

# Output-based assessment of country-specific ability to remain free and document freedom from bovine tuberculosis under different cattle meat inspection scenarios

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## Abstract

Bovine tuberculosis (bovTB) is a zoonotic infection. Despite of actions taken, bovTB is still present in some countries, whereas other countries have managed to eradicate the infection. Denmark has been officially free from bovTB since 1980. Still incisions into selected lymph nodes of all cattle at meat inspection continue due to the EU Meat Regulation. However, incisions are increasing the probability of spreading *Salmonella* on the carcass and bovTB is not considered meat-borne, so the value of this procedure is being questioned. We investigated to which extent a replacement of the traditional meat inspection with a visual-only inspection will impact on Denmark's ability to substantiate freedom from bovTB. To do so, we used a disease freedom modelling approach combined with two import risk assessments. The conclusion was that although the ability to detect bovTB will be lower, if visual-only inspection is applied, the surveillance system will continue to provide a sufficiently high confidence in substantiating freedom from bovTB, if the import risk is kept low, i.e. around 1% per year, which is in fact the recently estimated risk. However, cases may be found later than when using traditional inspection. It is interesting that the output-based approach combined with import risk assessment is able to provide a relatively small country, such as Denmark, with a high level of confidence in freedom from bovTB whereas the traditionally used approach, which based on system sensitivity estimation, might fail due to insufficient data amounts. This is relevant for both EU and OIE legislation.

**Keywords:** *Risk-based surveillance, meat inspection, bovine tuberculosis, freedom*

## Introduction

During meat inspection of slaughter animals spreading of *Salmonella* may happen. In the EU, a total of 82,694 human salmonellosis cases were seen in 2013 (1). In beef, *Salmonella* is the number one zoonotic hazard. Visual-only meat inspection has been recommended by EFSA's Biohaz panel as one way to minimise the risk, because the lack of handling reduces the spread of *Salmonella* on and between carcasses.

However, EFSA's Animal Health and Animal Welfare (AHAW) panel has raised concern about visual-only inspection, because that may lead to an impaired ability to detect bovine tuberculosis (bovTB) (2).

Originally, when meat inspection was developed more than 100 years ago, bovTB was identified as a relevant hazard in many countries all over the world. Since then bovTB has been eradicated in several countries. BovTB is a slowly-spreading infection among cattle, usually caused by air-borne transmission, and humans play a minute role in the transmission (3,4). The primary route of exposure of humans to bovTB is through non-pasteurised milk; and the incidence of human cases of bovTB plummeted in the entire EU after introduction of pasteurisation of milk (3) – making reactivation of childhood infection in elderly people and migrant-related cases the most common type of cases in most Member States. In EU, a total of 134 human cases of bovTB was reported from a total of nine Member States in 2013; and among these Ireland had the highest notification rate (1).

The current low risk combined with the risk of zoonotic infections during traditional meat inspection led to a wish to investigate what the impact would be of replacing the traditional meat inspection with a visual-only inspection on Denmark's ability to remain free from bovTB and to substantiate the freedom from bovTB.

## Materials and methods

Four studies were performed.

### Study 1

The disease freedom model approach developed by Martin *et al.* (5) was used to assess the ability to substantiate freedom from bovTB assuming either the current meat inspection or visual-only inspection of all slaughtered cattle (6). First, the annual surveillance system sensitivity (SSE) was estimated, and next, the SSE was used for estimation of the probability of freedom (*PFree*) over time, based on the epidemiological concept of negative predictive value to substantiate free status (5).

### Study 2

The study was repeated with updated parameter estimates (7) and compared with a model developed by EFSA, where the latter made use of SSE as a measure of confidence in OTF status (8).

### Study 3 and 4

In these two studies, the annual probability (*PIntro*) of introducing *Mycobacterium bovis* and *Mycobacterium*

*tuberculosis*, respectively, into the Danish cattle population was assessed through (a) imports of cattle and (b) foreign personnel working in Danish cattle herds. Data from 2000 to 2013 with date, number and origin of imported live cattle were obtained from the Danish Cattle Federation. Information on immigrants working in Danish cattle herds was obtained through a questionnaire sent by email to a sample of Danish cattle farmers (N=460). Inputs obtained from data analysis, expert opinion, the questionnaire and literature were fed into three stochastic scenario tree models used to simulate the effect of import trade patterns, and contact between immigrant workers and cattle (4,9).

## Results

The three studies - the EFSA study, Study 1 and 2 - found that changing from traditional meat inspection to visual-only would markedly decrease the SSE. However, the three studies reported diverging conclusions regarding the effect on the substantiation of Denmark as a bovine tuberculosis free country, if visual-only inspection were to be introduced. (6,7,8).

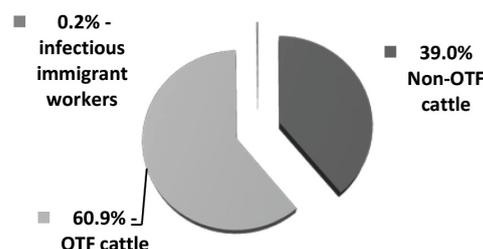
EFSA (8) showed how a reduction of the detection sensitivity could have a negative impact on the overall surveillance system sensitivity, especially in the Officially Tuberculosis Free (OTF) countries, where meat inspection is the only surveillance system in place.

However, the two models using the disease freedom approach concluded that a country such as Denmark would be able to substantiate freedom from bovine tuberculosis even if visual-only inspection was implemented. The condition was that the annual probability of introducing bovine tuberculosis to the country would be kept  $\leq 1\%$  (7,8).

The import risk assessment for *Mycobacterium bovis* (Study 3) showed that the median annual probability of introducing *M. bovis* into the Danish cattle population by either imported live cattle or infectious immigrant workers was estimated to 0.7% - and the risk was driven mainly by importation of live cattle (Figure 1) whereas infectious immigrant workers only played a negligible role (4). It can be noted from Figure 1 that the risk related to importing cattle from OTF countries was higher than cattle from non-OTF countries. This was related to a higher number of cattle imported from OTF-countries.

Contrary, the import risk assessment for *Mycobacterium tuberculosis* (Study 4) showed that the probability of introduction was mainly driven by infectious immigrant workers, and the median annual probability of introduction was 4.1% (9).

**Figure 1.** Relative contribution of three sources of introduction of *Mycobacterium bovis* to Danish cattle.



## Discussion

The EFSA study, Study 1 and 2 reached different conclusions regarding the impact of replacing traditional meat inspection with visual-only on a country's ability to substantiate freedom from bovine tuberculosis. The difference was mainly related to two factors: i) whether using SSE or the negative predictive value as a measure for substantiating freedom from bovine tuberculosis and ii) the fact that EFSA only used one year of data whereas our studies made use of temporal discounting of several years of test-negative data.

In the current EU and OIE set-up for recognition of OTF status only one year of data are used - making it more difficult for smaller countries to substantiate freedom. However, intuitively and in all fairness to countries that are able to remain free from infections for many years, methods that allow for including updated numbers from each year the country remains free from infection provide more convincing and encouraging surveillance.

According to EFSA's AHAW panel, detection of bovine tuberculosis would be more difficult if palpation and incision of relevant organs (lung, respiratory tract lymph nodes) were removed from inspection tasks (2). However, the AHAW panel did not look specifically at Member States, which are entirely free from bovine tuberculosis. Such Member States have safe trade patterns and risk mitigating production facilities, and thus, a high biosecurity level. This reduces the probability of disease introduction ( $P_{Intro}$ ) from abroad, (4,9) and, as a consequence, the historical confidence in freedom from bovine tuberculosis ( $P_{Free}$ ) could be maintained high; despite the low confidence in detection by VO meat inspection of an eventual introduction (6,7).

Moreover, *Mycobacterium bovis* is not considered meat-borne. Therefore a missed case at slaughter is unlikely to result in human cases. However, a lower SSE may easily lead to longer time until to detection of a positive case - including disease spread - should bovine tuberculosis emerge and missed at the port of entry. The effect of that should preferably be assessed prior to changing meat inspection. Here, the approach called "expected costs of error" - suggested by Cameron (10) - may be valuable as it among others will include an evaluation of the probability and costs of overlooking a case (false-negative) versus falsely identifying a negative as a positive (false-positive).

To accommodate the combined concerns regarding transmission of bovine tuberculosis (bovTB) and *Salmonella* it may be argued that visual inspection would be sufficient in countries, which are free from bovine tuberculosis, whereas traditional inspection - involving palpation and incision of certain lymph nodes - should be continued in non-free countries and countries experiences reinfection.

Such a risk-based approach would be in line with the European Commission White Paper on Food Safety from 1999, in which it is stated that risk analysis must form the foundation on which food safety policy is based (11). Moreover, the approach would be in line with the *Opinion of the Scientific Committee on Veterinary Measures relating to Public Health on Revision of Meat Inspection Procedures* from 2000, in which it is stated that current meat inspection procedures should be directed towards revealing agents which are of public health importance, because the most important goal of meat inspection is to prevent transmission of zoonotic infections and other contaminants to the consumer.

The import risk assessments pointed to a probability of introducing tuberculosis into a truly negative country. For bovine tuberculosis imports of cattle are accounting for the majority of the risk (Study 3), whereas for human tuberculosis caused by *M. tuberculosis* immigrant workers play a role. *M. tuberculosis* is not governed internationally, but may act as a differential diagnosis and therefore should be considered.

Denmark imports a low number of cattle per year, whereby *PIntro* can be kept low. However, further risk mitigating measures are feasible: cattle born in another country can easily be identified through their ear-tags. These animals can be subject to traditional meat inspection as a special precaution, if the importing country finds that this is of relevance. Also, if wildlife is infected in a specific area inside a country, special focus during meat inspection of bovines from this area could be established.

## Conclusion

Countries that are entirely free from bovine tuberculosis can remain free even though visual-only inspection is introduced for bovines, as long as the risk associated with imported animals or wildlife is kept low and closely monitored.

For countries entirely free from bovine tuberculosis, palpation and incisions only result in risk of transmitting zoonotic agents. Entirely free means a country with no autochthonous cases and a very low probability of spill-over from infected wildlife.

Freedom from infection should be based on the negative predictive value – and more years of data can form the basis of the assessment. Only in this way, can the freedom be substantiated meaningfully and encourage risk mitigating surveillance activities.

## References

1. EFSA. *EFSA J.* 3(1), 3991, 2015
2. EFSA. *EFSA J.* 11(6), 3266, 2013
3. EFSA. *EFSA J.* 12 (2), 3547, 2014
4. Foddai *et al.* *Prev. Vet. Med.* 122, 306-317, 2015a
5. Martin *et al.* *Prev. Vet. Med.* 79, 71-97, 2007
6. Calvo-Artavia *et al.* *Agriculture* 3, 310-326, 2013
7. Foddai *et al.* *Prev. Vet. Med.* 121, 21-29, 2015b
8. EFSA. *Technical report, Supporting Publications: EN-4501–40*, 2013b
9. Foddai *et al.* *Prev. Vet. Med.* 122(1-2), 92-98, 2015c
10. Cameron. *Prev. Vet. Med.* 105(4), 280-286, 2012
11. Anonymous. The White Paper on Food Safety. *The Commission of the European Communities* 719 final, 1999