danish meat association

Ministry of Food, Agriculture and Fisheries
Danish Veterinary and Food Administration

Assessment of risk for humans associated with Supply Chain Meat Inspection – The Danish Way

December 2008

List of contents

Preface

In 2007, the Danish Parliament decided that a modernisation of meat inspection should be initiated. As a part of the modernisation three institutions – The Danish Veterinary and Food Administration (DVFA), Department of Veterinary Pathobiology, Faculty of Life Science, University of Copenhagen (KU-Life) and Danish Meat Association (DMA) - in collaboration undertook a project regarding meat inspection of finisher pigs, housed under controlled conditions. The intention of the project was to identify how meat inspection could be modernised without jeopardising human health.

The objective of meat inspection is to focus on the hazards that constitute a risk for food safety. Moreover it should be ensured that the control of finisher pigs conducted ante- and post mortem is performed in a way that results in a high level of food safety.

When changing the meat inspection it must be ensured, that not just food safety but also the zoo-sanitary standards are not affected negatively.

The Danish pig meat production system is covered by a thorough registration, marking and documentation which makes a tracing of the meat through the production chain possible. This is in line with the mandatory requirement within the European Union that so-called food chain information from all parts of the food chain should be exchanged prior to sending animals for slaughter. This includes the primary producer, the slaughterhouse and the competent authority.

We suggest that two specific inspection procedures will be omitted from the routine meat inspection: the opening and incisions of the heart and the incisions and palpation of major mandibular lymph nodes. A carcass with visually observable pathological findings will still have its hearts and mandibular lymph nodes palpated and incised.

We combine this approach with the food chain information which is being exchanged between the herd and the slaughterhouse and we call the entire approach Supply Chain Meat Inspection – The Danish way. This modernisation of meat inspection will only apply to finisher pigs from integrated production systems.

Prior to initiating such a change, we undertook a risk assessment to identify if there was a risk for humans or for the zoo-sanitary status. We followed international guidelines for how to conduct risk assessments. To ensure the quality of the risk assessment, we asked three independent, internationally recognised as experts in food safety to act as external reviewers. Their reviews – and our response to the issues raised - have been included in an appendix to the risk assessment. The experts were:

1) Katharina Stärk, Professor, Veterinary Public Health, the Royal Veterinary College, London,
2) Truls Nesbakken, Professor, Food Safety, the Norwegian School of Veterinary Science, Oslo,
3) Eystein Skjerve, Professor, Epidemiology of Food-borne Diseases, the Norwegian School of Veterinary Science, Oslo.

The risk assessment is public and can be obtained either upon request or directly on the home page of our institutions www.danishmeat.dk and www.fvst.dk. The risk assessment acts as decision support for the Danish Meat Association. Just as importantly, it constitutes a documentation of why the changes suggested are safe for both humans and animal health. This is of importance for both our trading partners as well as the Danish consumers.

The authors
Lis Alban[1], Charlotte Vilstrup[2], Birthe Steenberg[1], Henrik Elvang Jensen[3],
Bent Aalbæk[3], Flemming Thune-Stephensen[1] and Susanne Jensen[1]

[1] Danish Meat Association, Axelborg, Axeltorv 3, DK-1609 Copenhagen V, Denmark
[2]: Danish Veterinary and Food Administration, Mørkhøj Bygade 19, DK-2860 Søborg, Denmark
[3]: Department of Disease Biology, Faculty of Life Sciences, University of Copenhagen, Grønnegårdsvej 15, DK-1870 Frederiksberg C, Denmark

Abstract

Recent changes in the legislation of the European Union enable the introduction of modifications of the traditional meat inspection of finisher pigs and calves from integrated production systems. Denmark intends to make use of this possibility, initially for finisher pigs and later on for calves. Based on an analysis of the pig-pork chain, two issues came up: what is the food safety value of the routine palpation and incision into the major mandibular lymph nodes as well as the routine opening of the heart? To address the impact on food safety when omitting these incisions, a risk assessment was conducted following international guidelines. To generate input data, two studies were conducted on ten Danish slaughterhouses. Study 1 included the collection of 43 lymph nodes with granulomatous lesions. Study 2 comprised the collection of 88 hearts with macroscopic changes indicating presence of endocarditis. Microbiological and pathological examinations were conducted. Moreover, relevant data from slaughterhouse and laboratory statistics as well as information from the literature and expert opinion were included in the risk assessment.

If lymph nodes are not opened routinely, lymph nodes with lesions might pass the meat inspection unnoticed. Among the different lesions possibly observed in lymph nodes, granulomatous lesions are the most important with respect to food safety, because these might be a result of infection with bovine tuberculosis. A very low prevalence of granulomatous lesions in lymph nodes is observed in Denmark (0.01-0.02%) and only a part of these lesions are found in the mandibular lymph nodes. Study 1 showed that all lymph nodes examined were negative for *Mycobacterium* spp. *Rhodococcus equi* was most commonly found (63%). In one case (2%) *Nocardia farcinica* was found, and the remaining 35% of the samples were culture-negative. Avian tuberculosis is occasionally found in backyard poultry, zoological gardens and pigs. There is no risk that consumers should acquire bovine tuberculosis from eating Danish pork because Denmark is officially free from this disease since 1980. There is a low risk of exposure to avium tuberculosis from pork, because of the low prevalence and because the mandibular lymph nodes are entirely used as pet food after adequate heat-treatment. Moreover, the prevailing opinion in the literature is that avian tuberculosis is not pork-borne. There is a very low exposure risk of *Rhodococcus equi* but this organism is not considered pork-borne either. It should be noted, that routine palpation and opening of lymph nodes in the head area might result in spreading of food safety hazards like *Salmonella* and *Yersinia*.

If hearts are not opened routinely, a case of endocarditis might pass the meat inspection unnoticed. A very low prevalence of endocarditis is generally observed in Danish finisher pigs (0.01%). Study 2 showed that endocarditis was primarily associated with *Streptococcus* spp. (51%), secondly by *Erysipelothrix rhusiopathiae* (32%), *Lactobacillus* (5%) and *Arcanobacterium pyogenes* (1%). The remaining samples were either awaiting identification (6%) or culture-negative (6%). The agents found in the hearts are primarily occupational hazards and not meat-borne. This implies that you do not get ill from consuming meat contaminated with these micro-organisms. To reduce exposure of the consumers to these occupational hazards, we suggest that the hearts are opened after meat inspection by slaughterhouse workers and prior to sales. This will reduce the spreading of these hazards from the heart to the carcass and further on to slaughterhouse personnel and consumers.

In conclusion, it was found that omitting the incisions into the mandibular lymph nodes as well as omitting the routine opening of the heart do not seem to be associated with an increased risk for human health. Likewise, the suggested changes seem to have a positive effect on the working environment, and there is no negative effect on the zoo-sanitary status.

Keywords: Pigs, Meat inspection; Risk-based; Food safety; Granulomatous lesions; *Mycobacterium spp*; Endocarditis; *Streptococcus* spp.; Supply Chain; Traceability

1. Introduction

1.1 Background

The objective of meat inspection is to ensure safe and savoury meat for human consumption. Meat inspection has been conducted for more than 100 years. During that time period, the hazards have changed. However, the current meat inspection is to a large extent based on the hazards of the past. This implies that in some countries resources are spent on looking for *Mycobacterium bovis* even though this kind of tuberculosis was eradicated decades ago. Moreover, the hazards of today, like *Salmonella* and *Yersinia*, are not addressed adequately because they cannot be found macroscopically. That results in a number of people getting ill. A part of these cases could have been avoided, if meat inspection was adjusted to the hazards of today.

With the creation of the internal market in 1992 in the European Union (EU), several directives in the area of food hygiene were adopted. This has resulted in a high level of food safety, whilst ensuring free circulation of commodities. The directives cover food of animal origin on the one hand, and food of non animal origin on the other hand, reflecting a difference in approach. For food of animal origin a set of very detailed and product-specific rules has been developed.

For the EU Commission there was a legal obligation to examine the relationship between the different Community food hygiene rules. This resulted in The White Paper on Food Safety (Anon., 1999) which introduced the principles of risk-based approach, the farm-to-table principle, the prime responsibility of food business operators, and the supervising role of the competent authority. Moreover, according to EU regulation (EC) No. 852/2004, the primary responsibility for food safety rests with the food business operator (Anon., 2004a). Those basic principles are the cornerstones in the EU-legislation on food hygiene.

In reality, no inspection can remove all hazards, but correctly conducted, meat inspection will lower the risk of humans becoming ill. To increase effectiveness, meat inspection should focus on the most important hazards found in the population of interest. It should here be taken into account that the hazards might vary due to variations over the years as well as between geographical areas and production types. According to this line of thinking, meat inspection should be risk-based. The risk-based approach to meat inspection was endorsed by the Ruwenberg World Congress on Meat and Poultry Inspection in 1997 (Anon., 1998). Since then several countries have worked with a modernisation of meat inspection (See section 1.3 for a wider description).

In 2000, the EU Scientific Committee on Veterinary Measures relating to Public Health published its opinion on revision of the meat inspection procedures (Anon., 2000). This report evaluated the effect of traditional meat inspection compared with the effect of a visual meat inspection. The conclusion was among others that post-mortem inspection for finishers in itself assists little in improving food safety with regards to microbiological and chemical hazards. Moreover, the report found that not all lesions were best detected in a traditional system, and the pattern of which lesions were detected with the highest sensitivity in the visual or traditional system varied. The report also listed requirements for which animals that could undergo visual inspection.

This report formed the basis for the relatively new EU regulation (EC) No 854/2004 which specifies how meat inspection of finisher pigs in the EU should be conducted. The regulation has opened up for introduction of modifications of the traditional meat inspection of finishers from integrated production systems reared under controlled housing conditions, if a risk assessment can show that such changes will not jeopardize human health. A list of requirements to controlled housing conditions and integrated production systems can be found in an appendix to Annex VIb of Regulation (EC) No 1244/2007 (Anon., 2007a). The list includes requirements to feed, in-door/out-door rearing, bedding, access to premises, garbage dumps, pest management, and sewage.

Tailored to the new legislation is the requirement that farmers should register all health-related problems observed in the herd. This is called food chain information (FCI) and more details can be found in Regulation (EC) No 853/2004 (Anon., 2004b), Regulation (EC) No 854/2004 (Anon., 2004c), Regulation (EC) No 2074/2005 (Anon., 2005a), Regulation (EC) No 2076/2005 (Anon., 2005b). The FCI should be sent to the slaughterhouse prior to the animals being transported to the slaughterhouse. This enables the slaughterhouse to take appropriate measures concerning logistics and meat inspection.

In Denmark, electronic recording systems which cover the requirements regarding exchange of FCI between the herd owner and the slaughterhouse are in place (Fig. 1). One example is the Central Husbandry Register (http://www.glr-chr.dk/pls/glrchr/chrmenu$.menu) and the central recording of the use of veterinary medication called VetStat (http://www.vet.dtu.dk/Default.aspx?ID=9205) as well as the Zoonosis Register, which contains information about the Salmonella status in the herd. This programme ensures e.g. that finishers from herds with an unacceptable high seroprevalence for *Salmonella* a subjected either to sanitary slaughter or hot-water decontamination after slaughter.

The consumer will receive information through television, radio, or newspaper if meat sold on the market has to be recalled. Such recalls occur through the rapid alert system (http://ec.europa.eu/food/food/rapidalert/index_en.htm).

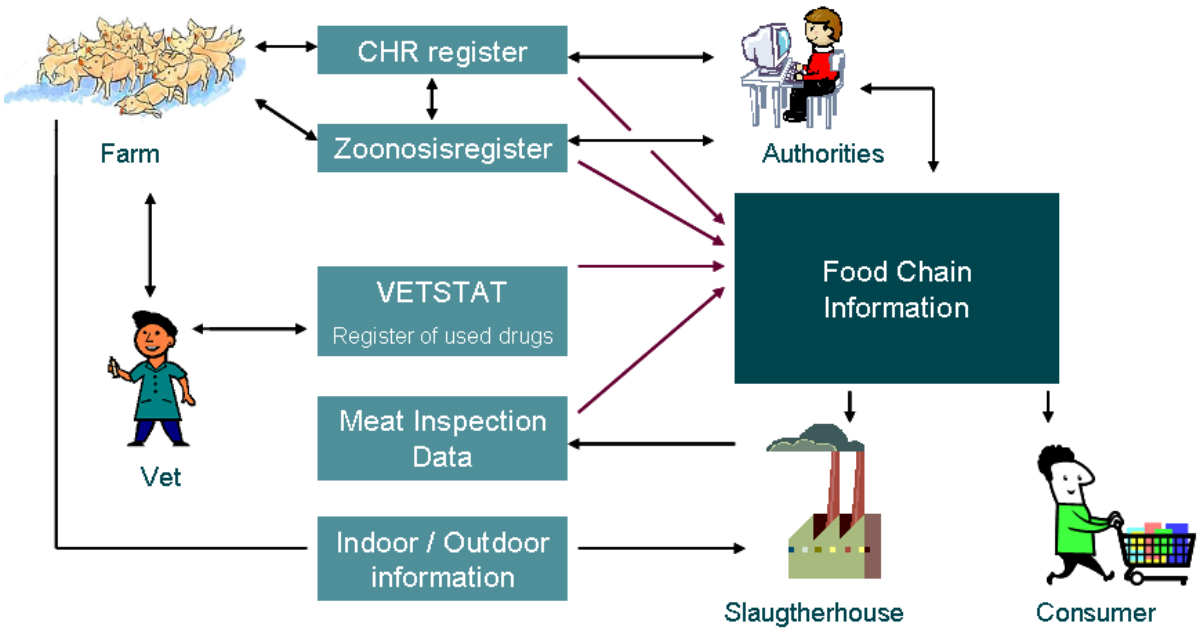


Figure 1
Description of the connection between collection of food chain information during animal production and the slaughterhouse, Denmark 2008

1.2 Identification of relevant modifications to the meat inspection

To identify which changes to evaluate, an analysis of the entire meat chain was conducted. As part of such analysis, discussions were taken among others with slaughterhouse personnel including meat inspectors.

Any modification of the meat inspection will have an effect on not just food safety but often also on other aspects like the working environment. Ideally, a modification will result in the following:

a) improvement of food safety,
b) more cost-effective,
c) no adverse effect on zoo-sanitary standard, and
d) improvement of the working environment.

Through such discussions in Denmark, it was revealed that it was questionable whether two specific routine procedures had any positive impact on food safety. The first dealt with palpation and incision of the mandibular lymph nodes; the second with the opening of the heart. Berends & Snijders, (1997) recommended that the incisions of lymph nodes and palpation of the carcass should be replaced by visual inspection to reduce the potential for further carcass contamination. Moreover, Olsen et al. (2001) found that leaving the tongue in the intact head was associated with a reduction in the prevalence of *Salmonella* positive carcasses. Hence, omission of these cuts might lower the contamination and cross-contamination of the carcasses with common food safety hazards like *Salmonella* and *Yersinia*. The effect might not be statistical significant as found by Hamilton et al. (2002). This is probably because the slaughterhouse workers are also touching the carcass when trimming it.

Finishers from integrated production systems that are kept in-door since weaning have less variation in disease pattern than finisher pigs from other types of production e.g. outdoor-reared pigs. Moreover, exchange of food chain information will ensure that all relevant information reaches the abattoir prior to slaughter. For herds that fulfil these criteria we suggest that the routine incisions into the mandibular lymph nodes and into the heart are omitted. Finishers that do not fulfil these requirements should be subjected to traditional meat inspection. In line, if anything abnormal is observed, then the carcass will go to extended control during meat inspection. We call this way of inspection "Supply Chain Meat Inspection – The Danish Way" to acknowledge the similarities with the kind of meat inspection conducted in The Netherlands but also to distinguish it from this because there are some minor differences (The Dutch system will be described later on in this section).

When conducting Supply Chain Meat Inspection, the meat inspectors neither touch nor cut the lymph nodes or the hearts as a routine action, but only when required. Another term for this is visual inspection. Several studies have compared the effect of visual inspection with the traditional inspection (Hamilton et al., 2002; Mousing et al., 1999; Mousing et al., 1997). These studies have shown that more or less the same pathological findings are found when visual inspection is conducted compared to traditional inspection of finisher pigs. In line, studies carried out in a Danish slaughterhouse have shown that visual inspection of the head of finisher pigs reduced the prevalence of food safety bacteria such as *Salmonella* on the carcass (Sørensen & Petersen, 1999; Petersen et al., 2002).

Supply Chain Meat Inspection is not a 100% visual inspection. The only change compared to traditional meat inspection is that the mandibular lymph nodes and the heart are not opened routinely as a part of the meat inspection.

1.3 Risk-based meat inspection in other countries

Several countries have looked into how an efficient and modern meat inspection should be conducted. Recently, a Scandinavian working group published a common report, in which it was pointed out that there is a need to make the official meat inspection more risk-based and that the use of resources should be optimised (Tema Nord, 2006).

In Sweden, a project on visual inspection of pigs was initiated in the beginning of 2007. The overall aim of the project is to examine to which extent visual inspection is able to reduce contamination of the meat with food-borne pathogens. The project does also focus on how changes in the performance of the meat inspection influence the physically activities and ergonomics for the inspection personnel and the possibility to increase cost efficiency of the meat inspection. The project has been worked out

in close cooperation between the competent authorities in Sweden and the meat industry organisation. In line with the Danish system, a precondition for pigs to undergo visual inspection is the fulfilment of the mandatory requirements on food chain information as well as the pig should be part of an integrated production system. A second phase of the project was started in the early spring 2008 and the project has not yet been concluded upon (V. Larsson, personal communication; Å. Rutegard, personal communication).

In Denmark, a comparative study of the frequency of lesions, detected by visual and traditional inspection of slaughter pigs was conducted from January to July 1993 at a Danish export slaughterhouse. The study included 183,383 slaughter pigs which were first subjected to a visual inspection and then to traditional meat inspection procedures (incision and palpation), as per current rules, by two different inspection teams (Mousing et al., 1997). The conclusion of the study was that more or less the same pathological findings are found when visual inspection was conducted compared to traditional inspection of finisher pigs. Please see section 6.2 for a wider description of the results of the project.

In The Netherlands, a revised meat inspection system has been developed called “The Pork Supply Chain Meat Inspection”. The system is based on exchange of food chain information available at the slaughterhouse prior to slaughter. Moreover, a risk profile on farm level with regards to *Mycobacterium avium* is made available based on serology, performed on a routinely basis. This risk profile should be neutral or low for pigs that are intended for visual meat inspection. The system is audited and verified by the competent authorities. At the slaughterhouse level, the system is supervised by the official veterinarian. The supervision includes a check of the performance of the official auxiliaries as well as a monitoring of the establishment operators on slaughter defects and pathological observations just before cooling, where a certain set of performance standards are to be met (Jelsma, 2008). The inspection of the mandibular lymph nodes and hearts are performed visually in the Dutch inspection system, which was approved by the USA in July 2008 (FSIS, 2008a)

Outside the EU, the Australian meat inspection system is an example of both a risk-based and integrated meat inspection system. Personnel employed by the slaughterhouses carry out the ante- and post-mortem inspection. The competent authority demands that the meat inspection system is based on implementation of an official risk-based quality assurance system, which is audited / revised by the official veterinarian (Anon., 2003). In Australian exporting abattoirs, excision of the sub-maxillary and cervical lymph nodes is performed on a routinely basis by the abattoir company (Anon., 1997a). The excision procedure is considered a quality control point under the company’s HACCP-based Quality Assurance system. Specific requirements from an importing country may indicate additional or alternative procedures. The routine task on examination of hearts is visual with additional palpation of the external surfaces of the heart (Anon., 1997b).

The meat inspection system of slaughter pigs in USA is another example of placing greater responsibility on the industry for the production of safe food. Since 1996, the Food Safety and Inspection Service (FSIS) is conducting a project called HACCP-based Inspection Models (HIMP). The models are based on data collected on five slaughterhouses. The aim is to determine the current food safety and other consumer protection achievements related to the traditional inspection systems. Based on this, performance standards have been developed. As part of HIMP, FSIS has conducted a verification inspection to assure compliance with the standards both ante-mortem and post mortem. A cornerstone of this project is that establishments must take more responsibility for independently identifying and removing minor dressing defects and abnormal conditions that could pose a threat to the consumer. Furthermore, carcasses and viscera that have passed inspection must meet finished product standards, established by the FSIS (FSIS, 2008b). When conducting routine inspection of pig carcasses in the US, the inspection program personnel are required to incise and observe the mandibular lymph nodes, while the heart is only visually inspected (Anon., 2007b).

On Iceland, post-mortem inspection of lambs are performed solely visual according to an equivalence agreement between Iceland and the USA (S.Ö. Hansson, personal communication).

1.4 Aim

The aim of the present study was to assess the food safety risk associated with discontinuing the following two routine procedures in the meat inspection of Danish finisher pigs originating from farms which are a part of an integrated production system:

a) The incision and palpation of the major mandibular lymph nodes

b) The opening and incision of the heart

Moreover, the impact on the zoo-sanitary standard was thoroughly dealt with, while the impact on the working environment was dealt with in brief.

Summary of section 1: Recent changes in the legislation of the European Union enable the introduction of modifications of the traditional meat inspection of finisher pigs and calves from integrated production systems. Denmark intends to make use of this possibility initially for finisher pigs and later on for calves. Based on an analysis of the pig-pork chain, two issues came up: what is the food safety value of the routine palpation and incision into the major mandibular lymph nodes as well as the routine opening of the heart? To address the impact on food safety when omitting these incisions, a risk assessment was conducted. Moreover, the impact on the zoo-sanitary standard was thoroughly dealt with, while the impact on the working environment was dealt with in brief.

2. Materials and Methods

2.1 Description of risk assessment

Risk assessment is an internationally recognised process that enables an objective, transparent, data-based evaluation of risks associated with a given act; in this case two proposed changes in the meat inspection of Danish finisher pigs. A risk assessment can be qualitative or quantitative depending among others on the question raised and the data availability. This risk assessment is primarily qualitative and it is based on the general approach described by OIE (OIE, 2004). This approach differs only in the order of the elements from the guidelines described by Codex Alimentarius. Hence, the following elements were included:

1. Hazard identification
2. Release assessment
3. Exposure assessment
4. Consequence assessment
5. Risk estimation

In the hazard identification (step 1) we judged which agents could be associated with a risk for humans and if so how (occupational hazard or food safety hazard). This was based on information from the literature.

In the release assessment (step 2) the probability of the hazards (identified in step 1) in/on the live animals or the carcass was assessed both based on our two studies as well in-house statistics, the literature, report from official laboratories and expert opinion.

In the exposure assessment (step 3) we estimated the prevalence of the exposure of consumers to the relevant hazards.

In the consequence assessment (step 4) the consequences related to the unwanted outcome were described, based on data from the literature. The unwanted outcome was first seen as a person becoming ill due to exposure to the hazards. Furthermore, the number of people becoming ill was assessed. Data from official statistics as well as expert opinion were used here.

Then we compared the two ways of conducting meat inspection (traditional versus Supply Chain Meat Inspection). Here, we used data from a large scale side-by-side study conducted in Denmark in 1993 (Mousing et al., 1997).

Next, the impact on the national zoo-sanitary status was evaluated based on data from the literature as well as expert opinion. Finally, the impact on the working environment was dealt with in brief.

In Risk estimation (step 5) the conclusions from the previous sections were integrated in an overall risk estimate. Here, focus was on the difference between traditional and Supply Chain Meat Inspection.

2.2 Data collection

The Danish Meat Association (DMA) is an organisation which represents a number of abattoirs accounting for 92% of the pigs slaughtered in Denmark in 2007. A central meat inspection database is run by DMA. Meat inspectors (official veterinarians and auxiliaries) on the slaughterhouses associated with DMA are obliged to report abnormal findings to the database. The database has been in place for more than 10 years. This implies that the prevalence of specific conditions is known even though that reporting might vary slightly from slaughterhouse to slaughterhouse.

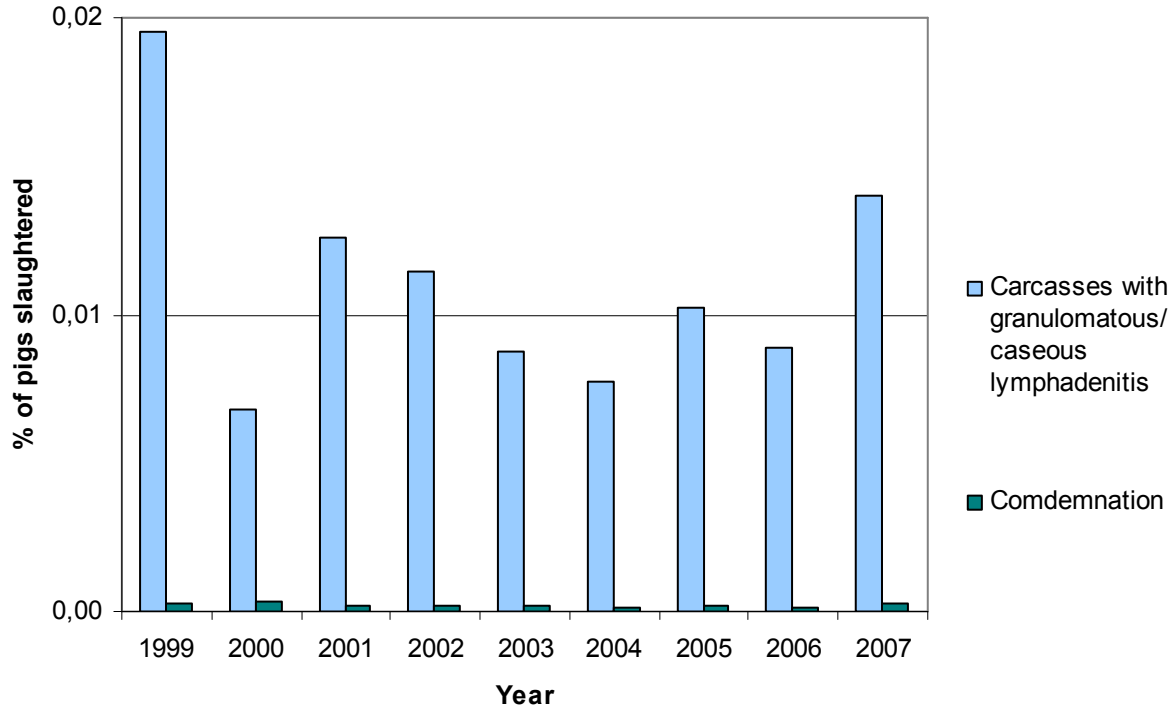


Figure 2
Prevalence of pig carcasses with granulomatous/caseous lymphadenitis and prevalence of condemnation as result of these lesions. Denmark, 1999-2007. Source: Danish Meat Association

The prevalence of granulomatous lymphadenitis in Danish finisher pigs is very low: varying from less than 0.01% to 0.02%. Only a minor part of these findings results in condemnation of the carcass (Fig. 2).

Likewise, the prevalence of endocarditis in Danish finisher pigs is very low; slightly lower than 0.01% in all years from 1999 to 2007. However, around 89% (ranging between years from 85%-92%) of these carcasses are condemned (Fig. 3). Please see section 6.1 for a more detailed description of the meat inspection circular describing when a carcass should be condemned.

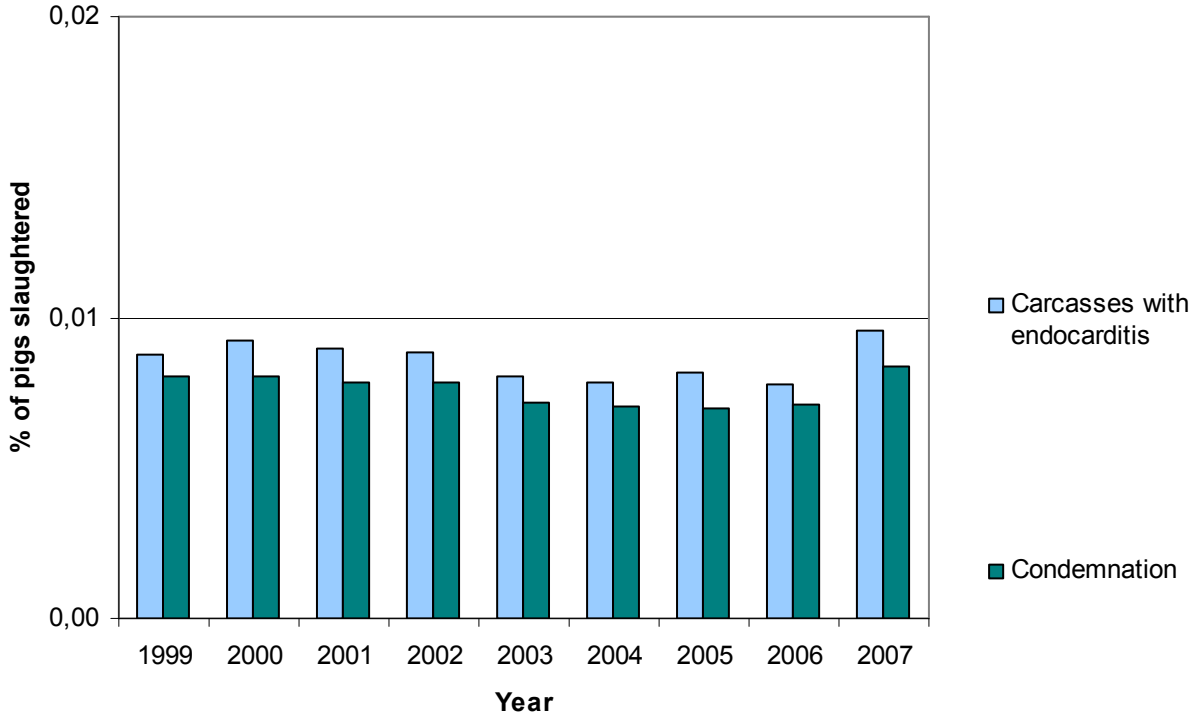


Figure 3
Prevalence of pig endocarditis and the prevalence of condemnation as a result of this finding. Denmark, 1999-2007. Source: Danish Meat Association

As an input to the risk assessment we sampled 43 mandibular lymph nodes with granulomatous lesions. Furthermore, we collected 88 hearts with endocarditis and 57 normal hearts (acting as controls). This took place during normal slaughter operations at ten modern DMA slaughterhouses from March to November 2008. The sample size considerations as well as the design of the study are explained in detail in Appendix A. Sampling was intended to be a 100% sampling (all mandibular lymph nodes with lesions indicative of tuberculosis corresponding to granulomatous/caseous lesions observed in one million finishers). However, the sampling was associated with difficulties; the prevalence was very low and we were only interested in lesions in the mandibular lymph nodes. In several cases the slaughterhouse workers had cleaned out the lymph nodes before the carcass reached the meat inspector.

To ensure a wider basis of information than data from our studies alone, data from the official Danish laboratories and the literature as well as expert opinion were included in the risk assessment. According to Martin et al. (2007a) the confidence to a statement about disease occurrence increases if several kinds of surveillance data are combined and that these are in line and cover a longer time period than one time period only.

Summary of section 2: The risk assessment was conducted following international guidelines. To generate input data, two studies were conducted on ten Danish slaughterhouses. Study 1 included the collection of 43 lymph nodes with granulomatous lesions. Study 2 comprised the collection of 88 hearts with endocarditis. Microbiological and pathological examinations were conducted. Moreover, relevant data from slaughterhouse and laboratory statistics as well as information from the literature and expert opinion were included in the risk assessment.

3. Hazard identification

3.1 Mandibular lymph nodes

According to the EU regulation, traditional meat inspection includes incision of the major mandibular lymph nodes (*Ln mandibulares*). These lymph nodes are in some countries called the submaxillary lymph nodes. Lymph nodes serve as organs that can clear infection from the organism. Several hazards can be present in these organs. Some hazards have or might have a zoonotic impact by being meat-borne or occupational hazards, whereas others are not considered pathogenic at all.

Tuberculosis is the main hazard of interest that can be found in the mandibular lymph node. Infection with tuberculosis might result in development of granulomatous lesions in the lymph nodes. This is seen macroscopically as half-transparent, greyish processes. Often necrosis is present (caseous lymphadenitis) and / or mineralization (Jensen, 2006).

3.1.1 Tuberculosis

Tuberculosis is caused by *Mycobacterium* spp. When dealing with livestock, two types of tuberculosis are of interest: *Mycobacterium bovis* (bovine tuberculosis) and *Mycobacterium avium* subsp. *avium* (in the following called *M. avium* or avian tuberculosis).

Mycobacterium bovis can infect both humans and animals. Humans are infected through meat, milk, fresh cheese or contact. The agent is present in several countries like the United Kingdom. However, Denmark is officially free from bovine tuberculosis since 1980. A large-scale surveillance programme in cattle in Denmark is in place ensuring a constant documentation of the free status (see section 7.1 for a description of the surveillance programme).

Mycobacterium avium can infect birds and animals like pigs and cattle. However, it is only potentially pathogenic to humans. According to Bauer (1999) the clinical presentation of humans infected with *M. avium* complex (MAC) can be largely divided into three groups: 1) pulmonary infections in patients with pre-existing lung disease, 2) lymph node infections in the throat of otherwise healthy, small children, and 3) disseminated infection in severely immune-compromised patients. During the HIV-pandemic the latter group became very important in the 1980s and 1990s. However, due to improvements in treatment of HIV patients, this group is decreasing (Stout & Hamilton, 2006). In HIV/AIDS patients the infection is probably acquired via the gastrointestinal tract. This is contrary to persons without HIV/AIDS, where the most common site of MAC infection is the respiratory tract (Stout & Hamilton, 2006). Identical strains from human and pigs have been shown, reflecting either animals, like pigs, as a source of infection or a common reservoir for human and animals (Bauer, 1999; Komijn, 1999;

Tirkkonen et al., 2007). According to Bauer (1999) the most prevailing opinion is that the source of human infections with *M. avium* is unlikely to be animals, and that the source should be found in the environment. Other possible reservoirs for *M. avium* infection in humans have been reported to be tap water (Von Reyn et al., 1994), hard cheese (Horsburgh et al, 1994), cigarettes (Eaton et al., 1995), and peat (Bauer, 1999).

Outside Denmark, generalized tuberculosis in pigs is uncommon and in most cases a result of infection with *M. bovis* (Jepsen, 1968). The frequent occurrence of *M. avium* in lesions limited to the cervical and mesenterial lymph nodes in naturally infected pigs indicates that infection usually occurs by ingestion (Thoen, 2006). A study by Janetschke (1963 – cited from Thoen, 2006) revealed that the pulmonary route of infection was noted in only 2.7% of the cases, as indicated by involvement of the bronchial lymph node. However, the presence in the bronchial lymph nodes might also be a result of haematogenous spread. Hence, infection in pigs is primarily alimentary.

According to Thoen (2006), infection in a pig is a result of exposure to *M. avium* through 1) use of peat that has not undergone sufficient heat-treatment, 2) soil-contaminated wood shavings, or 3) contact to wild birds or poultry production (or offal from such productions). Previously, the practice of feeding pigs offal from poultry or cattle plants was a risk factor for the introduction of tuberculosis to pigs (Thoen, 2006). This infection route is negligible in the EU today because swill feeding has been prohibited for several years (Anon., 2002).

3.1.2 Other agents

When granulomatous lesions are observed at slaughter, several organisms might be the cause.

According to the literature, the predominant cause of granulomatous lymphadenitis is *Rhodococcus equi*. The lesions associated with infection with *R. equi* cannot be differentiated from those of tuberculosis unless bacteriology is performed (Taylor, 2006). *R. equi* is primarily a soil resident but it is also a transient in the intestinal tract of many species including pigs. Some pig isolates resemble those from humans; however it is not known whether this is because some human cases maybe of porcine origin or it is a result of a common source of exposure. There seem to be no incentive nowhere to institute control measures for *R. equi* (Taylor, 2006). A study by Ottosen (1945 – cited from Thoen, 2006) showed that *R. equi* occurred more frequently in the soil of hog pens than elsewhere. However, newer studies suggest that *R. equi* is less common today (Takai et al., 1996 – cited from Taylor, 2006). It might be speculated that modern in-door pig production systems do not favour the survival of a soil resident like *R. equi*. Humans are also occasionally infected with *R. equi*. The bacterium has been described as a contact zoonosis, and it is not known for being food-borne. In immunosuppressed humans infection might be more severe and in rare cases even life-threatening. Most cases are secondary to HIV infection (Esteves et al., 2007; Linder, 1997) but transplantation patients might also be at risk (Cronin et al., 2008).

M. avium paratuberculosis has also been associated with lesions in lymph nodes in pigs from a pig herd with close contact to a cattle herd infected with Johne's disease (Thoen, 2006). Parasites might occasionally be present as a result of visceral larvae migrans (Valli & Parry, 1993). Neoplasm and fungi can also be found (Jensen et al., 2006).

3.2 Hearts

As part of the traditional meat inspection, the heart is opened and inspected. The most important lesions in the heart of pigs from integrated production systems - that is recorded to the meat inspection database – are pericarditis, epicarditis, apostematous myocarditis (abscess in the heart) and endocarditis.

Most of the bacterial agents which can be found in the pericardium and epicardium are not zoonotic with the exception of *S. suis* which will be dealt with in the following (Leps & Fries, 2008). Moreover, pericardial and epicardial lesions will often be detected without incision because they are usually visible from the outside of the heart. Myocardial lesions might consist of abscesses (e.g. due *Arcanobacterium pyogenes)* (unpublished results).

The lesions in the myocardium might also be caused by parasites like *Echinococcus granulosis/multilocularis* or *Cysticercus cellulosae* (Leps & Fries, 2008). However, infection with *C. cellulosae* can be detected during meat inspection in the masseter muscle, tongue, diaphragm and intercostal muscles of the slaughtered animal (Jensen et al., 2006). *C. cellulosae* has not been observed in Danish finisher pigs since the 1930s (J. Boes, personal comment). Echinococcosis results in the development of cysts in the lung tissue (hydatidosis) (Jensen et al., 2006). The last case of echinococcosis was observed in 1996 (Anon., 2008a). In conclusion, parasitic infections in the myocardium will most likely be diagnosed during meat inspection of other parts of the carcass.

Endocarditis is usually bacterial in cause, the exceptions being an occasional parasitic or mycotic lesion. The lesions are usually primary on the valves. In the pig, *Streptococcus* spp. are the most commonly found organism followed by *Erysipelothrix rhusiopathiae* (Robinson & Maxie, 1993). Other organisms which can be found in association with endocarditis in pigs are among others *Arcanobacterium pyogenes* og *Staphyloccous* spp. (Taylor, 2006). These pathogens are mainly considered occupational hazards and not food-borne. This implies that people at risk are those that are getting regularly into contact with live animals (farmers, veterinarians) fresh carcasses or excretes from the slaughter process (slaughterhouse workers and meat inspectors). Infection is opportunistic and results from the invasion of skin or mucous membranes. Infection requires predisposing factors such as wound in the skin; infection is therefore often secondary.

In particular, *Erysipelothrix rhusiopathiae* is known for being an occupational hazard (Reboli & Farrar, 1989; Wood & Henderson, 2006). Most cases occur via scratches or puncture wounds of the skin. The most common manifestation in humans is a skin infection called erysipeloid. In rare occasions, septicaemia associated with endocarditis is seen (Reboli & Farrar, 1989). According to Fries (1999 - cited from Leps & Fries, 2008) heat-treatment inactivates the bacteria. This might explain why food-borne cases are not reported despite of a non-negligible prevalence of hearts with lesions are exposing consumers to *E. rhusiopathiae* regularly.

S*treptococcus suis* is also mainly considered an occupational hazard. The first case of *S. suis* infection in humans was reported from Denmark in 1968 by Perch. Since then, nearly 200 human cases have been reported world-wide (Statens Serum Institut, 2005). So, *S. suis* infections in humans are considered a rare event. The infection produces meningitis in humans, but other conditions like endocarditis, cellulites, and arthritis have been reported too (Higgins & Gottschalk, 2006). During 1996-1999, only one case of meningitis due to infection with *S. suis* was observed in Denmark, and that was in a pig farmer (Statens Serum Institut, 2000). However, in Hong Kong *S. suis* has been reported as one of the major causes of meningitis in adults (Statens Serum Institut, 2005; Higgins and Gottschalk, 2006). The diseased people all had contact to pigs (Staten Serum Institut, 2005). It is currently being investigated why *S. suis* apparently behaves more aggressively in Hong Kong than elsewhere. Despite of the low number of human cases, Leps & Fries (2008) do not exclude food as a carrier of *S. suis* and mention that consumption of raw or undercooked pork or pork blood might be considered as a source of human infection. This is in line with Berends et al. (1993) who noted that food-borne illness caused by *Streptococcus* might occur as a result of contamination of a meal or meat prepared in advance and stored incorrectly.

Staphylococcus aureus is widely distributed in the environment and is seen on both animals and humans. Strains are exchanged between individuals and across species. *S. aureus* multiplies on damaged mucosal surfaces or skin and can invade to cause bacteraemia. Usually, infection leads to formation of abscesses (Taylor, 2006). A special strain of *S. aureus* which is methicillin-resistant (MRSA) has

attracted attention in recent years. Although infection with MRSA in humans is mainly is a problem on hospitals and nursing homes, six cases related to contact with pigs was observed in Denmark in 2007 (Statens Serum Institut, 2008). Food-borne intoxication as a result of presence of *S. aureus* might also occur but is a result of the development of an enterotoxin related to inadequate storage and cooling of e.g. meat products (Berends et al., 1993; Sutherland & Varnam, 2002).

Arcanobacterium pyogenes is common on the mucous membranes of the upper respiratory tract and the genital tract of several animal species including pigs. Disease is therefore a result of endogenous infection and is sporadic, requiring some predisposing events, such as trauma to initiate the process. Infection is often secondary (Taylor, 2006).

Summary of section 3: If lymph nodes are not opened routinely, lymph nodes with lesions might pass the meat inspection unnoticed. Granulomatous lesions are the most important with respect to food safety, because this might be a result of infection with bovine tuberculosis. Other hazards might be present to. Among these, avian tuberculosis and *Rhodococcus equi* are of greatest importance.

If hearts are not opened routinely, a case of endocarditis might pass meat inspection unnoticed. The most important hazard are here *Streptococcus* spp. and *Erysipelothrix rhusiopathiae.* A pig with endocarditis might also have lesions in other organs.

4. Release assessment

4.1 Prevalence of relevant hazards in the mandibular lymph node

The result of Study 1 is presented in Table 1. It is noted that all lymph node samples were negative for *Mycobacterium* spp. since they were acid-fast negative by Ziehl-Neelsen stain. Moreover, in 63% of the samples *Rhodococcus equi* was found. One sample contained *Nocardia farcinica*. Even though no samples were positive for *M. avium*, the limited sample size makes it impossible to conclude much about the prevalence of *M. avium* in Danish finisher pigs. In the following other data will support the findings in Table 1 and show that the prevalence is probably very low.

The cut surface varied in size from 1-10 mm.

Table 1
Distribution of different organisms found in a study on 43 mandibular lymph nodes with granulomatous lesions and or caseous necrosis in finisher pigs, Denmark 2008

Organism	Number of samples (%)
Negative* for *Mycobacterium* spp.	43 (100)
Rhodococcus equi	27 (63)
Nocardia farcinica	1 (2)
Culture-negative	15 (35)
Total	43 (100%)

* Acid-fast negative by Ziehl-Neelsen stain

In The Netherlands, a significant increase in the incidence of granulomatous lesions in lymph nodes from finisher pigs was seen in the late 1990s. This prompted a large-scale investigation in five slaughterhouses. A total of 856 out of 158,763 pigs (0.5%) had granulomatous lesions either in the submaxillary or the mesenteric lymph nodes. A follow-up study on 402 affected lymph nodes revaled that around half of these lesions were caused by *M. avium* (Komijn et al., 1999). A more recent investigation in The Netherlands again revealed a relatively high prevalence of lesions in the submaxillary lymph nodes in finisher pigs (Komijn et al., 2007). More than 2 million pigs were examined, and 0.75% of these had lesions in the submaxillary lymph node. Infection was clustered within herds and in the nine farms with the highest prevalence, 2.3-5.7% of the animals were found with lesions. Lesions in the submaxillary lymph nodes were 77 times more common than in the mesenterial lymph nodes. A total of 99 lymph nodes with granulomatous lesions were cultured for *M. avium*. However *M. avium* could not be isolated from these 99 lymph nodes. *Rhodococcus equi* was found in 45% of the samples. The two Dutch studies indicate that the prevalence of *M. avium* has strongly decreased over the last decade.

The findings from The Netherlands are in line with the Danish situation; in the second half of the 1990s the prevalence of pigs with *M. avium* was higher than today. Today, the prevalence of avian tuberculosis in Danish pigs is very low. The official laboratory at the Veterinary Institute receives carcasses where more than one lymph node with granulomatous lesions is observed for mandatory laboratory investigation. According to this laboratory, only one to three submissions per year are received, and each submission includes one or two pigs. *M. avium* is sometimes found, but not each time (S.B. Giese, personal communication).

Tuberculosis is not seen in commercial poultry in Denmark, but occasionally in backyard farms with older hens or in birds from zoological gardens (S. Kabell, personal communication). A total of one to seven cases of avian tuberculosis in poultry have been found annually at the official laboratory during 1999-2005 (Anon., 2007c). No cases were found in 2006 and 2007 (Anon., 2008a). In 2008, one bird from a zoological garden was found positive. So, the poultry cases are restricted to backyard poultry or zoological gardens. Moreover, three to four cases are found in wild birds in Denmark annually (S. Kabell, personal communication). The very low prevalence of avian tuberculosis observed in backyard poultry is probably a result of an occasional spill-over from wild birds. The increased industrialisation and separation between poultry and pig production will most likely reduce this exposure further.

In the USA, a similar development in the prevalence of avian tuberculosis has been observed. Data from inspections at US abattoirs have revealed a constant decline since 1922, and data from 1995 shows that in 0.2% of all carcasses, lesions indicating tuberculosis are observed. Only 0.003% of these carcasses are – however - condemned as a result of evidence of generalized tuberculosis (Thoen, 2006).

The figures from The Netherlands and the USA indicate a higher prevalence of granulomatous lesions in lymph nodes than observed in Denmark where only 0.01-0.02% of the finisher pigs are observed with these lesions (see Fig. 2).

4.2 Prevalence of relevant hazards in the heart

The microbiological results of Study 2 on hearts with and without endocarditis are presented in Table 2. It is noted that the most commonly found microorganism was *Streptococcus suis* (46%), followed by *Erysipelothrix rhusiopathiae* (32%) and beta-hemolytic *Streptococci* (6%). The remaining samples consisted of a number of different pathogens, awaited identification, or the sample was sterile (6%) (Table 2). For the hearts without endocarditis, most were culture-negative (79%). Only in 4% of the hearts without endocarditis a pathogen was found. In the remaining cases, the sample had been contaminated (including findings of *Proteus*).

The endocarditis cases found varied in size from a few mm to several cm.

The meat inspectors were asked to record other lesions found on the carcasses where endocarditis had been found. Unfortunately, it was not the impression that the meat inspectors recorded/reported all such lesions. In 20 out of 75 hearts (28%) with endocarditis (and where information was available) other lesions were observed as well. These included: embolic pneumonia, chronic peritonitis, infarct in the kidney, lung stasis, purulent myocarditis, tail biting, osteomyelitis, chronic arthritis, or abscess in the brain. Sometimes more than one of these conditions was present. The presence of these conditions requires that the carcass being subjected to extended meat inspection. All these carcasses were condemned. Please see section 6.2.2 for a discussion of this issue in particular with respect to how this will be dealt with in the Supply Chain Meat Inspection.

Table 2
Distribution of organisms found in a study of 88 pig hearts with endocarditis and 57 pig hearts without endocarditis found at the slaughter line, Denmark 2008

	No. of hearts with organism (%)	
Organism	With endocarditis	Without endocarditis
Streptococcus suis like	40 (45.5)	
Erysipelothrix rhusiopathiae	28 (31.8)	
Beta-hemolytic *Streptococci**	5 (5.7)	
Mixed culture with *Streptococcus*		2 (3.5)
Lactobacillus garvieae	4 (4.5)	
Proteus		1 (1.8)
Arcanobacterium pyogenes	1 (1.1)	
Isolates awaiting identification	5 (5.7)	
Culture-negative	5 (5.7)	45 (78.9)
Contaminated		9 (15.8)
Total	88 (100.0)	57 (100.0)

* Awaiting final laboratory identification.

In a Danish study, Pedersen et al. (1984) reported that the organism most often found in slaughter pigs with endocarditis was *Erysipelothrix rhusiopathiae* (64%, N=147). This is contrary to the findings of the present study where *Streptococcus* spp. were the most commonly found organism (Table 2), however, our findings are in line with Robinson & Maxie (1993). The world-wide development within pig production towards a more industrialised housing and management - with little if any contact to the outdoor environment - might change the distribution of the organisms.

Summary of section 4: Denmark is officially free from bovine tuberculosis since 1980. A very low prevalence of granulomatous lesions in lymph nodes is observed in Denmark (0.01-0.02%) and a part of these lesions are found in the mandibular lymph nodes. Study 1 showed that all lymph nodes examined were negative for *Mycobacterium* spp. In 63% *Rhodococcus equi* was found. In one case (2%) *Nocardia farcinica* was found, and the remaining 35% of the samples were culture-negative. In Denmark, avian tuberculosis is occasionally found in backyard poultry, zoological gardens and pigs.

There is a very low prevalence of endocarditis in Danish finisher pigs (0.01%). Study 2 showed that endocarditis was primarily associated with *Streptococcus* spp. (51%), secondly *Erysipelothrix rhusiopathiae* (32%), *Lactobacillus* (5%) and *Arcanobacterium pyogenes* (1%). The remaining samples were either unidentified (6%) or culture-negative (6%).

5. Consequence assessment

5.1 Assessment of impact of disease on the individual

As shown in the previous section, several organisms present in or on a pig might result in disease in humans either as a result of a food-borne infection or contact to infected pigs or carcasses. Such cases of disease have an impact on the individual they affect. We have grouped the hazards that were identified in the hazard identification based on the following parameters: symptoms, duration, degrees of complications, hospitalization rate, and mortality. Three categories were used: mild, moderate or severe. The details of the grouping can be found in Appendix C and a summary is presented in Table 3.

Human infection with tuberculosis is considered severe. For avian tuberculosis this is only the case for vulnerable groups of the population, which consists of small children, immunosuppresed persons as well as people with pre-existing lung lesions (please see section 3.1.1. for a more thorough description). Infection with *Streptococcus suis* is seldom observed in humans but it might result in meningitis (Higgins & Gottschalk, 2006). The remaining diseases are considered to have a mild or moderate impact of the individual (Table 5).

Table 3
Qualitative assessment of impact of specific infection possibly related to pigs and pork on the individual patient, Denmark 2008

Pathogen	Assessment
Streptococcus suis	Mild to Severe
Staphylococcus aureus	Mild
Erysipelothrix rhusiopathiae	Mild
Mycobacterium bovis	Severe
Mycobacterium avium	Severe among vulnerable groups
Campylobacter spp.	Moderate
Salmonella spp.	Moderate
Yersinia enterocolitica	Moderate

See Appendix C for a detailed description of the assessment

5.2 Observed number of human cases in Denmark

In Denmark, a report of zoonotic diseases in animals and man is published annually and can be found at: http://www.food.dtu.dk/Default.aspx?ID=9202#74145. However, not all diseases are notifiable, and hence, for some of the non-notifiable our knowledge about their incidence is limited. The most common cause of food-borne disease in humans in Denmark is *Campylobacter* spp. and the primary source of campylobacteriosis is poultry and poultry products (Anon., 2006). The second most common cause is *Salmonella*. Here, the primary sources are eggs, poultry and pork of either national or imported origin (Anon., 2006). Currently, Denmark is going through a *Salmonella* epidemic due to a specific strain of *S.* Typhimurium called U292. By November 2008, the source was still unknown (http://www.foedevarestyrelsen.dk/forside.htm - accessed November 26, 2008).

The question of interest is the number of human cases ascribed to pork (outbreaks not included). These are estimated in Table 4. It is noted that *Yersinia enterocolitica* is ascribed to the highest number of human cases (215 cases) followed by *Salmonella enterica* (6.1% of 1,658 cases = 101 cases)

(Anon., 2006). *S. aureus* can act directly as an occupational hazard giving rise primarily to skin infections in humans. It can also be related to food poisoning, but here it is a result of the bacteria developing an enterotoxin during inadequate cooling of e.g. meat products (Sutherland & Varnam, 2002).

In 2006, three cases of bovine tuberculosis in elderly people were reported in Denmark. Infection was believed to consist of a reactivation of an infection acquired years ago when bovine tuberculosis was present in Denmark (Anon., 2006).

Human cases of avian tuberculosis are not notifiable making it difficult to know the exact incidence in Denmark. A survey was made based on specimens received at the Statens Serum Institut in 1995 and 1996. Based on these data, a total of 198 patients were found to be infected with *M. avian* complex (MAC) (Thomsen et al., 2002). If the assumption is made that the incidence has remained the same (and the patients in the 1995-96 study were newly infected and successfully treated), then around 100 cases or less of MAC can be expected per year in Denmark. The number of MAC is lower today than ten years ago because of better treatment possibilities of HIV patients which results in an improvement of their immune system (Stout & Hamilton, 2006). The cause of infection is unknown but is probably a result of environmental exposure (See section 3.1.1 for a further discussion).

Table 4
Incidence of human Danish cases of infection with selected zoonotic pathogens and assessed proportion that is ascribed to pork as well as judgement of ways of transmission, 2008

Pathogen	Incidence[a]	No. of cases	Proportion ascribed to pork	Comment on transmission	Source of information
Streptococcus suis	<0.02	<1 per year	100%	Occupational hazard	Statens Serum Institut, 2005
Staphylococcus aureus	Not notifiable[b]	Unknown	Unknown	Two routes: Occupational hazard and foodborne[c]	Statens Serum Institut, 2008, Sutherland & Varnam, 2002.
Erysipelothrix rhusiopathiae	Not notifiable[b]	Unknown	Unknown, probably very low[d]	Occupational hazard	Reboli & Farrar, 1989
Mycobacterium bovis	0.05	3 cases – all elderly people	Zero	Reactivation of latent infection acquired long ago	Anon., 2006
Mycobacterium avium	2[e]	100[e]	Unknown, probably close to zero	Primarily environmental exposure	Thomsen et al., 2002
Campylobacter	60	3,242	Minority of cases	Batch cooling after slaughter kills *Campylobacter*	Anon., 2006
Salmonella spp.	30.5	1,658	6.1%	Food-borne	Anon., 2006
Yersinia	4	215	100%	Food-borne	Anon., 2006

a: Incidence is measured as number of new cases during the year per 100,000 inhabitants

b: It is not possible to estimate the number of cases of a disease which is not notifiable

c: Enterotoxin might develop during inadequate cooling of heat-treated meat product

d: Contact to Danish Slaughterhouse Workers' Union (NNF) revealed that the prevalence is very low

e: Based on data from a two-year survey from 1995-1996 (Thomsen et al., 2002); lower today due to more effective treatments of HIV-infections

A contact to the Danish slaughterhouse workers' union (NNF), the Confederation of Danish Industry as well as the slaughterhouse Danish Crown revealed that the number of human cases of *Streptococcus* and *Erysipelothrix* among slaughterhouse workers is so low that these hazards are not considered a problem (M. Eliasen, personal communication).

The estimated probability of exposure is presented in Fig. 4 followed by the estimated probability of becoming ill due to consumption of Danish pork (Fig. 5). The figures display the overall risk irrespective of the type of meat inspection in place. The uncertainty around these estimates is displayed too. For example, regarding bovine tuberculosis, our estimate is that there is no risk and we are certain about. The reason is that we are free from this disease since 1980 and we have a surveillance program in place to document freedom. It is noted that there is a high degree of certainty for all prevalence estimates except for avian tuberculosis. Regarding exposure, we know the prevalence of *M. avium* in finisher pigs is very low, but we do not know exactly how low. Moreover, regarding consequences the prevailing opinion in the literature is that *M. avium* is not meat-borne, but we do not know for sure.

Campylobacter is primarily related to poultry and not to pork. Moreover, *Rhodococcus equi*, *Streptococcus spp*. and *Erysipelothrix rhusiopathiae* are considered occupational hazards that only occasionally result in human infection. Only *Staphylococcus aureus* might be food-borne and that is related to development of toxin as a result of inadequate cooling after heat-treatment. This makes *Salmonella* spp. and *Yersinia enterocolitica* the most important pathogens related to Danish pork. Meat inspection *per se* does not have any impact on *Salmonella* or *Yersinia* unless specifically considered. Therefore, a *Salmonella* surveillance-and-control program is in place in Denmark since 1995 (Alban et al., 2002).

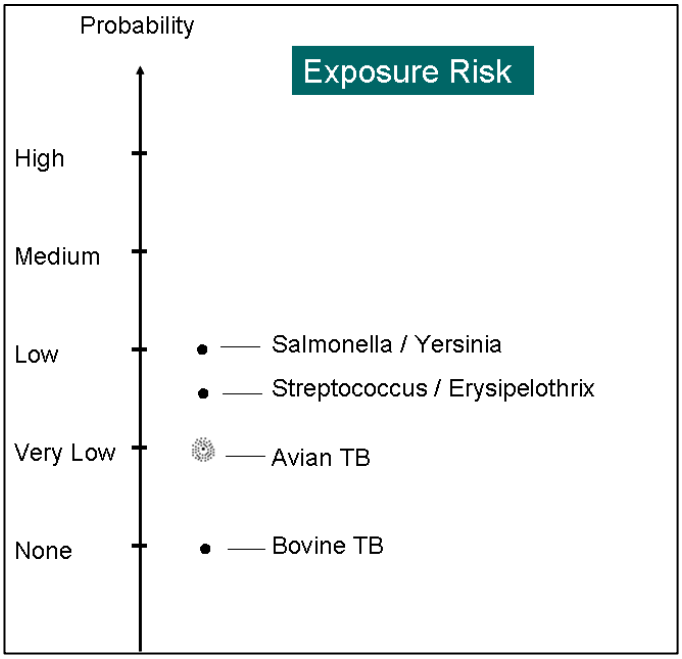


Figure 4
Exposure risk – Probability of exposure of consumers due to consumption of Danish pork, irrespective of type of meat inspection, Denmark 2008

Explanation of symbols used in Fig. 4 and Fig. 5:

- = High certainty linked to estimate of probability
- = Some uncertainty linked to estimate

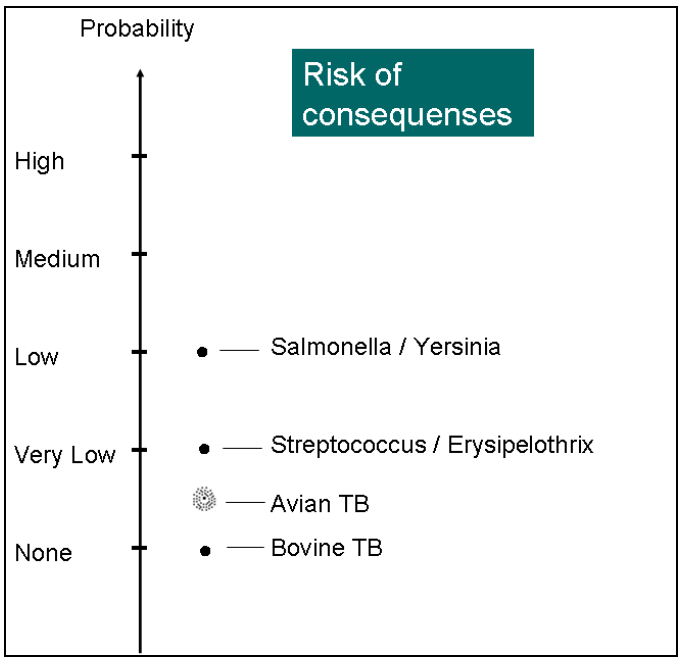


Figure 5
Risk of consequences – Probability of getting ill from consumption of Danish pork, irrespective of type of meat inspection, Denmark 2008

Summary of section 6: Bovine tuberculosis was eradicated in 1980. Hence, there is no risk of this infection related to Danish pork. Avian tuberculosis is not considered meat-borne, neither is *Rhodococcus equi*. Hence, these hazards are not of concern. The pathogens found in the heart are occupational hazards and they are not considered meat-borne. This is contrary to *Salmonella* spp. and *Yersinia enterocolitica* which cause disease in a non-negligible number of people. These infections are considered of medium severity in the individual infected. Hence, *Salmonella* spp. and *Yersinia enterocolitica* are the most important hazards related to Danish pork. A surveillance-and-control program for *Salmonella* is in place since 1995.

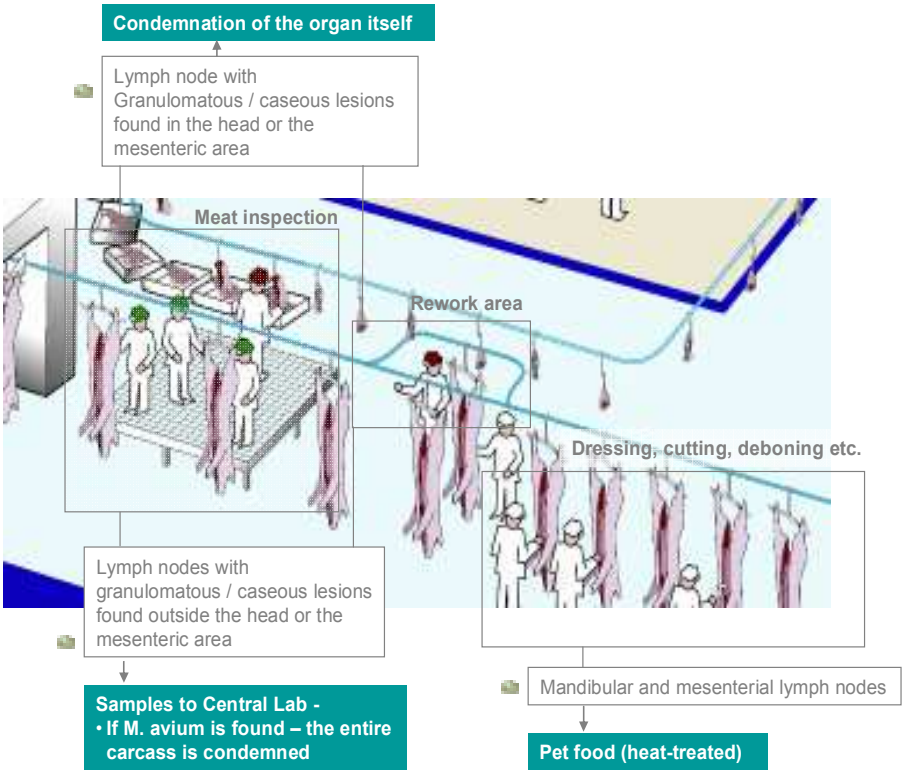
6. Effect of meat inspection

6.1 The regulatory framework

The regulatory framework for meat inspection is among others described in the Danish circular regarding performance of meat inspection (DVFA, 2007a). In here it has been specified in details which action to take in case of any macroscopically finding. This is graphically described in Fig. 6 and Fig. 7. Accordingly, if lymph nodes with granulomatous lesions are found in the head or the mesenterial area of a pig, local condemnation of the affected organ is required. The finding of lesions indicative of tuberculosis outside the head and the mesenterial area requires that the veterinarian sends the material for further laboratory examination to the Danish Veterinary Institute. This only happens infrequently; one to three cases are received per year including one or two pigs per case – and *Mycobacterium*

avium is not found each time (S.B Giese, personal communication). If *M. avium* is found in the latter cases, the carcass is condemned. As noted in Fig. 2, this occurs but not very often.

If healed endocarditis is found, local condemnation of the heart is required. In case additional lesions linked to endocarditis are present on the carcass, the entire carcass will be condemned. In case of trombosing endocarditis (ulcerative or verrucous) the judgment will be condemnation of the entire carcass too. According to in-house slaughterhouse statistics, around 89% of the cases of endocarditis result in condemnation of the entire carcass at present (Fig. 3). This strict judgment is a result of the habit to react on knowledge obtained: the presence of endocarditis possibly increases the exposure to several pathogens. Although when the heart is incised, the pathogens possibly present are not considered food-borne but occupational – and they have already exposed the slaughterhouse workers and meat inspectors



.

Figure 6
Graphical description of how traditional meat inspection is conducted with respect to the mandibular lymph nodes, Denmark 2008

Supply Chain Meat Inspection will only be conducted on finishers from integrated production systems where the finishers have been kept in-door since weaning. Moreover, exchange of food chain information prior to the slaughter of the pigs is required. This makes documentation and auditing of the pig production system vital. Moreover, performance standards are needed in order to measure the quality of the meat inspection. These element are not part of the risk assessment but are described elsewhere (Anon., 2008bc) and it is a part of the regulatory framework.

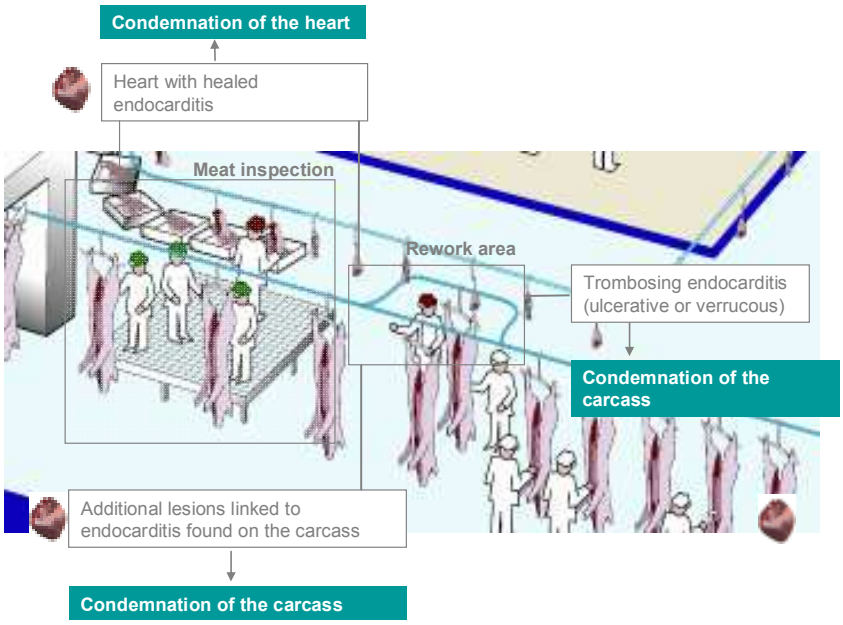


Figure 7
Graphical description of how traditional meat inspection is conducted regarding hearts, Denmark 2008

6.2 Comparison of traditional inspection with Supply Chain Meat Inspection

For any kind of meat inspection the difficult working conditions and the limited time available to inspect a carcass, will question the validity of the quality of the classification of lesions (Willeberg et al., 1984/85). This makes performance standards important. These have been developed specifically for Supply Chain Meat Inspection (Anon., 2008bc). By use of these, the quality of the meat inspection can be assessed.

The main question of interest for the present risk assessment is what effect the suggested changes will have on food safety. Focus will be on the difference in exposure between the two ways of conducting meat inspection: traditional versus risk-based (defined as not opening the heart and not cutting the mandibular lymph nodes routinely but only upon suspicion (Table 5). The effect on zoosanitary status is dealt with in section 7.

The number of human cases ascribed to pork will most likely remain unchanged due to the introduction of Supply Chain Meat Inspection. If cross-contamination can be reduced as a result of less cutting into the carcass, the prevalence of *Salmonella* spp. and *Yersinia enterocolitica* might decrease. This conclusion is supported by the experience obtained through a large slaughterhouse study that was conducted in Denmark in 1993 (will be presented in the following) as well as by findings from the literature.

In Denmark, a comparative study of the frequency of lesions, detected by visual and traditional inspection of slaughter pigs was conducted from January to July 1993 at a Danish slaughterhouse authorised for export. The study included 183,383 slaughter pigs which were first subjected to an en-

tirely visual inspection and then to traditional meat inspection procedures (incision and palpation) by two different inspection teams (Mousing et al., 1997).

The results of the study showed that a system based entirely on visual inspection in general performed slightly poorer than traditional inspection because the non detection rates (ADNDR) was higher for all classes of lesions, including those that are detected visually in both systems, for example, chronic pleuritis. This inferior performance of the visual procedure was due to a greater monotony of the physical work involved.

It should here be noted that the present risk assessment does not evaluate an entirely visual inspection; but only omission of the routine opening of the heart and the mandibular lymph nodes. The figures presented in the following can therefore be interpreted as worst case scenario with regards to which and how many lesions will be overlooked.

Mousing et al. (1997) estimated that per 1,000 carcasses, an additional 2.5 abscessal lesions in the edible tissue containing *S. aureus*, 0.2 with arthritis due to *Erysipelothrix rhusiopatiae*, 0.1 with granulomatous lymphadenitis, 0.7 was contaminated with *Salmonella enterica* and 3.4 with *Yersinia enterocolitica* would remain undetected as a result of changing from traditional to an entire visual inspection. This should be balanced by the risk of cross-contamination due to infection with *Yersinia enterocolitica* (Mousing et al., 1997; Mousing et al., 1999).

Unfortunately, the effect of meat inspection on endocarditis was not evaluated in the study by Mousing et al. (1997). The authors mention that 5.5 chronic pericarditis cases might be overlooked per 1,000 carcasses – however they did not consider this meat as edible tissue. For acute pericarditis – which was considered belonging to edible tissue - around 0.16 cases would be overlooked (Mousing et al., 1997)

A valuable reason for the implementation of a visual system (without palpation, incision or manual handling of the carcase) is the potential for decreased cross-contamination of hazardous bacteria, in particular from the contaminated pharyngeal region and from the plucks (Mousing et al., 1997).

This is in line with Petersen et al. (2002) who state that traditional meat inspection will result in cross-contamination of food safety pathogens like *Salmonella* from the oral cavity and the head. This is a result of the techniques used which involve removal of the tongue with the tonsils attached, together with the trachea, lungs, liver and heart (the plucks), and possibly splitting the head while the meat inspector palpates the surface of the head and cuts into the lymph nodes. Therefore, Petersen et al. (2002) recommend that the slaughter technique is modified to the head is not being split, the tongue is left in the oral cavity, and the head is only inspected visually, without palpation or incision.

This recommendation goes far beyond the changes suggested to the current meat inspection which only deals with omission of two specific routine incisions; into the heart and the mandibular lymph nodes.

6.2.1 The mandibular lymph node

The exposure risk for bovine tuberculosis is considered negligible for both kinds of meat inspection because Denmark is officially free from bovine tuberculosis since 1980 (Please see section 7.1).

According to Wisselink et al. (2006) meat inspection in general has a low sensitivity with respect to diagnosing infection with *Mycobacterium avium*. Wisselink et al. (2006) based this conclusion on an experimental study where only half of the artificially infected pigs developed lesions either in the mandibular lymph nodes or the mesenteric lymph node. However, the prevailing opinion is that *M. avium* is not meat-borne (see section 3.1.1. for a detailed discussion). As long as freedom from bovine tuberculosis can be documented, the question about imperfect sensitivity of both traditional and Supply Chain Meat Inspection plays no role. Moreover, mandibular lymph nodes from Danish finisher pigs are not consumed by humans but end up in pet food after adequate heat-treatment (G. Pedersen, personal

communication; S. Tinggaard, personal communication). Hence, there is no food safety relevance, neither an aesthetic issue.

A possible disadvantage related to Supply Chain Meat Inspection is that minor lesions in the lymph nodes not giving rise to an observable increase in size are not found during meat inspection. Apart from granulomatous lesions that could e.g. consist of abscesses and foreign bodies. Moreover neoplasm like melanoma in duroc pigs could be overlooked. However, the efficiency of incision of lymph nodes is limited. A number of mycobacterial infections in pigs caused by *M. avium* might not be detected by incision of lymph nodes because the lesions are not visible. Hird et al. (1983) e.g. isolated *M. avium* from 6.7% of 280 *lnn. mesenteriales* with no visible lesions. Many of the younger meat inspectors in countries where bovine tuberculosis has been eradicated have never seen tuberculosis in slaughter animals. Some of these inspectors might not be familiar with the appearance of tuberculosis, and hereby, the disease might not be detected. However, we believe that when the lesions are large and observed in several lymph nodes, they will be found. In line, infection with *M. avium* might also be detected by visual inspection of the liver. In this context it is important that the meat inspector is able to distinguish mycobacterial lesions in pig livers from spots of other origin, especially "milk spots" caused by ascarid larvae (Alfredsen, 1992). In line, lymphadenopathy in the lever might be a differential diagnosis to *M. avium* in the lever (Jensen et al., 2006).

When the mandibular lymph nodes are not palpated and incised routinely, the risk of cross-contamination with pathogenic bacteria will be lowered (Nesbakken et al., 2003, Petersen et al., 2002). A study performed by Nesbakken et al. (2003) showed that it was possible to isolate *Yersinia Enterocolitica* from around 5 -13 % of the mandibular lymph nodes investigated. In line, Pointon et al. (2000) showed that it was possible to isolate *Salmonella* spp. and *Yersinia Enterocolitica* in 2% of enlarged mandibular lymph nodes compared to 1.4% in normal sized mandibular lymph nodes.

Table 5
Exposure risk for the most relevant food safety hazards present in Danish finisher pigs from integrated production systems: A comparison of the effect of traditional versus Supply Chain Meat Inspection, 2008

	Type of meat inspection	
Food safety hazard	Traditional	Supply Chain Meat Inspection[a]
Bovine Tuberculosis	No risk[b]	No risk[b]
Avian tuberculosis	Very low risk[c]	Very low risk[c]
Salmonella and Yersinia	Risk of cross-contamination	Possibly reduced risk of cross-contamination
Erysipelothrix rhusiopathiae and *Streptococcus* spp	Risk of exposure and cross-contamination	Possibly reduced risk[d] of cross-contamination

a. Lymph nodes and the hearts will only be opened upon suspicion. Moreover, a food chain information system is in place ensuring that all relevant information reach the slaughterhouse prior to slaughter of the pigs
b. Denmark is officially free from bovine Tuberculosis since 1980 (Anon., 2007c)
c. The mandibular lymph nodes are used for pet food after adequate heat-treatment
d. If hearts are opened separately by slaughterhouse workers, then the risk of cross-contamination from the heart to the carcass will be lower than at present

6.2.2 The heart

According to our analysis, the hazards that are found in association with endocarditis are mainly occupational and not food-borne. In this case an omission of the routine opening will reduce the spreading of the organisms to the remaining part of the carcass. When the heart is not opened, blood coagula will be present as well as occasional findings of endocarditis. A cleaning of the heart is there-

fore required prior to the sale to the consumer. To reduce exposure of consumers to the occupational hazards that might be present in case of endocarditis, we suggest that the hearts are opened by slaughterhouse workers separately after meat inspection and prior to the hearts leaving the slaughterhouse. An opening of the hearts at this stage will reduce spreading of these organisms to other parts of the carcass. Moreover, it will allow the identification of abscesses in the myocardium as well as cases of pericarditis not found during meat inspection. Presence of any lesion in the heart should result in condemnation of the heart.

If the infection is generalised, other organs will be infected, too, and hence this will be found during visual meat inspection. The current meat inspection circular contains a specified list of actions required in case of different pathological findings (DFVA, 2007a). Accordingly, any carcass with abnormalities will undergo extended control. Hereby, it can be judged whether condemnation of the organs or possibly the entire carcass is required. According to our study 2 on hearts, 28% of the cases with endocarditis had other lesions which would have lead to an extended examination whereby the hearts would have been opened anyway. The proportion of carcasses with endocarditis which had other lesions too is probably higher than 28%. This is because the recording of other lesions was not believed to have functioned properly in study 2. This implies that at least 28% of the endocarditis cases will be found in Supply Chain Meat Inspection.

Based on the before-mentioned it is concluded that omission of the routine opening will not jeopardise food safety. This is in accordance with Leps & Fries (2008) and in line with the US meat inspection rules (Anon., 2007a).

It should here be noted that around 30% of the pig hearts are sold directly to Danish supermarkets, whereas more than 50% of the hearts are exported to export countries outside the EU e.g. Russia and USA. The remaining 20 % are sold to supermarkets within the EU (G. Pedersen, personal communication; S. Tinggaard, personal communication).

Summary of section 6: For any kind of meat inspection the difficult working conditions and the limited time available to inspect a carcass, will question the validity of the quality of the classification of lesions. Therefore, performance standards for meat inspection are needed in order to conduct an effective quality control. Moreover, training of personnel is required so they are prepared for the new way of meat inspection. A documentation-and-auditing programme for the herds supplying finishers is required to ensure the correctness of the food chain information; in particular, whether the pigs were kept in-door since weaning.

Omission of the routine incision into the mandibular lymph nodes does not seem to have an impact on food safety since the hazards possibly present are not meat-borne. Moreover, less handling will reduce the risk of cross-contamination with food safety hazards like *Salmonella* and *Yersinia*. The agents found in pig hearts are primarily occupational hazards and not meat-borne. To reduce exposure of the consumers to these hazards, it is suggested that the hearts are opened after meat inspection slaughterhouse workers but prior to sales by. Any heart with lesions should be condemned. This will reduce the spreading of these hazards from the heart to the carcass and further on to slaughterhouse personnel and consumers. The number of human cases ascribed to pork will most likely not change because of the introduction of Supply Chain Meat Inspection.

7. Impact on zoo-sanitary status

It is important for a large pig-producing and exporting country like Denmark to ensure that we are not jeopardizing animal health when we change our way of management; in this case the way meat inspection is conducted. We have therefore included zoo-sanitary hazards in the risk assessment. This is both for the sake of the Danish pig production and the export of breeding pigs and pork. Denmark has been declared officially free from a number of livestock diseases that might cause disease in pigs (Table 6). In the following, the impact of Supply Chain Meat Inspection compared to traditional inspection will be evaluated for Tuberculosis (both due to *M. bovis* and *M. avium*), Foot and mouth disease, Classical swine fever, Aujezsky's disease, Brucellosis (both due to *B. abortus* and *B. suis*) as well as *Trichinella*. It will be noted, that all these diseases (apart from *M. avium* and *B. suis*) are exotic in Denmark as a result of successful eradication followed by implementation of large-scale surveillance programmes (or they have never been seen in the country). Moreover, the diseases are notifiable in animals. Moreover, because the national population is naïve with respect to these diseases, clinical signs related to any of these diseases - except trichinellosis - will be pronounced. Therefore, diagnosis would probably first be made in live animals, either on farms or during the ante-mortem inspection at the slaughterhouse and only secondly at post-mortem.

7.1 Tuberculosis

Denmark is officially free from bovine tuberculosis since 1980 (Table 6). The Danish surveillance programme for demonstrating absence of bovine tuberculosis in cattle consists of a clinical examination in conjunction with meat inspections and tuberculin tests of selected animals. All slaughter animals are examined at the meat inspection for macroscopic lesions indicative of tuberculosis. Furthermore, bulls are tuberculin tested prior to the introduction into a bull station, and cattle are tuberculin tested prior to exportation (Anon., 2007c). Denmark only imports a limited number of cattle and pigs, and requirements for testing and quarantine are in place (Bronsvoort et al., 2004; Bronsvoort et al., 2008). Hence, if bovine tuberculosis should enter the country, there is a high probability that it will be found during quarantine. Bovine tuberculosis has been found in farmed deer previously. However, no free-living deer have ever been found tuberculosis-positive in Denmark (DVFA, 2008).

The pigs considered for supply chain meat inspection originate from integrated production systems with no contact to wildlife, limiting the probability of exposure to bovine tuberculosis, should this occur in wildlife. Outdoor-reared pigs will be subjected to traditional meat inspection. Breeding pigs are - as for cattle - tested prior to export to certain countries which require testing. The number of tuberculin tests taken vary considerably, and e.g. from April to September 2008, 467 samples were taken only by veterinarians working for the Danish Pig Production Company. Other similar tests are taken by the veterinary practitioners visiting farms from which breeding animals are leaving for export. A double test is used enabling the differentiation between *M. bovis* and *M. avium*. Neither *M. bovis* not *M. avium* have been found for more than ten years (T. Kjeldsen, personal communication).

According to Danish law, all types of tuberculosis in animals are notifiable. However, the finding of avian tuberculosis in a bird or any other animal does not result in any actions taken by the Veterinary Services (P. Vestergaard, personal communication). Therefore, if a pig reacts positive to *M. avium*, it will not be exported but remain in Denmark without any further actions required (P. Vestergaard, personal communication; T. Kjeldsen, personal communication).

In Ireland, both avian and bovine tuberculosis are present. As a part of the control programme for bovine tuberculosis, cattle are tuberculin tested. A double test is made enabling a differentiation between *Mycobacterium bovis* and *Mycobacterium avium* (J. Cassidy, personal communication). Like in

Denmark, the finding of a reaction against the latter does not result in any action because the agent is not considered meat-borne.

This is in line with the USA, where regulations of the Meat and Poultry Inspection Programme of the USDA require local condemnation if lesions are only found in one primary site on the carcass. If lesions indicative of tuberculosis are found in more than one primary site, the carcass needs to undergo heat-treatment (76.7°C for 30 minutes). If no cooking facilities are available, the carcass is condemned (Thoen, 2006).

Only in The Netherlands is there a concern about the possible meat-borne route related to pig meat. This has lead to the introduction of a surveillance programme for avian tuberculosis in Dutch finisher herds (Jelsma, 2008).

The international organisation for animal health, OIE, has recently adjusted its list of diseases which are of international concern. For a disease to be on the list, certain conditions should be met:

1) capacity to be spread internationally,
2) zoonotic impact,
3) significant morbidity or mortality in naïve populations, and
4) emerging disease.

Please see Appendix VIII in http://www.oie.int/tahsc/eng/Reports/A_TAHSC_SEP2005_A.pdf for a more detailed description of these criteria. According to Resolution No. XVIII adopted by the International Committee of the OIE during its 76th General Session, 25 – 30 May 2008, avian tuberculosis will be deleted form the list because:

”It is ubiquitous and has no significance for international spread. The morbidity and mortality are not significant in birds. Human infections may occur under exceptional circumstances, but natural infection in humans is rare”.

The report from the working group can be downloaded from http://www.oie.int/tahsc/eng/Reports/A_SCCDBJAN2005.pdf .(please see Appendix XXVIII). The Terrestrial Animal Health Code Chapter 2.1.1 will be changed as suggested by the Code Commission in Appendix VI in Report of the Meeting of the OIE Terrestrial Animal Health Standards Commission, 17 - 28 January 2005.

7.2 Foot and Mouth Disease

Denmark is officially free country where vaccination is not practised. The last case of Foot and mouth disease (FMD) was observed in 1983. Combination of a limited import of breeding pigs and a volunteer testing and quarantine programme in place as well as no import of pigs for slaughter and a unique geographical location has made it possible for Denmark to stay free from this disease for decades. FMD is not present in Europe, and should it be found in a European country, several risk-mitigating strategies will be put in place (Anon., 2007c). FMD is associated with the development of vesicles in the mouth and on the feet, which will be observed during ante-mortem inspection. Hence, Supply Chain Meat Inspection will not lower the probability of identifying a case of FMD.

7.3 Classical Swine Fever

Denmark is free from Classical swine fever (CSF) – the last case was seen in 1933 (Table 6). Wild and domestic pigs are the only natural reservoirs. CSF is a notifiable disease in the European Union (EU) since 1983. In the 1970s, CSF was virtually endemic in the then six EU member states and routine

vaccination was a commonly practiced control measure. In contrast the newly entering states Denmark, Ireland and the UK were CSF-free (Bendixen, 1988). The different national policies to control CSF were replaced by the Community legislation in 1980 (according to Council directive 80/217/EEC). Between 1986 and 1990, a non-vaccination policy of CSF was adopted by all Member States (Terpstra et al., 2000). Although the disease has been eradicated from domestic pigs in western Europe, CSF remains endemic in some populations of wild boar, and farms in these areas are at risk of reintroduction (Fritzemeier et al., 2000). In Eastern Europe, the large numbers of backyard herds makes it difficult to control the disease and therefore leads to many outbreaks (http://www.oie.int/wahid-prod/public.php, visited 18th February 2008). The surveillance programme in place to demonstrate absence of CSF in Denmark includes serological samples from around 7,000 samples from nucleus herds, as well as 18,000 from sows and boars annually (Martin et al., 2007b; Anon., 2007c; P.T Christensen, personal communication). The pathological findings in post mortem examinations of both domestic pigs and wild boar are swollen, oedematous and haemorrhagic lymph nodes, petechial to ecchymotic bleedings in the skin, kidneys, urinary bladder, larynx, epiglottis and heart (Gruber et al., 1995) Moreover, an infectious disease like CSF would usually result in not just one but several infected animals which would increase suspicion of the disease being present. Most likely, a case of CSF will be diagnosed in the herd or during pre-slaughter inspection. Hence, omitting incisions into the heart and the mandibular lymph node will not lower the probability of identifying a case of CSF.

Table 6
Denmark's zoo-sanitary status[a] for a number of diseases in pigs, 2008

Disease	Status	Last case seen in year
African swine fever		Never recorded
Aujeszky's disease	Officially free[b] since 1992	1991
Avian Tuberculosis		2008[e]
Bovine Brucellosis (*B. abortus*)	Officially free[b] since 1979	1962
Brucellosis in pigs (*B. suis*)		Outdoor herd 1999 Wild hares 2002
Brucellosis in sheep and goats (*B. melitensis)*		Never recorded
Bovine Tuberculosis	Officially free[b] since 1980	1988
Classical swine fever		1933
Foot and mouth disease	Officially free[c] country where vaccination is not practised	1983
Swine vesicular disease		Never recorded
Transmissible gastroenteritis		Never recorded
Trichinellosis	Officially recognised by EU as area with negligible prevalence since 2007[d]	1930

a: General source: Anon. (2007)

b: Status is based on a recognition by the European Union

c: Status is based on a recognition by OIE

d: Based on Alban et al. (2008)

e: One bird from a zoological garden found positive in 2008

7.4 Aujeszky's Disease

Denmark is free from Aujeszky's disease since 1992. Pigs are the natural host of Aujeszky's disease; other species are dead-end hosts. The disease is characterised among others by very high mortality among young piglets. In these animals severe neurological disorders are observed. Respiratory

signs are seen among older pigs and sows. The clinical course is very severe in naïve pig populations (Pejsak & Truszczyński, 2006). Because of its significance for pig production, Denmark has a surveillance programme in place which includes the samples taken for CSF, as well as additional samples taken yielding a total of more than 40,000 samples taken annually (Anon., 2007c). Based on this it is judged that the suggested change in meat inspection will have no impact on the ability to identify a case; should Aujeszky's disease enter Denmark, then it will be diagnosed in a herd and not at an abattoir.

7.5 Brucellosis

Denmark is free from *B. abortus* since 1979 (Table 6). A surveillance programme is in place to demonstrate absence of this agent. The programme includes testing of around 8,000 bulls per year (T. Grubbe, personal communication). Moreover, clinical surveillance of live cattle (abortions and swollen testicles) post-mortem inspection of slaughtered cattle is conducted.

Brucella melitensis has never been observed, and a surveillance programme is in place including annual blood testing of 5,000-7,000 sheep and goats (Anon., 2007c).

A testing programme is also conducted for *B. suis*. This includes testing of boars entering and leaving boar stations. So far no positive results have been found (T. Kjeldsen, personal comment). *Brucella suis* is occasionally found in hares in some restricted areas in Denmark; the most recent finding of an infected hare was in 2002 (Anon., 2008a). In 1994 and 1999, a total of two outdoor herds, located in the area where infected hares have been found previously, were found infected with *B. suis*. The signs in the herds were swollen testicles and abortions which are the classical signs related to brucellosis (MacMillan et al., 2006). The testicles of one of the boars found in 1994 were around four times the normal size (K.D. Winther, personal communication). This implies that omitting incisions into the mandibular lymph nodes and into the heart will have no impact on the ability to detect a case of brucellosis. Furthermore, only pigs from integrated production systems that have been reared in-door since weaning will be able to undergo Supply Chain Meat Inspection. All outdoor pigs will need to go through traditional meat inspection.

7.6 Trichinellosis

In 2007, Denmark was recognised by the EU as an area with negligible prevalence of *Trichinella* in pigs. The background for this status is that millions of Danish pigs have been tested annually for more than 70 years, and no positive samples have ever been found. This implies that Denmark intends to change the surveillance towards a risk-based surveillance where only subpopulations (outdoor pigs as well as sows and boars) of higher risk will be surveyed directly (Alban et al., 2008). *Trichinella* larvae cannot be observed macroscopically but requires laboratory diagnostics (Stewart and Hoyt, 2006). Hence, omitting incisions into the mandibular lymph nodes and into the heart will have no impact on the ability to detect a case of trichinellosis

Summary of section 7: There is no negative impact on the zoo-sanitary status because most of the pig diseases are more easily recognised in a live animal than on a carcass. The only exception is *Trichinella*, where laboratory testing is required. Denmark is officially recognised by the EU as a country with a negligible prevalence of *Trichinella* in pigs. Moreover, extensive surveillance programmes are in place for most of the infections of concern.

8. Impact on working environment

It is well known that performing meat inspection is an activity which is a physically strain. During a working day, the workers stand up for many hours inspecting the carcasses and organs. Moreover, the work is carried out at the line speed of the slaughter line and is characterized as a repetitive work task.

This one-sided, repeated work causes high risk for back and shoulder problems. Traditional meat inspection includes incision of the mandibular lymph nodes as well as an incision into the heart. These routine incisions add to the risk of back and shoulder problems. In particularly, the incision of the mandibular lymph nodes requires that the meat inspectors on most of the slaughter plants bend forward in order to palpate and cut the lymph nodes in the head and throat area this action results in a risk of work-related musculoskeletal disorders

On some plants the meat inspection platforms have been changed so that the head is presented for inspection already separated from the rest of the carcass, which lowers the risk of injury in the back due to bending forward to cut the lymph nodes).

Additionally, the handling of knives might result in risk of damage by cutting. In 2007, 17 cases with reference to cutting damage were reported from the abattoirs to the Danish Veterinary and Food Administration (DVFA, 2007b).

Supply Chain Meat Inspection is estimated to reduce the strain of the physically activity in performing the meat inspection. This is supported by studies of meat inspection of finisher pigs in Sweden and The Netherlands (Hall, 2007; Jelsma, 2008). In general, these studies conclude that less time is used on performing the post mortem inspection along the slaughter line after introduction of Supply Chain Meat Inspection. Furthermore these studies conclude that the staff – both company employee and veterinarians belonging to the official control - is more satisfied and pleased with their work mainly because of improvements of the environment.

This assessment is preliminary since we do not have sufficient data to evaluate the impact on working environment thoroughly.

Summary of section 8: The preliminary analysis indicated that Supply Chain Meat Inspection might have a positive effect on the working environment.

9. Risk estimation

In the following all elements described in the previous sections (release, exposure and consequences) are integrated to form a risk estimate regarding the effect on food safety related to the proposed changes to meat inspection.

The risk for the zoo-sanitary status was evaluated in section 7 – it is judged that the probability of diagnosing a pig with an exotic disease remains unchanged when the palpation and incision into the mandibular lymph nodes and the heart are omitted. Moreover, the serological surveillance programmes in place in Denmark ensures a high confidence of freedom from disease and act as effective tools to identify disease should it enter the country. The assessment of the impact on working environment is only preliminary because we do not have sufficient data to evaluate it thoroughly.

According to Danish slaughterhouse statistics, the prevalence of granulomatous lesions in lymph nodes is low (0.01%) in finisher pigs. The lesions occur primarily in the mandibular lymph node and the mesenterial lymph node, and they have various causes. The most common is infection with *R. equi*, and this organism is not considered meat-borne. Because Denmark is officially free from bovine tuber-

culosis since 1980, there is no risk of infection with bovine tuberculosis when consuming pork meat regardless of the type of meat inspection. *Mycobacterium avium* is occasionally observed in old hens from backyard herds or zoological gardens. In pigs, no high-quality data are available regarding prevalence of avian tuberculosis. Based on the results found in Study 1 and consultations with the official veterinary laboratory for *Mycobacterium* spp. in Denmark, it was concluded that *M. avium* occurs at a very, very low prevalence in pigs from integrated production systems. The predilection site for *M. avium* is the mandibular and mesenterial lymph nodes. These organs are used for pet food after adequate heat-treatment. Furthermore, the prevailing opinion in the literature is that this organism is not considered meat-borne. In conclusion, omission of the routine palpation and incision of the major mandibular lymph not increase the risk of *M avium*. Moreover, omission of incision as a routine action will lower the probability of spreading of known food safety hazards like *Salmonella* and *Yersinia*. In conclusion, there is no increased risk for human health associated with omission of routine palpation, incision and inspection of the mandibular lymph nodes.

Table 7
Estimation of consumer risk associated with Supply Chain Meat Inspection of finishers from integrated production systems, reared in-door, compared to traditional inspection, Denmark, 2008 – the mandibular lymph node

Organ	Release Assessment	Exposure Assessment	Consequence assessment	Risk estimation
Mandibular lymph node	Granulomatous lymph nodes observed at a prevalence of 0.01-0.02% *Rhodococcus equi* main cause. Avian tuberculosis observed primarily in old backyard hens or in the Zoo (1-7 cases per year) and 0-3 times per year in pigs	Denmark officially free from bovine tuberculosis since 1980. Lymph nodes not eaten but used for pet food only Probably very low probability of exposure to avian tuberculosis and *R. equi*	The number of cases* related to *Salmonella* spp and *Yersinia enterocolitica* will not increase but maybe decrease No risk of bovine tuberculosis Avian tuberculosis and *R. equi* not considered meat-borne	No risk for consumers associated with omission of routine palpation, incision of the mandibular lymph nodes

*: Omission of routine incision into the mandibular lymph nodes will lower the risk of cross-contamination to the rest of the carcass

Regarding the hearts, endocarditis is the condition of relevance for this work because often pericarditis and epicarditis can be observed without incision. Abscesses might also be overlooked initially (see later). Parasitic conditions related to myocarditis will be observable in other organs too if present, however, they occur with a very low prevalence in Danish pigs from integrated production systems. According to the Danish slaughterhouse statistics, endocarditis in finisher pigs occurs with a prevalence of 0.01-0.02%.

According to the literature and the results of study 2, the organisms found in endocarditis are mainly occupational hazards like *Streptococcus* spp. and *Erysipelothrix rhusiopathiae*. Hence, omissions of routine incisions into the heart will lower the probability of spreading these occupational hazards to the carcass. Furthermore, less handling will result in less spreading of food safety organisms

like *Salmonella* spp. and *Yersinia enterocolitica* which are the two most important sources of infection related to Danish pig meat (Fig. 4 and Fig. 5). To reduce exposure of consumers to these occupational hazards, we suggest that the hearts should be opened by slaughterhouse workers separately after meat inspection and prior to the hearts leaving the slaughterhouse. An opening of the hearts at this stage will also allow the identification of abscesses in the myocardium as well as cases of pericarditis initially overlooked during meat inspection. Presence of any lesion in the heart should result in condemnation of the heart.

Table 8
Estimation of consumer risk associated with Supply Chain Meat Inspection of finishers from integrated production systems, reared in-door, compared to traditional inspection, Denmark, 2008 – the heart

Organ	Release Assessment	Exposure Assessment	Consequence Assessment	Risk estimation
Heart	Endocarditis observed at a prevalence of 0.01% *Streptococcus* spp. and *Erysipelothrix rhusiopathiae* main causes	Low probability of exposure to *Streptococcus* spp. and *Erysipelothrix rhusiopathiae*. Even lower probability if hearts with lesions are disposed of*	*Streptococcus* spp. and *Erysipelothrix rhusiopathiae* are not meat-borne but occupational hazards The number of cases related to *Salmonella* spp and *Yersinia enterocolitica* will not increase but maybe decrease	No risk for consumers associated with omission of routine incision into the heart

*: It is recommended that the hearts are opened prior to sales by a slaughterhouse worker, and any heart with lesions should be disposed of.

There seems to be no increased risk for human health associated with omission of routine palpation and incision into the mandibular lymph node or the heart. In line, the number of human cases is not expected to change with the introduction of Supply Chain Meat Inspection. This is conditioned on that if lesions are found, the carcass should be subjected to extended meat inspection.

This conclusion is valid for finisher pigs, reared in-door in herds that are part of an integrated production system and where exchange of food chain information is in place

This is in line with Hathaway and McKenzie (1991): As tuberculosis and other classic zoonoses have become rare in most developed countries, contamination of carcasses during slaughtering, dressing and meat inspection is the main public health hazard linked to meat.

We expect that around 90% of the finishers slaughtered in Denmark will qualify for Supply Chain Meat Inspection. A documentation-and-auditing programme for the herds supplying finishers is required to ensure the correctness of the food chain information; in particular, whether the pigs were kept in-door since weaning. Moreover, performance standards for the meat inspection are needed to conduct an effective quality control. Finally, training of personnel is required so they are prepared for this way of meat inspection. All these issues have been dealt with prior to the possible introduction of the Supply Chain Meat Inspection (Anon., 2008b). However, these issues will not be described here because they are not a part of a risk assessment.

Summary of section 9: there seems to be no increased risk for human health associated with omission of routine palpation and incision into the mandibular lymph node or the heart conditioned on if lesions are found, the carcass should be subjected to extended meat inspection. This is valid for finisher pigs, reared in-door since weaning, in herds that are part of an integrated production system and where exchange of food chain information is in place.

10. Conclusion

According to the risk assessment, the two suggested changes to the traditional meat inspection – the omission of the routine incision into the mandibular lymph nodes as well as the routine opening of the heart - seem to have limited impact on food safety. Nor is there a negative effect on the zoo-sanitary status. Finally, the preliminary assessment indicated that the modernisation will have a positive impact on the working environment. These conclusions are valid for finisher pigs reared in-door and originating from herds belonging to integrated production systems where exchange of food chain information is in place prior to slaughter. In case lesions are observed on the carcass, the carcass should undergo extended meat inspection. Hearts should be opened by slaughterhouse workers prior to sales to remove blood coagula from the hearts. Any heart with abnormal findings should be condemned.

We call this way of slaughter Supply Chain Meat Inspection – The Danish way.

Acknowledgements

The official veterinarians and auxiliaries at the DMA slaughterhouses that were involved in the project are kindly acknowledged for the sampling of data. Moreover, the following persons are acknowledged for providing data or input to the risk assessment: Jaap Boes, Anette Boklund, Poul Tolstrup Christensen, Anne-Mette Olsen and Jesper Valentin Pedersen, (DMA), Kirsten Pihl, Kjeld Dahl Winther, and Torben Kjeldsen (Danish Pig Production), Peter Arendt Nielsen and Bjørn Lorenzen (SPF-Sus), Gitte Petersen (Tican), Søren Tinggaard (Danish Crown), Åke Rutegard (Scan AB), Joseph Cassidy (University College Dublin), Vibeke Thomsen (Statens Serum Institut), Susanne Kabell and Sten B. Giese (National Veterinary Institute), Torben Grubbe and Pia Vestergaard (Danish Veterinary and Food Administration), Sigurdur Ö. Hansson (Icelandic Food and Veterinary Administration) and Viveka Larsson (Swedish National Food Administration).

References

Alban, L., Stege, H., Dahl, J., 2002. The new classification system for slaughter-pig herds in the Danish Salmonella surveillance-and-control program. Prev. Vet. Med., 53, 133-146.

Alban, L., Boes, J., Kreiner, H., Petersen, J.V., Willeberg, P. 2008. Towards a risk-based surveillance for *Trichinella* spp. in Danish pig production. doi.org/10.1016/j.prevetmed.2008.05.008

Anonymous, 1997a: Changes to current meat inspection procedures for pigs. Australian Quarantine Inspection Service (AQIS) Notice Meat: 97/20.

Anonymous, 1997b: Australian Export Manual Volume 3 WP005.6 – Pigs. Australian Quarantine Inspection Service (AQIS)

Anonymous, 1998. The Ruwenberg Conference. World Congress on Meat and Poultry Inspection in the Next Century. 8-13 June 1997. The Netherlands. Ministry of Agriculture, Nature Management and Fisheries. 173-178.

Anonymous, 1999: The White Paper on Food Safety. The Commission of the European Communities, January 12, 1990 Com (1999) No. 719 final, 52 pp. http://ec.europa.eu/dgs/health_consumer/library/pub/pub06_en.pdf

Anonymous, 2000. Opinion of the Scientific Committee on Veterinary Measures relating to Public

Health on Revision of Meat Inspection Procedures. The European Commission, Health & Consumer Protection Directorate-General. 31 pp.

Anonymous, 2002. Regulation (EC) No. 1774/2002 of the European Parliament and of the Council of 3 October 2002 laying down health rules concerning animal by-products not intended for human consumption.

Anonymous, 2003. Meat Safety Quality Assurance System (MSQA) for fresh meat and processed meat products, Second edition, Canberra, Australian Quarantine and Inspection Service, 78 pp.

Anonymous, 2004a. Regulation (EC) No 852/2004 of the European Parliament and of the Council of

Anonymous, 2004b. Regulation (EC) No 853/2004 of the European Parliament and of the Council of 29 April 2004 laying down specific hygiene rules for food of animal origin

Anonymous, 2004c. Regulation (EC) No 854/2004 of the European Parliament and of the Council of 29 April 2004 laying down specific rules for the organisation of official controls on products on products of animal origin intended for human consumption.

Anonymous, 2005a. Commission Regulation (EC) No 2074/2005 of 5 December 2005 laying down implementing measures for certain products under Regulation (EC) No 853/2004, (EC) No 854/2004 and (EC) 882/2004 of the European Parliament and of the Council.

Anonymous, 2005b. Commission Regulation (EC) No 2076/2005 of 5 December 2005 laying down transitional arrangements for the implementation of Regulation (EC) No 853/2004, (EC) No 854/2004 and (EC) No 882/2004 of the European Parliament and of the Council.

Anonymous, 2006. Annual Report on Zoonoses in Denmark 2006. Technical University of Denmark. 46 pp.

Anonymous, 2007a. Post mortem Livestock Inspection. Food Safety and Inspection Service (FSIS) Directive, 6100.2

Anonymous, 2007b. Commission Regulation (EC) No 1244/2007 of 24 October 2007 amending Regulation (EC) 2074/2005 as regards implementing measures for certain products of animal origin intended for human consumption and laying down specific rules on official controls for the inspection of meat.

Anonymous, 2007c. Animal Health in Denmark 1999-2005. The Danish Veterinary and Food Administration. http://gl.foedevarestyrelsen.dk/FDir/Publications/2007090/rapport.pdf. 68 pp.

Anonymous, 2008a. Monthly Animal Health Report. June 2008. Danish Veterinary and Food Administration, Mørkhøj, Denmark. 4 pp. http://gl.foedevarestyrelsen.dk/FDir/Publications/2008646/Rapport.pdf

Anonymous, 2008b. Supply Chain Meat Inspection – The Danish Way. Prerequisites and enforcement procedures. Letter sent electronically from the Danish Veterinary and Food Administration to Food Safety and Inspection Service (FSIS). November 21. 2008. 23 pp. DW No. 103348.

Anonymous, 2008c. Supply Chain Meat Inspection – The Danish Way. An overview including references and links to Regulations. Letter sent electronically from the Danish Veterinary and Food Administration to Food Safety and Inspection Service (FSIS). November 21. 2008. 23 pp. DW No. 103394.

Bauer, J., 1999. Molecular epidemiology studies and the Mycobacterium tuberculosis complex and the Mycobacterium avium complex. Ph.D. thesis. Department of Mycobacteriology. Statens Serum Institute. The Faculty of Health Science, University of Copenhagen, Denmark.

Bendixen, H.J., 1988. Control of classical swine fever. In: B. Liess (Ed.), Classical Swine Fever and Related Viral Infections. Martinus Nijhoff, Boston MA. 217-232.

Berends, B.R., Snijders, J.M.A., van Logtestijn, J.G., 1993. Efficacy of current EC meat inspection procedures and some proposed revisions with respect to microbiological safety: a critical review. Vet. Rec. 133, 411-415.

Berends, B.R., Snijders, J.M.A., 1997. Risk factors and control measures during slaughter and processing. Proceedings of the 2nd International Symposium on Epidemiology and Control of Salmonella. 20-22. August 1997. Copenhagen, Denmark. 36-41.

Boes, J., Danish Meat Association. Copenhagen, Denmark. jbo@danishmeat.dk

Bronsvoort, B.M. de C., Alban, L., Greiner, M., 2008. Quantitative assessment of the likelihood of the introduction of classical swine fever virus into the Danish swine population. Prev. Vet. Med. 85, 226-240.

Bronsvoort, B.M. de C., Alban, L., Greiner, M., 2004. An assessment of the likelihood of the introduction of exotic diseases to the Danish swine population. EpiLab report. March 2004. 118 pp. http://www.dfvf.dk/Default.aspx?ID=9726

Cassidy, J., 2008. School of Agriculture, Food Science & Veterinary Medicine. University College Dublin, Ireland. joseph.cassidy@ucd.ie

Christensen, P.T., 2008. Danish Meat Association. Copenhagen, Denmark. ptc@danishmeat.dk

Cronin, S.M., Abidi, M.H., Shearer, C.J., Chandrasekar, P.H., Ibrahim, R.B., 2008. *Rhodococcus equi* lung infection in an allogenic hematopoietic stem cell transplant recipient. Transpl. Infect. Dis., 10 (1) 48-51.

DVFA, 2007a. Cirkulære om udøvelse af kødkontrol af 26. juli 2007 (Circular regarding the conduct of meat inspection of 26 July 2007 (in Danish). The Veterinary and Food Administration. Mørkhøj, Denmark. 32 pp. https://www.retsinformation.dk/Forms/R0710.aspx?id=32047

DVFA, 2007b. Arbejdsmiljøregnskab 2007 (Working environment 2007) – in Danish. Danish Veterinary and Food Administration, Mørkhøj, Denmark. 24 pp. www.fvst.dk/arbejdsmiljoe/arbejdsmiljoeregnskab

DVFA, 2008. Tuberkulose. Danish Veterinary and Food Administration, Mørkhøj, Denmark. http://www.foedevarestyrelsen.dk/Dyresundhed/Dyresygdomme_og_zoonoser/Sygdomsoversigt/Tuberkulose_bovin_og_human_type/forside.htm

Eaton, T., Falkingham, J.O., von Reyen, C.F., 1995. Recovery of *Mycobacterium avium* from cigarettes. J. Clin. Microbiol. 33, 2757-2758.

Eliasen, M., 2008. Slaughterhouse Workers' Union (NNF). me@nnf.dk

Esteves, P., Mineiro, A, Serrado, M., Diniz, A., 2007. *Rhodococcus equi* pneumonia in an HIV+ patient: An uncommon association. Rev. Port. Pneumol, 13, (5) 703-709.

Fritzemeier, J., Teuffert, J., Greiser, W.I., Staubach, C., Schlüter, H., Moenning, V., 2000. Epidemiology of classical swine fever in Germany in the 1990s. Vet. Microbiol. 77, 29-41.

FSIS, 2008a. Letter to the Netherlands from United States Department of Agriculture, Food Safety and Inspection Service. Signed by Sally White, Director of International Equivalence Staff, Office of International Affaires, dated July 16, 2008.

FSIS, 2008b. Overview_of_the_HACCP_Based_Inspection_Models. Found when accessing htttp://www.fsis.usda.gov/Fact_Sheets/index.asp - Search for HACCP Based Inspection Models.

Grubbe, T., 2008. The Veterinary and Food Administration. Mørkhøj, Denmark. tgr@fvst.dk

Gruber, A, Depner, K., Liess, B., 1995. Experimental infection of weaner pigs with a field isolate of hog cholera/classical swine fever virus derived from a recent outbreak in Lower Saxony. II: Pathological findings. Wiener Tierärztliche Monatschrift 82, 179-184.

Giese, S.B., 2008. The National Veterinary Institute. Copenhagen, Denmark. stgi@vet.dtu.dk

Hall, M, 2007. Delrapport – Projekt okulär besiktning (Part Report – Visual Inspection Project) In Swedish. Tilsynsafdelingen, Enheten för kötttillsyn, National Food Administration, Uppsala,Sweden. 9 pp.

Hamilton, D.R., Gallas, P., Lyall, L., McOrist, S., Hathaway, S.C., Pointon, A.M., 2002. Risk-based evaluation of post-mortem inspection procedures for pigs in Australia. Vet. Rec. 151, 110-116.

Hansson, S.G., 2008. Icelandic Food and Veterinary Authority. sigurdur.hansson@mast.is

Hathaway, S.C., McKenzie, A.I., 1991. Postmortem meat inspection programs; separating science and tradition. J. Food Protect. 54, 471-475.

Higgins, R, Gottschalk, M., 2006. Streptococcal Disease. In: B.E. Straw, J.J. Zimmerman, S. D'Allaire, & D.J. Taylor (Eds.), Diseases of Swine 9th Edition. Blackwell Publishing. Ames, Iowa, USA. 769-783.

Hird, D.W., Lamb, C.A., Lewis, R.W, Utterback, W.W., 1983. Isolation of mycobacteria from California slaughter swine. In: Proceedings of the United States Animal Health Association, 87th Annual Meeting. Las Vegas, Nevada. 16-21 October 2003. 559-565.

Horsburgh, C.R., Chin, Jr., D.P., Yajko, D.M., Hopewell, P.C., Nassos, P.S., Elkin, E.P., Hadley, W.K., Stone, E.N., Simon, E.M., Gonzalez, P., Ostroff, S., Reingold, A.L., 1994. Environmental risk factors for acquisition of *Mycobacterium avium* complex in persons with human immunodeficiency virus infection. J. Infect. Dis, 170, 362-367.

Jelsma, A., 2008. Pork Supply Chain Meat Inspection. Modernisation of Slaughterhouse Health Inspections, Working support for the French Presidency of the Council of the European Union. 7.-11 July 2008. Lyon, France. 98-108.

Jensen, H.E., Leifsson, P.S., Nielsen, O.L., Agerholm, J.S., Iburg, T., 2006. Kødkontrol: Det patoanatomiske grundlag. (Meat Inspection: The pato-anatomical foundation – In Danish). Biofolia, Frederiksberg, Denmark. 764 pp.

Jepsen, A., 1968 Kødkontrol (Meat Inspection – in Danish). DSR Forlag – Boghandel. The Royal Veterinary and Agricultural University. 222 pp.

Kabell, S., 2008. The National Veterinary Institute. Århus, Denmark. skab@vet.dtu.dk

Kjeldsen, T., 2008. Danish Pig Production. tok@dansksvineproduktion.dk

Komijn, R.E., de Haas, P.E.W., Schneider, M.M.E. Eger, T., Nieuwenhuijs, J.H.M., van den Hoek, R.J., Bakker, D., van Zijd Erveld, F.G., van Soolingen, D., 1999. Prevalence of *Mycobacterium avium* in Slaughter Pigs in The Netherlands and Comparison of IS*1245* Restriction Fragment Length Ploymorphism Patterns of Porcine and Human Isolates. J. Clin. Microbiol. Vol. 37, No. 5, 1254-1259.

Komijn, R.E., Wisselink, H.J., Rijsman, V.M.C., Stockhofe-Zurwieden, N., Bakker, D., van Jijderveld, F.G., Eger, T., Wagenaar, J.A., Putirulan, F.F., Uhrlings, B.A.P., 2007. Granulomatous lesions in lymph nodes of slaughter pigs bacteriologically negative for *Mycobacterium avium* subsp. *avium* and positive for *Rhodococcus equi*. Vet. Microbiol. 120, 352-357.

Kreiner, H., 2008. Danish Veterinary and Food Administration. Mørkhøj, Denmark. hxkr@fvst.dk

Larsson, V., National Food Administration, Uppsala, Sweden. viveka.larsson@slv.se

Leps, J., Fries, R., 2008 Incision of the heart during meat inspection of fattening pigs – A risk-profile approach. J. Meat Sci. doi:10.1016/meatsci.2008.07.002

Linder, R., 1997. *Rhodococcus equi* and *Arcanobacterium haemolyticum* – Two "Coryneform" Bacteria Increasingly Recognised as Agents of Human Infection. Emerg. Inf. Dis. Vol. 3, No. 2. April-June 1997. URL: http://www.cdc.gov/ncidod/EID/vol3no2/linder.htm

MacMillan, A.P., Schleicher, H., Korslund, J., Stoffregen, W., 2006. Brucellosis. In: B.E. Straw, J.J. Zimmerman, S. D'Allaire, & D.J. Taylor (Eds.), Diseases of Swine 9th Edition. Blackwell Publishing. Ames, Iowa, USA. 603-611.

Martin P.A.J., Cameron, A.R., Greiner, M., 2007a. Demonstrating freedom from disease using multiple complex data sources: 1: A new methodology based on scenario trees. Prev. Vet. Med., 79: 71-97.

Martin, P.A.J., Cameron, A.R., Barfod, K., Sergeant, E.S.G., Greiner, M., 2007b. Demonstrating freedom from disease using multiple complex data sources 2: Case study—Classical swine fever in Denmark, Prev. Vet. Med. 79, 98–115.

Mousing, J., Kyrval, J., Jensen, T.K., Ålbæk, B., Buttenschon, B., Willeberg, P., 1997. Meat safety consequences of implementing visual inspection procedures in Danish slaughter pigs. Vet. Rec. 140, 472-477.

Mousing, J., Fries, R., Snijders, J.M.A., Bettini, G., Willeberg, P., 1999. Modernising post mortem meat inspection of pgs for slaughter – A European Union research perspective. In: Proceedings of the World Congress on Meat and Poultry Inspection. 28 February – 5 March 1999. Terrigal, Australia. 112-127.

Nesbakken, T., Eckner, K., Høidal, H.K., Røtterud, O.-J., 2003. Occurrence of *Yersinia enterocolitica* and *Campylobacter* spp. in slaughter pigs and consequences for meat inspection, slaughtering and dressing procedures. Int. J. Food. Microbiol, 80, 231-240.

OIE, 2004. Handbook on Import Risk Analysis for Animals and Animal Products. Vol. 1 OIE, Paris, France.

Olsen, A-M., Jensen, T., Dahl, J., Christensen, H. 2001. Reduction in level of Salmonella on swine carcasses after slaughter with and without splitting of the head. Proceeding, Salinpork 2 - 5 September 2001, Leipzig. 124-126

Pedersen, K.B., Henrichsen, J., Perch, B., 1984. The bacteriology of endocarditis in slaughter pigs. Acta path. microbiol. immunol. scand. Sect. B, 92, 237-238.

Pejsak, Z.K., Truszczyński, M.J., 2006. Aujeszky's Disease. In: B.E. Straw, J.J. Zimmerman, S. D'Allaire, & D.J. Taylor (Eds.), Diseases of Swine 9th Edition. Blackwell Publishing. Ames, Iowa, USA. 419-433.

Pedersen, G., 2008. Tican, Thisted, Denmark. gp@tican.dk

Petersen, J.V., Andersen, J.K., Sørensen, F., Knudsen, H., 2002. Food safety on the slaughterline: inspection of pig heads. Vet. Rec. 150, 782-784.

Pointon, A.M., Hamilton, D., Kolega, V., Hathaway, S., 2000. Risk assessment of organoleptic postmortem inspection procedures in pigs. Vet Rec, 146, 124-131.

Reboli, A.C., Farrar, W.E., 2008. *Erysipelothrix rhusiopathiae*: An Occupational Pathogen. Clin. Microbiol. Rev. Vol. 2, No. 4, 354-359.

Robinson, W.F., Maxie, M.G., 1993. The Cardiovascular System. In: K.V.F. Jubb, P.C., Kennedy, & N. Palmer (Eds.), Pathology of Domestic Animals Vol. 3. Fourth Edition. Academic Press, Inc. Hartcourt Brace Jovanovich, Publishers. Toronto, Canada. 1-100.

Rutegard, A., Scan AB, Stockholm, Sweden. Ake.Rutegaard@kcf.se

Statens Serum Institut, 2000. Bacterial meningitis 1996-1999. Epi-News, No. 50. http://www.ssi.dk/sw2976.asp

Statens Serum Institut, 2005. Outbreak of infection with Streptococcus suis in China. Epi-News, No. 25-32. http://www.ssi.dk/sw32363.asp?usepf=true

Statens Serum Institut, 2006. A foodborne group A Streptococcus outbreak. Epi-New, No. 37. http://www.ssi.dk/sw43881.asp

Statens Serum Institut, 2008. MRSA 2007. Epi-News, No. 26. http://www.ssi.dk/sw57895.asp

Stewart, T.B., Hoyt, P.G., 2006. Internal parasites. In: B.E. Straw, J.J. Zimmerman, S. D'Allaire, & D.J. Taylor (Eds.), Diseases of Swine 9th Edition. Blackwell Publishing. Ames, Iowa, USA. 901-914.

Stout J.E., Hamilton, C.D., 2006. Mycobacterium Avium Complex Disease. In: D. Schlossberg (Ed.), Tuberculosis & Nontuberculous Mycobacterial Infections. 5th edition. McGraw-Hill, New York, USA. 419-450.

Sutherland, J., Varnam, A., 2002. Enterotoxin-producing *Staphylococcus*, *Shigella*, *Yersinia*, *Vibrio*, *Aeromonas* and *Pleisiomonas*. In: C. de W. Blackburn and P.J., McClure (Eds.), Foodborne pathogens – Hazards, risk analysis and control. Woodhead Publishing Limited. Cambridge, England. 385-415.

Sørensen, F., Petersen, J.V., 1999. Survey of numbers and types of lesions detectable in pig heads and the implications for human and animal health. Vet. Rec. 145, 256-258.

Taylor, D., 2006. Miscellaneous bacterial infections. In: B.E. Straw, J.J. Zimmerman, S. D'Allaire, & D.J. Taylor (Eds.), Diseases of Swine 9th Edition. Blackwell Publishing. Ames, Iowa, USA. 817-843.

Tema Nord, 2006. Risk-based meat inspection in a Nordic context. T. Nesbakken (Ed.), Nordic Council of Ministers, Copenhagen. http://www.norden.org/pub/velfaerd/livsmedel/sk/TN2006585.pdf

Terpstra, C., Smit, A.d., de Smit, A.J., Thiel, H.J., 2000. The 1997/1998 epizootic of swine fever in the Netherlands: control strategies under a non-vaccination regimen. Vet. Microbiol. 77, 3-15.

Thoen, C.O., 2006. Tuberculosis. In: B.E. Straw, J.J. Zimmerman, S. D'Allaire, & D.J. Taylor (Eds.), Diseases of Swine 9th Edition. Blackwell Publishing. Ames, Iowa, USA. 807-816.

Tirkkonen, T., Pakarinen, J., Moisander, A.-M., Mäkinen, J., Soini, H., Ali-Vehmas, T., 2007. High genetic relatedness among *Mycobacterium avium* strains isolated from pigs and humans revealed by comparative IS*1245* RFLP analysis. Vet. Mic. 125, 175-181.

Tinggaard, S., 2008. Danish Crown, Randers, Denmark. srt@danishcrown.dk

Valli, V.E.O., Parry, B.W., 1993. The Hematopoietic System. In: K.V.F. Jubb, P.C., Kennedy, & N. Palmer (Eds.), Pathology of Domestic Animals Vol. 3. Fourth Edition. Academic Press, Inc. Hartcourt Brace Jovanovich, Publishers. Toronto, Canada. 101-265.

Vestergaard, P., 2008. The Veterinary and Food Administration. Mørkhøj, Denmark. pv@fvst.dk

Von Reyn, C.F., Maslow, J.N., Barber, T.W., Falkingham III, J.O., Arbeit, R.D., 1994. Persistent colonisation of potable water as a source of *Mycobacterium avium* infection in AIDS. Lancet, 343, 1137-1141.

Willeberg, P., Gerbola, M.A., Kirkegaard Petersen, B., Andersen, B., 1984/1985. The Danish pig health scheme: Nation-wide computer-based abattoir surveillance and follow-up at the herd level. Prev. Vet. Med. 3, 79-91.

Winther, K.D., 2008. Danish Pig Production. Kjellerup, Denmark. kdw@dansksvineproduktion.dk

Wisselink, H.J., Van Solt-Smits, C.B., Stockhofe-Zurwieden, N., Bergen-Buijs, H., Rijsman, V.M.C., Overduin, P., Van Prehn, M., Van Soolingen, D., Thole, J.E., 2006. Comparison of pathological and bacteriological examination of mandibulary and mesenteric lymph nodes in pigs, experimentally infected with *Mycobacterium avium* supsp. *avium*. Proc. 19th IPVS Congress, Copenhagen, Denmark. Vol. 1. 185.

Wood, R.,L., Henderson, L.M., 2006. Erysipelas. in: Diseases of Swine (eds. B.E. Straw, J.J. Zimmerman, S. D'Allaire, D.J. Taylor. 9th Edition. Blackwell Publishing. Ames, Iowa, USA. 629-638.

Appendix A: Sample size considerations

Initially, we decided to collect a sample size large enough to be able to estimate the prevalence of *M. avium* in finisher pigs and to look into whether there was a difference in the prevalence of microorganisms in pig hearts with and without endocarditis.

We subsequently used the data regarding prevalence of each of these conditions from the DMA slaughterhouse database. The prevalence of both lesions is about 0.01%. That implies that if 1 mio. pigs are slaughtered, then we would expect 100 cases of granulomatous lymphadenitis and endocarditis, respectively. This was a reasonable sample 100 lymph nodes with granulomatous lesions as well as 100 hearts with endocarditis and 100 normal hearts acting as controls.

Objective 1: Lymph nodes

However, for the lymph nodes we discovered problems in collecting the desired number of samples. This was because 1) granulomatous lesions are more common in the mesenterial lymph nodes than in the mandibular lymph node, hence, there were very few cases of granulomatous lymphadenitis is the mandibular lymph nodes seen, and 2) slaughterhouse workers routinely cut out observable changes in the mandibular lymph nodes before the carcass reaches the meat inspectors. We succeeded in collecting 43 samples from the mandibular lymph nodes. This limited sample size was negative for tuberculosis; however, it is far from large enough to conclude anything about the prevalence of *M. avium*. Therefore, we collected information about findings of tuberculosis in poultry and pigs from the official veterinary laboratories. These data supported the results of the small study: the prevalence of M. avium in finisher pigs in Denmark is very low. However, we are not able to estimate the prevalence closer than this.

Objective 2: Comparison of hearts with and without endocarditis

Also here, we had problems in collecting the desired number of samples; however, to a lesser degree (we got 88 hearts with endocarditis and 56 heart without endocarditis).

Pig hearts with endocarditis are considered unfit for human consumption, since it is believed that occupational hazards like *Erysipelothrix rhusiopathiae* or *Streptococcus* spp. might be present in large numbers and hereby expose the consumers. The zero-hypothesis was that there is no difference in the prevalence of zoonotic bacteria between hearts with and without macroscopic endocarditis. To estimate the needed sample size to evaluate the hypothesis the software programme EpiInfo version 3.4.3 November 2007 was used.

The following parameters were chosen:
Confidence level: 95%
Power: 80%
Ratio between case and control: 1:1
Exposure among controls: 10%
Exposure among cases: 26%

Resulting sample size (n) = 99 of each group => 198

During the study we came to the conclusion that it was of higher importance for us to get an idea about which pathogens are present in hearts with endocarditis than to compare between hearts with and without endocarditis (there were obvious difference in the prevalence of the pathogens found). And here we saw that the sample size obtained (88 hearts) was indeed providing us with that information.

Appendix B: Comments from external reviewers

Review of the "Assessment of risk due to proposed changes to carcass inspection of finisher pigs in Denmark"

Katharina Stärk, Professor, Veterinary Public Health, Royal Veterinary College, London, Great Britain

General comments

This risk assessment presents evidence related to possible effects of changes in organoleptic meat inspection of slaughter pigs in Denmark. The specific proposal is to move the following specific elements of meat inspection to visual inspection:

a) The incision and palpation of the major mandibular lymph nodes

b) The opening and incision of the heart

The outcomes of the assessments are food safety risks for individual consumers, but also national zoo-sanitary risk and occupational risk.

1. For communication purposes, it could have been useful to translate the risk outcome into number of additional cases of human infection/disease per year, but necessary information may not be available. ***We do not expect that the number of cases will change. We have highlighted this in section 6.2, Comparison of traditional inspection with Supply Chain Meat Inspection and in section 9, Risk estimation. Only if the meat inspectors and slaughterhouse workers can keep their hands in the pocket as much as possible and only touch the carcass when necessary, then there is definitely a lower probability of spreading Salmonella and Yersinia. This is explained in section 1.2, Identification of relevant modification to the meat inspection as well as in section 6.2, Comparison of traditional inspection with Supply Chain Meat Inspection.***

2. The impact on zoo-sanitary risk and ergonomic risk are considered at much lower level of detail than food safety risks. They are only discussed at the end as part of the risk estimation. For hazards discussed in sections 6.2.2-6.2.6, it is not clear why these additional hazards are introduced here. These pathogens do not lead to specific lesions that would be affected by the proposed changes and meat inspection in general and the specific elements considered in this assessment are not usually considered critical for the detection of these hazards. I propose to delete them and only mention additional effects in a more general way. ***We included zoo-sanitary hazards into the risk assessment because it is important for a large pig producing and exporting country like Denmark to ensure that we are not jeopardizing animal health when we change meat inspection. This is both for the sake of our own pig production and related to the export of breeding pigs and pork. You cannot be certain about side-effects related to a change in management unless you evaluate it carefully, which is what we have done. We have inserted a couple of sentences that explains this in the beginning of section 7, Impact on zoo-sanitary status***.

3. Similarly, for ergonomic risks, not enough data are presented to make this a formal element of the assessment in my opinion. ***The evaluation is only preliminary because we do not have sufficient data to make a thorough evaluation. This was already stated in section 1.4, Aim. We have made this clearer in the layman summaries and in section 8, Impact on working environment as well as in section 9, Risk estimation and section 10, Conclusion,***

4. In terms of risk management, the use of food chain information (FCI) as well as requirements for pigs to be produced in an integrated production system are mentioned from the beginning. However, the benefits

of these measures and how they would contribute to offset potential negative effects does not become clear. For example, the occurrence of pathogens is likely to be clustering within farms. Additional information on the possible clustering of the pathogens of concern would therefore be useful together with the discussion of the use of FCI in this context. ***In section 1.2 we have inserted a description of how we expect that the diseases pattern of finishers from integrated production systems that are kept indoor since weaning have less variation than pigs from other production systems. Moreover, in section 6.1, Regulatory framework, we describe that Supply Chain Meat Inspection will include a documentation-and-auditing programme of the finisher pig herds and that performance standards have been developed – but this is not a part of the risk assessment and hence not described here. We repeat this in section 9, Risk estimation. A reference to the programmes is given (Anon., 2008bc).***

5. It is not clear how many farms/pigs would fulfil the selection criteria regarding integrated production system and would therefore be processed in such a way. This appears to be an important dimension that would impact on the annual risk to consumers. ***Around 90% of the annual production of pigs would qualify for Supply Chain Meat Inspection. This we have mentioned in section 9, Risk estimation.***

6. The section on comparative risk in the NL who uses the same approach which was assessed by USA is useful. If the USA did also conduct a risk assessment, more specific details on that would be interesting. ***In section 1.3, Risk based meat inspection in other countries, we have elaborated on the description of the process that was carried out in the US with respect to modernisation of meat inspection.***

7. Two specific studies were conducted to provide additional data required for the assessment. However, very little information is provided regarding the sampling approach used. It would be important to ascertain that the samples were representative. ***In Appendix A we have described our intentions to collect 100 lymph nodes and hearts respectively. We have also described why we did not reach this number. This is now also mentioned in section 1.2, Data collection. We find that the combination of data (own-collected, official data from the veterinary services, as well as expert opinion) provide a better background for estimating the prevalence than 100 or even 500 lymph nodes could have provided when seen in isolation. This is already described in section 2.2.***

8. In study 2, it would be interesting to know how many of the carcasses would have been condemned if the inspection of the heart was visual only. ***We recorded presence of other lesions on 28% of the endocarditis cases. These lesions would have resulted in condemnation. We find that this figure probably underestimates the true proportion of endocarditis cases that has other lesions. This is explained in section 6.2.2, The heart.***

9. In general, I would have welcomed a bit more structure in the assessment, for example, at the end of each section you could have summarised the conclusions in terms of qualitative probability as well as uncertainty of the finding. The latter is currently completely missing and should be added. All steps can then been summarised in a final table as you have done in your Table 7. ***We have inserted a short summary at the end of each section. We have explained about the uncertainty in section 5.2, Observed number of human cases in Denmark. We have also inserted two new figures (Fig. 4 and Fig. 5) which in a graphical way displays the exposure risk (what are you exposed to) and the consequence risk (what do you get ill from) and herein explained about the uncertainty related to the prevalence estimates. The figures are also explained in the text in this section.***

10. A graphical risk pathway could have been provided as additional information and to provide structure. ***Please see Fig. 4 and Fig. 5 and the comments to issue number 9.***

Specific comments:

11. In Table 3, the use of the term "negligible risk" requires a risk management decision as to what is acceptable. This level should therefore be defined, e.g. 1 in 1 Mio. for Salmonella and Yersinia. In the same table, should it not say "reduced risk of cross-contamination"? The table is a little confusing as it is focusing on food safety risk (as stated in caption) but also includes occupational risks. For the latter, it is not clear what type of cross-contamination would be relevant. I would have expected direct exposure to be most relevant. ***We have exchanged the term "negligible risk" with "no risk" where we are talking about bovine TB – because as you mention it is the risk manager and not the risk assessor who decides what is negligible or not. Moreover, table 5 (former Table 3) has been revised.***

12. Figures 2 and 3: The data look a bit odd, as if there were identical values for most years. In Figure 2, there is no explanation why values in 1999 and 2007 are so different. ***You are right – it did look odd, and it was because too few decimals were used when creating the figures. That is now corrected in Fig. 2 and Fig. 3.***

13. Hazard characterisation: It is not clear whether *R. equi* infection might be food-borne. ***R. equi is not known to be food-borne. This is now specified in section 3.1.2. Two more references are inserted which shows that when R. equi causes infection it is most frequently in immunosuppresed patients like HIV-patients or transplantation patients***

14. P. 13: Are there any data on number of cases in meat inspectors due to heart incision/pathogens found there, e.g. Erysipeloid. Would these carcasses normally go into the food chain? ***A contact to the slaughterhouse workers' union (NNF), the Confederation of Danish Industry as well as the slaughterhouse Danish Crown revealed that human cases of Streptococcus and Erysipelothrix are occurring at such a low prevalence that it is not considered a problem (Mogens Eliasen, NNF, personal communication). This has been inserted into section 5.2, Observed number of human cases. A part of the carcasses would go into the food chain – as also demonstrated in Fig. 3.***

15. Are there any reported cases due to *S. suis* in slaughterhouse workers? I would expect slaughterhouses to have such data. ***Same answer as to question 14***

16. P. 16: The term "circular" is not very clear, do you mean cycle? ***No, a circular is a part of the regulatory framework. We have changed the title of section 5.1 to Regulatory framework and we have elaborated a bit on the sentence in this section to increase understanding***.
17. Section 6.1.(***current section 5.1)*** Arguments are not reproducible for all pathogens, particularly not for "mild" categories. Information or other justification should be provided. ***You could elaborate a lot on this table, but the intention is merely to give an overview of the consequences of infection of the different hazards, so we decided to stop here.***

Evaluation of the report "Assessment of the risk for humans associated with specific changes in meat inspection of Danish finisher pigs, 2008"

Truls Nesbakken, Professor, Food Safety, Norwegian School of Veterinary Science, Oslo

General comments

The assessment of the risk for humans associated with specific changes in meat inspection of Danish finisher pigs is carried out in a scientific and thorough way. Based on the available documentation presented, the conclusions are reasonable.

1. I fully agree with the conclusions of Hathaway and McKenzie (1991): As tuberculosis and other classic zoonoses have become rare in most developed countries, contamination of carcasses during slaughtering, dressing and meat inspection is the main public health hazard linked to meat. ***Reference cited and inserted in section 7, Risk estimation,*** The specific changes in meat inspection described in the Danish risk assessment report, and in particular, the avoidance of incision of lymph nodes is a step in the right direction in a veterinary public health perspective.

2. In general, I do not think that it is right to conclude that "risk-based meat inspection" is the same as "visual meat inspection" (per definition), and used as a synonym, see for instance in Table 3, and page 17, headline: "Comparison of traditional inspection with risk-based inspection". "Comparison of traditional inspection with visual meat inspection" might be more optimal. This is also one of the discussions which we had during the completion of the Nordic Council of Ministers report "Risk-based meat inspection in a Nordic context" (Tema Nord, 2006), and may be it should have been discussed and clarified in the Danish risk assessment report as well. ***You are correct – we should be more specific. We have changed the title in Table 3 (Table 5 in new version of report) to say that we are comparing traditional meat inspection with Supply Chain Meat Inspection. Moreover, in section 1.2 Identification of relevant modifications to the meat inspection we have defined Supply Chain Meat Inspection and listed the requirements to the herds.***

Some specific comments

3. Some more aspects connected to avoidance of incision of lymph nodes might be mentioned. One example is that some tumours will not be detected i.a. melanoma in duroc pigs (Anon. 1991). ***We agree with you and have extended the discussion in section 6.2.1, The mandibular lymph node***. However, additional arguments and references show that there are some doubts connected to the efficiency of incision of lymph nodes and support the conclusions in the report:

> **4.** A number of mycobacterial infections in pigs caused by *M. avium* might not be detected by incision of lymph nodes because the lesions are not visible. Hird et al. (1983) isolated *M. avium* from 6.7% of 280 *lnn. mesenteriales* with no visible lesions, ***Inserted into section 6.2.1, The mandibular lymph node***
>
> **5.** Due to the difficult work conditions and the limited time available, the validity of the quality of the classification of lesions has been questioned (Willeberg et al., 1984/85), ***Inserted into section 6.2, Comparison of traditional inspection with Supply Chain Meat Inspection***
>
> **6.** Many of the younger meat inspectors in the Nordic countries have never seen tuberculosis in slaughter animals or some of them might even not be familiar with its appearance, and the disease

might not be detected. ***We believe that when the lesions are large and observed in several lymph nodes, then they will be found. This is inserted into section 6.2.1.***

7. Infection with *M. avium* might also be detected by visual inspection of the liver. In this context it is important that the meat inspector is able to distinguish mycobacterial lesions in pig livers from spots of other origin, especially "milk spots" caused by ascarid larvae (Alfredsen, 1992). ***We agree with you - training of personnel is important. We have used the reference in section 6.2.1, The mandibular lymph node, and listed it in the reference list. Moreover, in section 9, Risk estimation, we have highlighted the need for training of personnel and explained that this is a part of the Supply Chain Meat Inspection.***

8. One comment in the end: Both the words "carcasses" and "carcases" are used in the report. ***This has been corrected so only one kind of spelling (carcasses) is being used throughout the report***

9. References

We would like to thank you for suggesting these scientific papers to us. We have used them all

Alfredsen, S.A, 1992. Differentiation between parasitic interstitial hepatitis and mycobacterial lesions in pig livers. Bull. Scand. Soc. Parasitol. 2, 33-35. ***Used in section 6.2.1, The mandibular lymph node, and cited in the reference list***

Hathaway, S.C., McKenzie, A.I., 1991. Postmortem meat inspection programs; separating science and tradition. J. Food Protect. 54, 471-475. ***Reference used in section 9, Risk estimation, and cited in the reference list***

Hird, D.W., Lamb, C.A., Lewis, R.W, Utterback, W.W., 1983. Isolation of mycobacteria from California slaughter swine. In: Proceedings of the United States Animal Health Association, 87th Annual Meeting: 559-565. ***Reference used in section 6.2.1, The mandibular lymph node, and cited in reference list***

Nord, 1992. Kjøttkontroll i de nordiske land – forslag til harmonisering og modernisering av regelverk, Nordic Council of Ministers, Copenhagen, 122 pp. ***We believe that you are referring to a reference already cited in reference list under Tema Nord, 2006. You are also referring to it in your comment number 2.***

Willeberg, P., Gerbola, M.A., Kirkegaard Petersen, B., Andersen, B., 1984/1985. The Danish pig health scheme: Nation-wide computer-based abattoir surveillance and follow-up at the herd level. Prev. Vet. Med. 3, 79-91. ***Cited in section 5.2, Comparison of traditional inspection with Supply Chain Meat Inspection, and listed in reference list***

Truls Nesbakken
Professor, Food safety
Norwegian School of Veterinary Science, Oslo

Eystein Skjerve
Professor, Epidemiology of Food-borne Diseases
Norwegian School of Veterinary Science
P.O. Box 8146 dep., 0033 Oslo
Norway
Mail: Eystein.Skjerve@veths.no
Phone: +47 22964844/
Mobile: +47 95243560

Oslo 26.11.2008

Danish Meat Association

Att. Dr. Lis Alban

Axelborg, Axeltorv 3,

DK-1609 Copenhagen V,

Denmark

External review of the report *"Assessment of the risk for humans associated with specific changes in meat inspection of Danish finisher pigs"*

I have been asked by Dr. Lis Alban to be one of three external experts to forward comments on the report presented. I have reviewed the report critically based upon my knowledge of meat inspection, epidemiology and risk assessments. My review has been undertaken without any discussions with dr. Nesbakken and dr. Stärk, the two other external experts.

The risk assessment is written within the approved tradition of OIE, a slightly different approach than the Codex Alimentarius approach. The work is a consequence of changed regulations in the EU, and builds upon a firm Nordic tradition of scientific views on the local adaptation of meat inspection with the infection status of pigs we have in the Nordic countries. Hopefully the report will also open for other countries to establish similar or other modifications of the meat inspection procedure for pigs.

I hope that my report will contribute to the important work of implementing a real risk-based meat inspection – not only in Denmark but also other countries.

I have some critical comments to the report, but fully support the conclusions presented.

Yours

Eystein Skjerve
Professor

Introductory comments
The specific comments cover the different parts of the reports, where the strengths and some weaknesses of the report are commented on. In spite of certain weaknesses, the report argues well and the conclusions are well supported.

Abstract
The abstract summarizes the report in an adequate way, and brings the reader into the questions addressed as well as summarizes well the conclusions of the report.

Introduction
The introduction comments on the term risk-based meat inspection, refers to the reports of importance and the legislative changes the last years. Of special importance is the documentation of the quality of the chain information in the Danish pig production chain. It is likely that Denmark has the pig production chain with the best documented production and disease status in the world, also including a professional interaction between the pig industry and the national authorities.

1. Based upon 4 criteria, the report presents the procedures questioned; the incision of mandibular lymph nodes and the opening of the heart. The report is a bit unclear on this point, and it is suggested that the report may present the reason for these two procedures to be questioned, as there is no direct relationship between the 4 criteria and the two (relevant) procedures. The form required of the risk assessment template may be one reason for this, as in principle the hazard identification should be the part where this is done. ***The identification of which modification to change was revealed through discussions with meat inspectors working at the slaughterhouse as also states in section 1.2, Identification of relevant modifications to the meat inspection. Then we evaluated the chosen modifications (omission of incisions into lymph nodes and heart) against the four criteria – so there is no direct relationship prior to that.***

The arguments against the use of the two procedures are linked to the disease situation in Denmark and the possible contamination of the carcasses by the incisions made in the procedures. Of special importance is the fact that it is possible to reduce contamination from enteric as *Salmonella* or *Yersinia* by avoiding the mandibular incisions. The report also brings the most important references documenting that visual inspection procedures are found as efficient as incision-based procedures. The report gives a proper introduction to the experiences from other countries, especially the Netherlands and USA, with Sweden in line without having concluded on any change so far.

The introduction ends with presenting the aim of the report, in full line with the rest of the introduction. For the reader, this aim may seem self-evident after reading the rest of the introduction, but it is still relevant to present the aim in such a precise way.

Materials and methods
2. After describing the essentials about the risk assessment procedures used, before presenting the data used in the risk assessment. There is an abundance of data from the Danish system, and some are presented in the report. Figure 1 and 2 could have been presented a bit more clearly with more marks on the y-axis, and Figure 2 gives a strange impression with the 1999 and 2007 almost exactly the double of the intermediate years. ***We have corrected Fig. 2 and Fig. 3. The odd appearance was a result of choosing too few decimals.***
As an input to the risk assessment, 25 mandibular lymph nodes and 76 abnormal/ 56 normal hearts were sampled. These data and their use are commented upon later.

Hazard identification

As in most microbiological risk assessment, the hazard identification seems a bit artificial, but the authors were strict to the procedures described, and this is more a reflection of the problems of using the risk assessment template. It does, however bring the basic information about tuberculosis in animals, also referring to the fact that Denmark is considered free of *M. bovis*, while the *M. avium* can occasionally be found in pigs. As the report states, there are no indications that *M. avium* lymph nodes represent any substantial health risk. Of more interest is the documentation that bacteria causing endocarditis in pigs are more likely an occupational hazard than a food borne hazard, underlining that it may be better not to incise the heart.

Release assessment

The main part of this chapter is based upon previous Danish data and data from the Netherlands, but the table brings the results from the current examination of the 25 lymph nodes as well as describes the bacteria found in the hearts with and without endocarditis. As the chapter stands, the data from the current dataset have a very small number of observations, and the main rationale behind the conclusions is linked to previous, published studies and not to the presented current data – although they are in line with the previous data.

Exposure assessment

The most interesting part here is the comparison between traditional meat inspection and the suggested revised procedure. As mentioned, a full visual procedure is not in question here, only removing two of the incision procedures. The main arguments are summarized in Table 3, where it is clearly documented that the revised procedure may be a better procedure for public health concerns. The lack of documented links between most agents in pigs and food borne infections are well documented in Table 4, where it correctly is stated that under the Danish scenario, the main public health concerns linked to pork are two enteric bacteria (*Salmonella* and *Yersinia*), which may be promoted by the incisions in the traditional procedures.

Consequence assessment

3. This is a bit long, and also brings in other zoonotic agents not present in Denmark and exotic swine diseases. It may be an idea to delete these from the report, or possibly mention them only in the introduction and not focus on these on the consequence assessment. It would be easier to read the chapter if the focus on possible agents linked to mandibular incisions and heart opening were focused. A strong side of the text on consequence assessment is the discussion about the impact on the working environment. ***Denmark is a large exporter of breeding pigs and pork. Hereby, it becomes very important to stay free of exotic animal diseases. Any change you make might have unexpected drawbacks which can only be predicted if a careful analysis has been made – which is what we have done. But we do agree that the chapter was very long. We have divided the chapter into three chapters: Consequences (section 5), Zoo-sanitary impact (section 7), and Working environment (section 8). This will hopefully make the report more readable.***

Risk estimation

4. This chapter is the best part of the report, and brings a clear and concise message about the assessments presented. The arguments behind the conclusion are mainly qualitative (appropriate enough), and it remains a bit obscure how the new data brought into the report were used. The report could have been written without these data, with exactly the same conclusions. However, I fully support the views of this chapter. ***We were of the opinion that it would be useful to collect own data in relation to the risk assessment, and we agree that the sample size stated in the version of the report that was sent for external review (25 lymph nodes and 76 hearts) was not going to impress anybody. Since then, more lymph nodes and hearts have been collected and analyzed. By November 28, 2008, we have 43 lymph nodes and 88 hearts with endocarditis, which is a bit better than the numbers we had the***

previous month. We are of the opinion that the best picture is when multiple sources of data are collected: own data, official laboratory data, expert opinion and published literature. If all these data point to the same direction, then we feel more confident about the conclusion. We have explained about this approach in section 2.2, Data collection

Conclusions
The conclusions are written clearly and directly to the point, and there is no doubt that the conclusions are rational.

Appendix A. Sample size considerations
5. The text on lymph nodes and the number of samples demonstrates that these data really could not mean much for the conclusion of the report. For the heart, the authors claim that a case-control approach would result in 99 samples in each group. This sample size approach is very crude and the real life is a bit more complex, as there are several categories of bacteria detected. Further, if the problem was the lack of hearth samples, it would be easy to obtain more negative samples for culturing to improve the power of the study. Again, it seems as these data are not really important for the conclusions taken. It may be better to delete the appendix and rather bring the necessary text into the report itself – or delete the use of these data. ***The appendix A on Sample size considerations has been rewritten. Please, also see comment to Risk estimation.***

Conclusions from the reviewer
I agree with the conclusions drawn and support the view that Denmark should allow a simplified procedure for certified herds of pigs, omitting mandibular incisions ad heart opening.

6. However, the report could have brought forward the same message in a much shorter form, as the literature cited without doubt supports the conclusions. The risk assessment form chosen seems to obscure the question more than needed. ***For people working in the area of meat inspection, a large part of the risk assessment seems obvious (and could be written in a shorter way). But for those who are not familiar with the area (politicians), or interested in food safety in general (like consumer protection groups) it is necessary to carefully analyze the impact of the suggested changes. In line, for a meat inspector who has been working with one regulatory framework for years, and is now being asked to change, it makes sense to provide him or her with a thorough analysis dealing with all concerns there might arise. Finally, an importing country might not be aware of the specific situation in Denmark which allows for a specific conclusion; again here a careful evaluation is needed.***

7. Having said this, I accept that the template of a risk assessment may have to be used in these evaluations, but this more shows that risk assessment may have severe limitations in this rather simple situation, where suing such a template mainly leads to a report of many more words than necessary. ***Yes, the report is long. Hopefully, the edited version with a better division into chapters and sections might assist in identifying the issues of importance to the individual reader. We have also chosen to summarize each chapter.***

8. A more relevant objection to the report is the use of the new data used in the report. The low number of mandibular lesions has of course no documentation effect compared to the overwhelming historical documentation of the absence of *M. bovis* in Denmark. Further, the sample size calculations for the heart data are rather crude. The authors may consider deleting these to datasets from the report, as they do not influence the conclusions, and only seem to be there to justify that some new empirical data have been presented. ***Same comment as to issue number 4, Risk estimation***

Appendix C: Impact of disease on the individual

Table C1

Assessment of impact of specific diseases possibly related to pigs and pork on the individual human

Pathogen	Symptoms	Duration	Complications	Hospitalization	Mortality	Assessment[a]
Streptococcus suis	Fever, nausea and vomiting[b]		In severe cases meningitis, skin bleedings, toxic shock and coma[b]	Yes, in severe cases	20%[a]	Mild to Severe
Staphylococcus aureus	Vomiting, diarrhoea, headache[c]	1 day[c] <2 days[e]	No	No	Close to 0%	Mild
Erysipelothrix rhusiopathiae	Localized cutaneous infection or diffuse cutaneous disease			No	Close to 0%	Mild
Mycobacterium bovis	Fever, weight loss, fatigue. Lung-tuberculosis: coughing and expectorate	Months to years		Yes		Severe
Mycobacterium avium	Small children: glandular symptoms. People with pre-exisitng lung infection: pulmonary infection. HIV/AIDS patients: disseminated infection	Months to years		Yes, in vulnerable groups	High in untreated HIV/AIDS patients	Severe among vulnerable groups
Campylobacter spp.	Self-limiting gastroenteritis	2-7 days[e] 5-10 days[c]	Relapse with abdominal pain. Infrequently reactive arthritis[c], and rarely Guillain-Barré syndrome (neurologic illness) [c,e,f]	5%	Close to 0% - 1 pr. 20.000[b]	Moderate
Salmonella spp.	Gatroenteritis, diarrhoea, vomiting	Mild course: 2-5 days[e]. Up to several weeks[c]	Infrequently sepsis (few percent)[c] appendicitis, arthritis, meningitis, peritonitis[e]	Yes, when sepsis occur	0,1%[c] –0,7%[fg]- depending upon Salmonella strain	Moderate
Yersinia enterocolitica	Enterocolitis, diarré, diarrhoea, arthralgia. Appendicitis-like syndrome in children[e]	14-22 days[e] 5-14 days[e]. However up to months[c,e,f]	Infrequently reactions in skin and connective tissue. Reactive arthritis 10-30%[f]. Sepsis rarely seen[c]	Sepsis is possible but often caused by blood transfusion	Sepsis: 7.5-50%[f]	Moderate

References to Table C1

a) The assessment is based on the most common form of infection seen
b) http://www.ssi.dk/sw32119.asp
c) Anon, 1999. Vejledning om vurdering af patogene mikroorganismer i fødevarer. Fødevaredirektoratet. 80 pp.
d) http://www.ssi.dk/sw665.asp
e) Anon, 1996. Microorganisms in foods, 5. Microbiological specifications of food pathogens. ICMSF, Blackie Academic & Professional. London, England
f) Anonym, 2002. Infections of the gastrointestinal tract, second edition. Lippincott, Williams & Wilkins.
g) Helms, M., Vastrup, P., Gerner-Smidt, P., Mølbak, K., 2003. Overdødelighed i relation til antibiotikaresistent Salmonella Typhimurium. Ugeskrift for Læger. 165, 235-239.

Layman summary – in English

A modernisation of meat inspection will make it possible to deal with the hazards that are relevant today. A risk assessment of Danish finisher pigs shows that it is unnecessary to cut into the mandibular lymph nodes and the heart routinely when slaughtering finisher pigs, A precondition is that the pigs originate from integrated production systems, where the pigs are kept indoor since weaning. And that food chain information is made available to the slaughterhouse prior to slaughter.

The aim of meat inspection is to ensure that the meat we consume is savoury and safe. Around 100 years ago people became ill from bovine tuberculosis and brucellosis. Meat inspection was designed to identify and dispose of carcasses from animals infected with these bacteria. Meat inspection is – in other words – targeting the hazards that were important 100 years ago. Since, bovine tuberculosis and bovine brucellosis have been eradicated from Denmark. Nowadays, other hazards fill up the statistics for food borne disease. In particular, Salmonella and Campylobacter are resulting in a larger number of human cases.

The rules for meat inspection should be updated to take into account the hazards that are most important at a given point in time. This is the philosophy behind recent changes in the legislation of the European Community that have made it possible to update the meat inspection. There are three requirements, which should be fulfilled. Firstly, a risk assessment should be undertaken. And this should demonstrate that the suggested changes do not jeopardise food safety. Secondly, only finishers from integrated production systems, where pigs are kept indoors since weaning can undergo a modernised meat inspection. And thirdly, the pig herds should ensure that food chain information has been made available to the slaughterhouse prior to slaughter. This includes among other data on use of antibiotics.

Two questions are relevant in relation to slaughter of Danish finisher pigs. Firstly, what is the effect of cutting into the large mandibular lymph nodes? Secondly, what is the effect of opening the heart? Both are done routinely today. The idea is only to make these incisions on carcasses where pathological changes are observed. This might reduce the spreading of Salmonella and Yersinia bacteria for the benefit of the consumer.

A risk assessment was undertaken in collaboration between University of Copenhagen (the former Royal Veterinary and Agricultural University), the Danish Veterinary and Food Administration and Danish Meat Association (DMA). The aim was to assess the impact on the suggested changes on food safety. Furthermore, it was of interest to evaluate the impact on the ability to identify exotic animal diseases, like foot and mouth disease. Finally, it was the intention to get an idea of the impact of the working environment on the slaughterhouses.

Samples were collected from ten Danish slaughterhouses. Mandibular lymph nodes with granulomatous/caseous lesions (the lymph nodes looks like gritty cheese on the inside) were collected and it was investigated which bacteria had caused the altered look. In line, it was investigated which bacteria were present in hearts with infection on the inside. Moreover, information was collected form the DMA slaughterhouse database as well as from the literature and experts.

The results show that the prevalence of granulomatous/caseous lymph nodes is very low among Danish finisher pigs (0.01-0.02%). Several pathogens might lead to this appearance among others avian and bovine tuberculosis. And the fear of bovine tuberculosis is in fact the reason for cutting into this lymph node. Denmark is officially free from bovine tuberculosis since 1980. Moreover, an extensive surveillance program is in place. Therefore, there is no risk of bovine tuberculosis as a result of Danish pork.

No bacteria were found in 35% of the collected lymph nodes. In 63% a bacterium called Rhodococcus equi was found, and in one case a bacterium called Nocardia was found. Neither Rhodococcus equi nor Nocardia are food-borne.

Veterinarians from official Danish laboratories stated that between zero and three cases of avian tuberculosis in poultry are found annually. The cases consist primarily of old hens from backyard herds or from zoological gardens. Approximately the same number of pigs is investigated, and occasionally avian tuberculosis is found. Human cases of avian tuberculosis are seen, in particular among AIDS patients. According to the literature the source of human infection is found in the environment. Avian tuberculosis bacteria are e.g. found in water, sphagnum, and cigarettes. When pigs are slaughtered, the mandibular lymph nodes are removed and end up in pet food after adequate heat-treatment.

Conclusively, there is no risk for humans associated with the omission of the routine cutting of the mandibular lymph nodes. On the contrary, unnecessary palpation and cutting will increase the risk of spreading bacteria such as Salmonella and Yersinia.

If pig hearts are not opened routinely, cases of infection on the inside of hearts might be overlooked. According to the DMA slaughterhouse database this occurs only at seldom (0.01%). The collected data shows that such infections are primarily caused by Streptococcus bacteria (51%) or swine erysipelas bacteria (32%). The types of bacteria found are primarily occupational hazards since they are known for giving rise to infections in wounds in people working with live animals or carcasses. These bacteria are generally not food-borne.

Other serious pathological changes were observed in 28% of the cases where infection on the inside of a pig heart was found. That led to an extensive control of the carcass and presumably to condemnation. Hearts are sold to supermarkets etc. They need to be opened to clean the heart from blood coagula prior to sales. If changes are seen when opening the heart, it will be disposed of. This can be conducted by slaughterhouse workers separately and after meat inspection. This will lower the spreading of bacteria to the rest of the carcass. The judgement is that there is no extra risk for the consumer, because the bacteria possibly present are not food-borne.

Exotic animal diseases are more easily observed in live animals than on carcasses. Trichinella is an exception and requires laboratory testing. In Denmark, extensive surveillance programs are in place. Hence, the ability to find these infections is not affected by the suggested changes to meat inspection.

Regarding the working environment, the preliminary assessment showed that fewer cases of cut damages are expected if the routine cutting of hearts and lymph nodes is omitted. Moreover, the strain of physical activity will probably be reduced, because the slaughterhouse workers do not have to bend over the carcass to palpate and cut routinely.

Conclusively, there is no risk associated with the omission of the routine cutting into the mandibular lymph nodes and the heart. There seems to be a positive effect on the working environment. And there is no impact on the ability to find exotic animal diseases. We call this way of slaughter “Supply Chain Meat Inspection – The Danish way” to emphasize that it is based on requirements to the pig herds.

The risk assessment can be found on the homepage of the Danish Veterinary and Food Administration on http://www.foedevarestyrelsen.dk/forside.htm and DMA http://www.danishmeat.dk/Forside.aspx

Layman summary – in Danish

Det er en god idé at modernisere kødkontrollen. Så kan der tages hånd om de smitstoffer, der giver problemer i dag. En risikovurdering viser, at det ikke er nødvendigt at skære ind i kæbelymfeknuden og hjertet af slagtesvin – snarere tværtimod. En forudsætning er, at svinene har været holdt indendørs siden fravænning, og at slagteriet modtager såkaldte fødevarekædeoplysninger, inden svinene slagtes.

Formålet med kødkontrol er at sørge for, at det kød, vi spiser, er sikkert og appetitligt. For omkring 100 år siden blev mange mennesker syge af kvægtuberkulose og brucellose. Kødkontrollen blev derfor udformet, så man kunne finde og bortskaffe slagtekroppe fra dyr, der led af disse sygdomme. Kødkontrollen er med andre ord bygget op ud fra de farer, der var aktuelle for 100 år siden.

Vi har udryddet både kvægtuberkulose og brucellose. Nu er det andre sygdomme, der fylder i sygdomsstatistikken. Især Salmonella og Campylobacter.

Reglerne for kødkontrol bør opdateres så de afspejler de smitstoffer, der giver problemer. Dette synspunkt er baggrunden for nylige ændringer i europæisk lovgivning, der gør det muligt at ændre i kødkontrollen. Tre krav skal være opfyldt: 1) En risikovurdering skal gennemføres. Og den skal vise, at de foreslåede ændringer ikke forringer fødevaresikkerhed. 2) Kun slagtesvin fra indendørs besætninger kan slagtes efter andre regler end den traditionelle kødkontrol. 3) Besætninger, der leverer svin, skal levere såkaldte fødevarekædeoplysninger. Dette dækker bl.a. information om brug af lægemidler.

To spørgsmål er særlig interessante i forbindelse med slagtning af svin: Hvad er effekten af at skære i de store lymfeknuder i kæben? Og, hvad er effekten af at åbne hjertet? Begge dele foretages rutinemæssigt i dag. Forslaget til modernisering er, at man kun skal gøre dette på slagtekroppe med synlige forandringer. Dette kan måske begrænse spredning af Salmonella og Yersinia bakterier til glæde for forbrugeren.

En risikovurdering blev iværksat som et samarbejde mellem Københavns Universitet (det tidligere KVL), Fødevarestyrelsen og Danish Meat Association (DMA). Formålet var at vurdere effekten af de foreslåede ændringer på fødevaresikkerhed. Dernæst skulle man se på evnen til at finde eksotiske, smitsomme sygdomme såsom mund- og klovesyge. Sidst ville man se på effekten for arbejdsmiljøet på slagterierne.

Som input blev der indsamlet prøver fra ti slagterier i Danmark. Lymfeknuder med såkaldt forostede forandringer (lymfeknuden ligner grynet ost indeni) blev undersøgt for hvilke bakterier, der gav det forandrede udseende. Ligeledes blev det undersøgt hvilke bakterier, der eventuelt var til stede i hjerter med betændelse på hjerteklapperne. Der ud over blev der indhentet information fra DMAs slagteridatabase samt fra litteratur og eksperter.

Resultaterne viser, at der er en meget lav forekomst af forostede lymfeknuder i Danmark (0,01-0,02%). Forostede lymfeknuder kan skyldes mange ting - blandt andet fugletuberkulose og kvægtuberkulose. Og frygten for kvægtuberkulose er faktisk årsagen til, at man skærer i denne lymfeknude. Danmark er officielt fri for kvægtuberkulose (og har været det siden 1980). Et omfattende overvågningsprogram er på plads. Der er derfor ingen risiko for at få kvægtuberkulose som følge af at spise dansk kød.

I 35% af de indsamlede lymfeknuder kunne man ikke finde nogen bakterier. I 63% af lymfeknuderne blev fundet en bakterie ved navn Rhodococcus equi. Der udover blev der i en lymfeknude (2%) fundet en bakterie kaldet Nocardia. Hverken Rhodococcus equi eller Nocardia kan overføres til mennesker i forbindelse med at spise kød.

Dyrlæger fra officielle, danske laboratorier har oplyst, at der årligt findes mellem nul og tre tilfælde af fugletuberkulose hos fjerkræ. Det drejer sig om gamle høns fra hobbybesætninger eller zoologiske haver. Tilsvarende undersøges der hvert år et lignende antal svin med forostede lymfeknuder – og fugletuberkulose findes ind i mellem i disse dyr. Man kan godt se tilfælde af fugletuberkulose hos mennesker; f.eks. blandt AIDS patienter. Ifølge litteraturen smitter fugletuberkulose gennem kontakt til miljøet bredt set. Der kan f.eks. findes fugletuberkulosebakterier i både vand, spagnum og cigaretter. Når man slagter svin, fjerner man i øvrigt altid kæbelymfeknuderne, der herefter går til hundefoder efter varmebehandling.

Baseret på al dette er konklusionen, at der ikke er risiko for mennesker, selv om rutinemæssig undersøgelse og snit i kæbelymfeknuderne ophører. Unødig berøring udgør derimod en risiko for spredning af bakterier såsom Salmonella og Yersinia.

Åbner man ikke hjerter rutinemæssigt, kan man overse tilfælde af betændelse på hjerteklapperne. Ifølge DMAs slagteridatabase ses denne form for betændelse kun sjældent hos danske slagtesvin (0,01%). De indsamlede data viser, at der især er tale om betændelse forårsaget af streptokok-bakterier (51%) og rødsygebakterier (32%). De bakteriearter, der blev fundet, har primært betydning for arbejdsmiljøet. De er nemlig kendt for at kunne give betændelse i sår hos folk, der håndterer levende dyr eller slagtekroppe. Disse bakterier smitter generelt set ikke gennem indtagelse af fødevarer.

I 28% af tilfældene af hjerteklapbetændelse var der andre alvorlige forandringer på slagtekroppen. Dette har medført en særlig udvidet undersøgelse af kroppen og formentlig kassation. Hjerter sælges til konsum i både ind- og udland. Og de skal åbnes inden salg for at fjerne blod og observere, om der er forandringer af/på hjerteklapperne. Er der forandringer, smides hjertet ud. Dette kan foretages af slagteriarbejdere separat og foregå efter kødkontrol. Det vil mindske spredning af bakterier til resten af slagtekroppen. Det vurderes, at der ingen ekstra risiko er for forbrugeren, da bakterierne ikke er fødevarebårne.

En analyse af evnen til at finde eksotiske, smitsomme husdyrsygdomme viser, at disse sygdomme lettere ses hos levende dyr end på slagtekroppe. Trikiner kræver dog laboratorieundersøgelse, idet de ikke kan ses med det blotte øje. Danmark har omfattende overvågningsprogrammer for alle disse sygdomme. Så man vil finde sygdommene via disse programmer – hvis de skulle komme til landet. Evnen til at finde eksotiske sygdomme påvirkes ikke af en moderniseret kødkontrol.

En foreløbig analyse af betydning for arbejdsmiljø viser, at der forventes færre tilfælde af skæreskader, hvis man ophører med rutinemæssigt at skære i lymfeknuder og hjerter. Ligeledes vil der være mindre fysiske anstrengelser, hvis kødkontrollørerne ikke behøver at bøje sig for at komme til at skære disse to organer rutinemæssigt.

Konklusionen på risikovurderingen er, at der ikke er nogen risiko for mennesker forbundet med ophør af den rutinemæssige undersøgelse og indskæring i kæbelymfeknuder samt åbning af hjertet. Snarere tværtimod. Ligeledes er der tilsyneladende en positiv effekt på arbejdsmiljøet. Og som sagt påvirkes evnen til at finde eksotiske, smitsomme husdyrsygdomme ikke. Vi kalder den nye måde at slagte svin på for Supply Chain Meat Inspection for at vise, at den er baseret på krav til besætningerne.

Rapporten kan findes på Fødevarestyrelsens hjemmeside http://www.foedevarestyrelsen.dk/forside.htm
og på DMAs hjemmeside http://www.danishmeat.dk/Forside.aspx