the range of values extend towards the top end of the range that may be considered tolerable.

If all meat is sold off the bone, then the median value of the total infectivity ingested is estimated to be 0.08 human oral ID_{50} units (Case 1.2), and the median value of the individual risk is reduced to 3×10^{-8} human oral ID_{50} units. The distribution for this case is shown in Figure 1 b) and is now mainly below the 1 in a million risk acceptance level.

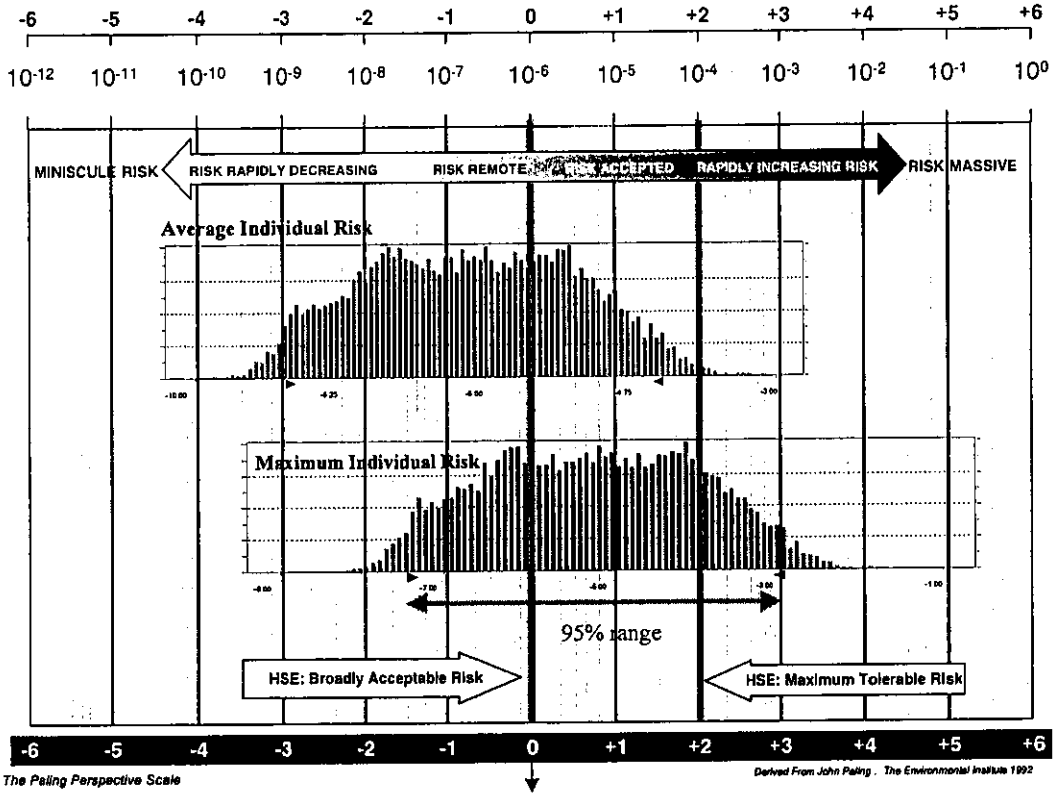
As noted above, the model of BSE epidemic in Ireland predicted that there were no animals slaughtered in the calendar year before clinical onset of BSE at less than 3 years of age. This would suggest that there is no risk associated with animals slaughtered when less than 3 years old, which represent 95% of the animals used for domestic consumption. However, in the probabilistic assessment it is assumed that there is a low probability of some animals being slaughtered in the calendar year before clinical onset. In the risk assessment, 93% of the overall risk is estimated to be due to animals slaughtered at more than 3 years old. Thus over 90% of the risk reduction could be achieved by banning the sale of beef on the bone only from cattle slaughtered at over 3 years of age, rather than from all cattle.

An alternative scenario (Case 2) has also been evaluated with a less pessimistic assumption about the amount of infectivity cut away with the meat by a butcher taking meat from the bone (0.1% as opposed to 1%). This change in assumption makes little difference when meat is sold on the bone (the total infectivity consumed being 0.5 human oral ID_{50} units as compared to 0.6) as most of the exposure is through the bone in meat. When meat is not sold on the bone, this change in assumption reduces the risk by a factor of 10. The total infectivity consumed reduces to 0.008 human oral ID_{50} units and the average individual risk reduces to 3×10^{-9} human oral ID_{50} units per person per year. This latter result is shown in Figure 1 b), and it can be seen that this distribution is now all below the 1 in a million "broadly acceptable" level.

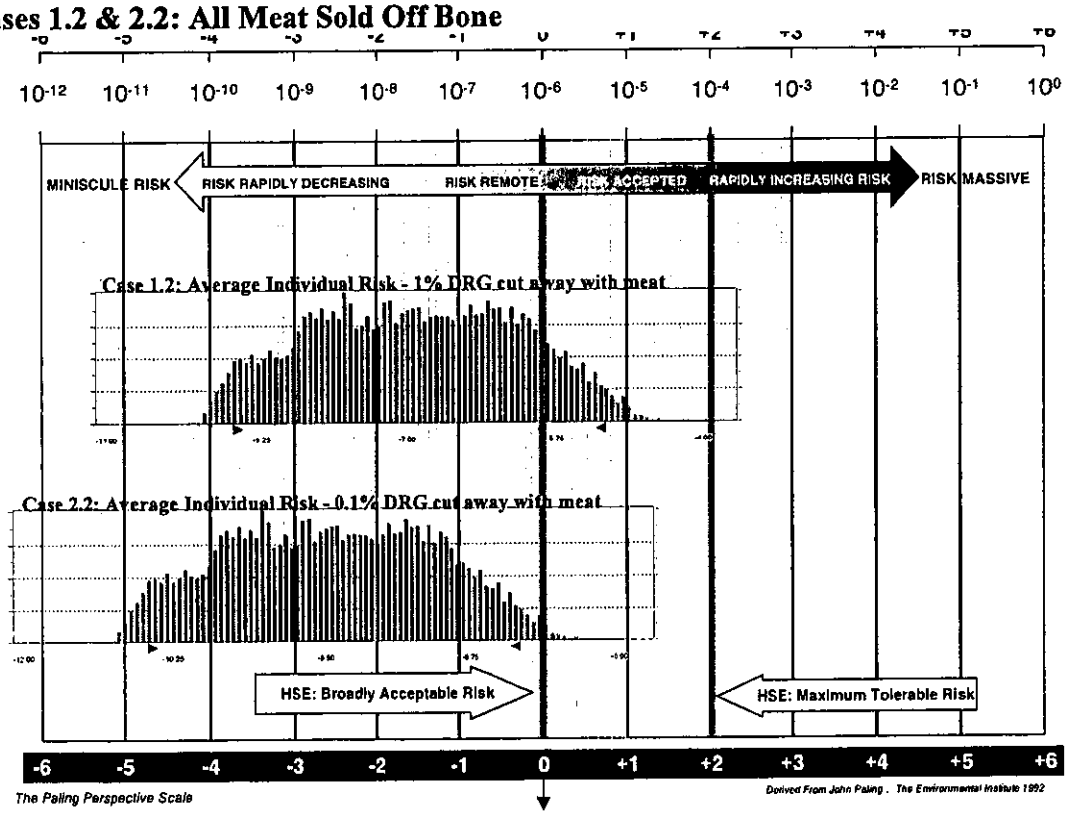
An alternative approach to assessing the risk is to consider the exposure to infectivity for a person who eats a bone in cut taken from an animal with significant infectivity. The infectivity present in one DRG is estimated to range from zero to 22 human oral ID_{50} units, with a median value of 0.1. There is about a 50% chance that any one T-bone would contain a DRG, and 72% of all DRG (average weight 0.5 grams) would contain less than 1 human oral ID_{50} unit. The chance of any one T-bone steak consumed in 2000 having more than 1 human oral ID_{50} unit of infectivity is estimated to be 7×10^{-7} (about one in a million).

Figure 1: Individual Risk of Ingestion of Infectivity (Human oral ID_{50} units /person/ year)

a) Case 1.1: Average and Maximum Individual Risk



b) Cases 1.2 & 2.2: All Meat Sold Off Bone



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1. INTRODUCTION

1.1 Background

In recent years the numbers of BSE cases in the Republic of Ireland have been increasing, although they continue to remain at a relatively low level. This has led to a review of the BSE controls that are in place, and questions about the potential risk from beef on the bone.

One control introduced to safeguard human health early in the epidemic is the removal of all tissues in which any infectivity may be present in an infected animal. These tissues, referred to as Specified Risk Material (SRM), include the brain and spinal cord as well as other tissues. In 1997 experiments being carried out by MAFF in the UK found infectivity in the dorsal root ganglia (DRG) of experimentally infected cattle. DRG are part of the peripheral nervous system and are located within the vertebral column but were not included in the definition of SRM. A problem arose because the DRG would not normally be removed with the spinal cord when that is removed at the time of slaughter. Some cuts of beef, notably T-bone steaks and some cuts of rib of beef are sold to the consumer with the vertebral column; there is therefore the possibility that people could be exposed to potentially infectious material.

In 1998, the UK Government took the decision to ban sales of beef on the bone following the discovery of infectivity in dorsal root ganglia. Sales of beef on the bone were allowed to resume in 2000 following a review by the Chief Medical Officer. In the UK this only applies to cattle aged under 30 months as older animals are excluded from food for human consumption. Subsequently, the EC took a decision to ban sales of beef on the bone across Europe. This came into effect in April 2001.

At the request of the CJD Advisory Committee of the Department of Health and Children, the Food Safety Authority of Ireland (FSAI) established a DRG Task Force and decided to carry out a risk assessment. DNV were asked to undertake this risk assessment as they had carried out the study for the UK Ministry of Agriculture Fisheries and Food in 1997 that helped inform the advice given by the Spongiform Encephalopathy Advisory Committee to government.

1.2 Study Objectives

The objective of the study is to quantify, so far as is possible, the risks to the population of Ireland from the consumption of beef products due to the possible contamination with BSE infectivity in the dorsal root ganglia (DRG) of cattle, and to assess the risk reduction from banning the sale of beef on the bone.

1.3 Approach

The method used for this study has closely followed the approach used for the UK MAFF in 1997 (Assessment of Risk from Possible BSE Infectivity in Dorsal Root Ganglia, DNV Report C7831, December, 1997). The approach has been updated to take account of any new research or data, and applied to the situation in Ireland.

In order to assess the risk from infectivity in DRG it is necessary:

1. To estimate the expected number of cattle slaughtered for human consumption with significant levels of BSE infectivity .
2. To assess the level of infectivity in DRG in an infected animal.
3. To assess what happens to the DRG when meat is cut from the bone, or when bone-in cuts (e.g. rib of beef or T-bone steaks) are consumed.

This information is then combined in an event tree that shows what happens to the DRG in a slaughtered animal and allows the fraction of DRG consumed to be calculated. The event tree model is developed as an excel spreadsheet. There is significant uncertainty about much of the data on which an assessment of this sort is based. The range of uncertainty in the data can be modelled using a probabilistic risk assessment approach such as Monte Carlo simulation. To do this a range and distribution is defined for each of the input factors, and a Monte Carlo simulation tool is used to predict the range of possible values for the result. A software tool called Crystal Ball (Crystal Ball Version 4.0; Decisioneering Inc, Denver, Colorado), that works with Excel spreadsheets has been used to carry out the simulation.

Monte Carlo simulation is a well established technique that enables the modeller to take account of the chance variation that is inherent in most real life problems. The simulation is based on the use of random number generators to select a value from each of the input parameters for which a distribution has been defined. Over a number of iterations the simulation enables the full range of possible values for each variable to be tested, but weights each scenario by its probability of occurrence. In each iteration a new value is selected for each variable and an output value (or values) calculated. This is repeated a large number of times so that a distribution of the output value is built up.

2. BEEF PRODUCTION AND CONSUMPTION

2.1 Beef Production

The Republic of Ireland has a large beef farming sector, with a significant amount of the production going for export. The total cattle population is some 7,800,000. The focus of this study is on the animals slaughtered for domestic consumption, mainly in Local Authority (LA) approved abattoirs, rather than those slaughtered for export.

A total of 1.9 million cattle were slaughtered in Ireland in 2000. The breakdown by age range is summarised in Table 2.1. This shows that whilst 7% of animals were slaughtered in LA Abattoirs for domestic consumption, only 1% of the animals over 3 years, and so more at risk of infection, were slaughtered in LA Abattoirs.

The LA Abattoirs supply about two thirds of the domestic market, with the remainder being supplied from the export approved plants. The latter mainly supply the major supermarket outlets who will normally specify prime beef. It has been assumed that the age profile of animals supplied by the export plants for domestic consumption will be the same as that for the LA Abattoirs. The total number of cattle slaughtered for domestic consumption is estimated to be 205,700 in 2000 (11% of the total).

Table 2.1: Age Profile of Cattle Slaughtered in 2000

Age range	LA Abattoirs		Export approved meat plants		Total
1. Less than 30 months	118,220	86.2%	791,431	45.4%	909,651
2. 30 to 36 months	12,047	8.8%	395,063	22.7%	407,110
3. 3 years to 4 years	5,023	3.7%	230,309	13.2%	235,332
4. Greater than 4 years	1,846	1.3%	326,409	18.7%	328,255
	137,136		**1,743,212**		**1,880,348**

Note: Numbers notified to CMMS

Information was also obtained on the animals slaughtered in LA Abattoirs in each of the 26 counties of Ireland. This is summarised in Table 2.2 below. The data in Table 2.2 show that 21% of all bovines are slaughtered in Cork, with the remainder spread fairly uniformly over the remaining counties. It is also noted that the total in Table 2.2 is different to the total reported to the CMMS in Table 2.1.

Table 2.2: Cattle Slaughtered in LA Abattoirs by County (2000)

County	Number Slaughtered	Percent	County	Number Slaughtered	Percent
Carlow	502	0.3%	Longford	1577	1.1%
Cavan	3987	2.7%	Louth	3335	2.2%
Clare	8320	5.6%	Mayo	6321	4.2%
Cork	31679	21.2%	Meath	8106	5.4%
Donegal	7393	4.9%	Monaghan	2559	1.7%
Dublin	37	0.0%	Offaly	4839	3.2%
Galway	7687	5.1%	Roscommon	7719	5.2%
Kerry	9532	6.4%	Sligo	1410	0.9%
Kildare	3230	2.2%	Tipperary	6733	4.5%
Kilkenny	3499	2.3%	Waterford	1725	1.2%
Laois	4323	2.9%	Westmeath	4226	2.8%
Leitrim	1657	1.1%	Wexford	6969	4.7%
Limerick	5440	3.6%	Wicklow	6725	4.5%
Total	149,530				

2.2 Location of Dorsal Root Ganglia

Dorsal Root Ganglia (DRG) are peripheral nervous system tissues located within the vertebral column. They would not generally be removed with the spinal cord but remain attached to the vertebral column. What happens to the DRG will depend on how the carcase is divided into different cuts of meat and how these are subsequently used.

The vertebrae along the vertebral column can be divided into four groups: cervical vertebra (7), thoracic vertebra (13), lumbar vertebrae (6) and sacral vertebra (5). There are two DRG associated with each of these 31 vertebrae, one on each side of the vertebrae. It is assumed that each DRG weighs about 0.5 g, so that there is a total weight of about 31 g of DRG in one carcase.

The meat associated with the cervical vertebrae is the neck and this is always sold off the bone. The thoracic vertebrae is the part of the carcase used for chuck or rib steaks and again these are sold off the bone.

The next four vertebrae and rib bones are used for rib roasts. This part of the carcase may be sold as rib on the bone, but is also prepared as a boneless rolled joint or as steaks. When sold bone-in, it is common for the bone of the vertebral column to be removed, and to leave only the rib bone. This would remove the DRG.

The sirloin cut includes the 6 lumbar vertebrae and 3 thoracic vertebrae; i.e. 9 out of the total 31 (29%) of the vertebrae and therefore DRGs. It is used to produce both fillet steak and sirloin steak, both boneless, and also T-bone steaks. Some may also be used for a bone-in sirloin roast, but this is not common.

The final section of the carcase along the vertebral column is the rump, associated with the 5 sacral vertebrae. Meat from the rump is sold off the bone.

2.3 Beef Consumption

This study is focussed on assessing the risk from exposure to DRG particularly from beef products sold to the consumer attached to the back bone. In practice, as noted above, this means either a rib roast or T-bone steak.

The FSAI sent out a questionnaire to all abattoirs in Ireland asking for information on the numbers and age profiles of bovines slaughtered during 2000, and the proportion of beef sold from the abattoir on the bone. Unfortunately, the results of this survey were difficult to interpret, and did not provide the data needed to assess the amount of T-bones or rib sold.

A follow up survey was then undertaken to a selection of abattoirs asking for more detailed information on the amount of rib of beef and T-bones sold. Responses were received from a total of 72 abattoirs from 7 counties. These 72 abattoirs slaughtered 12,133 bovines during 2000, out of the total of 149,530 slaughtered in local authority abattoirs (8%).

Rib of Beef: Of the 72 respondents, 17 (24%) sold rib on the bone but only 6 (8%) sold it with the backbone. On average, these 6 abattoirs sold a total of 58.3 ribs on the bone per week in 2000 at an average weight of 8.3 kg. However, 55 of these were from a single large wholesale butcher which has a significant influence on these results. These results indicate that rib of beef on the bone is produced from 12% of all animals slaughtered. (This assumes that one rib with 4 rib bones is cut from each half carcase).

T-bone steak: 68 (94%) of the 72 respondents sold T-bone steaks. On average 19 steaks of 460 g each were cut from each half carcase. The numbers sold per week ranged from 1 to 1330, the latter being from the same large wholesale butcher as mentioned above, with an average of 73. The maximum possible number of T bones from each butcher was estimated by multiplying the number of animals slaughtered by the recorded number of T bones per carcase. In some cases the respondent had estimated a larger number of T bones sold than the maximum possible from the numbers slaughtered. In these cases the number based on the number of animals slaughtered was used. With this adjustment, the survey shows that on average 44% of the sirloin section of the carcase is used for T bone steaks.

Customer Survey: In addition to the data from the abattoirs, a survey of beef consumption habits was also carried out by Lansdowne Market Research in February/March 2001. 1200 interviews were conducted among a nationally representative sample aged 15+. The main results of the survey are summarised in Table 2.3. The survey indicates that 40% of all adults ate rib of beef at least once last year, with 30% eating it once a week and 17% once a month. However, much of this would have been bought with the rib bone but not the back bone (this was not differentiated in the survey). For T bone steaks, again 40% of all adults ate this some time last year with 21% eating it once a week and 22% once a month. For all beef products, the survey showed that 67% of respondents eat beef weekly. The survey also showed that a high proportion of people eat out, with 27% eating out weekly and 26% monthly. However, relatively few of those eating out choose either rib on the bone or T bones regularly (20% Sometimes, 33% Occasionally, and 33% Never).

Table 2.3: Beef Consumption Survey Results

	Frequency of eating beef in 2000 All Adults 15+		
	Any Beef	Rib Roast	T-bone Steak
Daily	2	0	0
Weekly	67	30	21
Monthly	10	17	22
Less Frequently	4	11	17
Never	14	10	10
Don't know	2	32	31

The survey results suggest an unexpectedly high proportion of people eating T-bones and rib of beef frequently. If it is assumed that a weekly consumer eats a rib roast/T-bone 52 times a year, a monthly 12 times and Less frequently 4 times, then with an Irish population of 3.7 million (and assuming 80% aged 15+ - guess) the survey results would indicate that about 42 million T-bone steaks were consumed in 2000. However, it is known that 205,700 animals were slaughtered for the domestic market, and that 44% of these were used to produce T-bone steaks with an average of 38 per carcase. This indicates a total production of about 3.5million T-bone steaks in the year, about a factor of 10 less than that suggested by the beef consumption survey. Thus the survey results seem to have overestimated beef consumption, but the reason for this anomaly is not known. Reducing the percentage of weekly and monthly T-bone eaters from 21% to 1.8% gives a match to the beef production figures, and it is proposed to use this modified result for this assessment.

2.4 Exposure to DRG

In order to estimate the exposure to infectivity in DRG it is necessary to estimate how much of the DRG would be consumed. Two situations need to be considered, a) meat that is removed from the vertebral column by the butcher or wholesaler, and b) meat that is sold to the customer on the bone.

Meat sold off the bone: Some limited trials were carried out to examine whether the DRG is likely to be removed when meat is cut from the bone by the butcher or whether it would remain with the back bone. In this study, carried out by the Department of Veterinary Anatomy at University College Dublin, the vertebral columns removed from four beef carcases were examined for the presence or absence of DRGs. They reported that the only nerve tissues remaining were spinal nerve roots at each intervertebral foramen, associated with which were the DRGs, easily discernible as small brown masses. In all the segments examined DRGs remained on the vertebral column and were not cut away with the meat. The only exception to this was the DRG of the first cervical spinal nerve. This nerve emerges through the lateral vertebral foramen of the atlas on each side. Its DRG lies towards the outside of this foramen. In one instance a portion of this ganglion was removed.

This would suggest that about 1 in 240 (0.4%) of DRG may be cut away with the meat when the bone is removed. Whilst this is useful to confirm the likely range of values, it was only a limited trial and does not provide statistically significant results. It is therefore proposed to assume that 1% of DRG would be cut away with the meat when the bone is removed. This is

in line with the assumption made in the UK study, and should err on the side of caution. An alternative case where only 0.1% is cut away with the meat will also be evaluated.

In commercial boning plants, which operate at high throughput, it was thought that DRG would be less likely to be removed than in small butcher shops, where the butcher may have more time to cut residual tissue from the bone for inclusion in mince etc.

Meat sold on the bone: For meat sold on the bone, it is necessary to estimate how much of the DRG contained within the vertebral column would be consumed. There are no data for this and it would be difficult to determine with any certainty. In the previous DRG risk assessment for the UK it was considered that the DRG would not normally be eaten and it was assumed that any DRG present would be consumed 5% of the time. A worst case of the DRG being consumed 100% of the time was also considered.

Some members of the DRG Task Force considered that 5% was low, as once the meat was cooked the DRG would come away from the bone easily. In addition, there is also the possibility that the bones would be used to make stock. In this situation it is more likely that all tissues would be removed from the bone.

Following discussions with the DRG Task Force, it is proposed to use a distribution of values with a normal distribution having a 95 percentile range from 5% to 95%. The sensitivity to this range of values will be tested by using fixed values at the limits of this range.

Cooking: It is assumed that cooking will have no effect on the infectivity.