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Green offal inspection of cattle, small ruminants and pigs in the United Kingdom: Impact assessment of changes in the inspection protocol on likelihood of detection of selected hazards

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Abstract

The changes in detection of selected public and animal health as well as welfare hazards due to the change in current inspection of green offal in cattle, small ruminants and pigs were assessed. With respect to public health and animal health, the conditional likelihood of detection with the current green offal inspection was found to be *low* for eleven out of the twenty-four selected hazard-species pairings and *very low* for the remaining thirteen pairings. This strongly suggests that the contribution of current green offal inspection to risk mitigation is very limited for public and animal health hazards. The removal of green offal inspection would reduce the detection of some selected animal welfare conditions. For all selected public and animal health as well as welfare hazards, the reduced detection could be compensated with other pre-harvest, harvest and/or post-harvest control measures including existing meat inspection tasks.

Keywords: Meat inspection; Risk; Biohazard; Welfare.

1. Introduction

The traditional meat inspection system was developed in the mid-nineteenth century to detect zoonotic diseases in animals, such as trichinellosis, tuberculosis and taeniasis, that posed the highest risk for meat consumers at that time (Edwards et al., 1997). Although the nature of veterinary public health challenges has significantly changed over time, this system practically remained the same until today. Consequently, concerns have been expressed that current meat inspection can no longer be considered adequate to protect public health, as it is ineffective in controlling the microbial meat-borne hazards that currently pose highest public health burden such as *Salmonella*, *Campylobacter*, pathogenic *Yersinia* and verotoxigenic *Escherichia coli*. Hence, it has been widely advocated that the official meat inspection, as a risk management measure, shall take into account the results of risk assessment of hazards that affect meat safety at the abattoir level (FAO/WHO, 2006; Blagojevic and Antic, 2014).

Weaknesses of the current meat inspection system are well recognized in the European Union (EU), where significant actions have been initiated in order to review and modernise meat inspection moving towards a more risk-based approach (EFSA, 2011, 2013a, 2013b). The UK Food Standards Agency (FSA) is also contributing to build the evidence base for the modernization of meat inspection. Green offal inspection is one of the control activities set out in Regulation EC 854/2004 on the organization of official controls on food from animal origin intended for human consumption (EC, 2004). The extent to which this meat inspection task contributes to the reduction in public and animal health and welfare risk is under discussion.

The aim of this study was to qualitatively assess the changes – if any – in detection of public health, animal health and animal welfare hazards in cattle, small ruminants and pigs posed by downscaling to a visual-only inspection of green offal or by removing green offal inspection completely.

2. Material and methods

2.1 Scope of the assessment

Within the scope of this assessment were cattle, small ruminants and pigs of common slaughter age in the UK (i.e. cattle between 1.5 and 4 years, small ruminants between 6 months and 1.5 years, and pigs between 5 and 6 months old; DEFRA, 2011) that are fit for transport and with no abnormalities detected during Food Chain Information (FCI) analysis and ante-mortem inspection. Therefore, these animals are subject to “routine” post-mortem meat inspection, consisting only of the mandatory tasks according to the current legislation (EC, 2004); i.e. it excludes animals subject to emergency slaughter, or those that require more detailed post-mortem inspection.

2.2 Green offal inspection scenarios

Three green offal inspection scenarios were considered:

i) Current inspection as laid down in EC (2004) that require visual inspection of stomach and intestines, mesentery, gastric and mesenteric lymph nodes, and palpation of gastric and mesenteric lymph nodes in cattle and pigs, and visual inspection of stomach and intestines, mesentery, gastric and mesenteric lymph nodes in small ruminants;

ii) Visual-only inspection that implies visual inspection of stomach and intestines, mesentery, gastric and mesenteric lymph nodes (applicable to cattle and pigs since for small ruminants current green offal inspection is already visual-only);

iii) Absence of green offal inspection.

2.3 Selection of hazards

2.3.1 Public health hazards

Based on the scientific literature and reports from official organizations (European Food Safety Authority (EFSA), FSA, UK Health Protection Agency), a comprehensive list of biological public health hazards was created. From the list, the following hazards were excluded: hazards that are known to not cause any gross lesions in green offal of animals of slaughter age, hazards for which no human cases were reported in the UK in years 2007 and 2008, and hazards for which there was no evidence of meat-borne transmission to humans.

2.3.2 Animal health hazards

Based on the scientific literature and reports from official organizations (UK Department for Environment, Food and Rural Affairs; World Organisation for Animal Health (OIE)), a comprehensive list of biological animal health hazards was created. From the list, the hazards which were already selected as public health hazards, the hazards which did not occur in the UK since the year 2000, and the hazards that are known to not cause any gross lesions in green offal of animals of slaughter age were excluded.

2.3.3 Animal welfare hazards

Conditions of animal welfare relevance were selected through an expert elicitation process. Experts were all either active in research in the field of animal welfare in academic or other research institutions or working as animal welfare specialists in a reputable organisation;

three experts were UK-based, four from EU member states and one from the OIE. The experts were asked to identify conditions i) with the potential of compromising animal welfare at the level of the farm as a result of either being caused or not prevented by the people in charge of the animals and ii) that can manifest with macroscopic lesions in green offal organs of animals of slaughter age. Conditions that are common diseases by themselves, conditions resulting from husbandry practices that are not known in the UK, and conditions with highly detectable and specific lesions in other parts of the body were not considered.

2.4 Assessment of changes in detection

2.4.1 Public and animal health hazards

For public health and animal health hazards, the framework for assessment of changes in detection consisted of two parameters: first, the likelihood of detectable lesions present in green offal if the hazard is present in an animal (Lp) and second, the likelihood that, if present, these lesions are detected with different inspection scenarios (Ld). These two parameters were combined according to the matrix provided in Table 1 to obtain the final, conditional likelihood of detection of hazards/lesions. The outputs were interpreted as the changes in the likelihood of detection of a hazard when present in an animal (i.e. related detectable lesions) if current green offal inspection is switched to visual-only (cattle and pigs only) or completely omitted.

2.4.1.1 Data collection for assessing the likelihood of lesion presence

The literature search on likelihood of lesion presence (Lp) in green offal, when a specific hazard is present in an animal, was conducted using several scientific databases (ScienceDirect, Pubmed and Scopus) and available veterinary textbooks. The following key words were applied for finding literature: *hazard animal species* [e.g. Salmonella cattle] AND *green offal lesions* [each lesion mentioned in the case definition was included, e.g. enteritis]. Literature was captured if the following conditions were satisfied: i) data referred to animals considered fit for travel and routine slaughter and routine post-mortem inspection (this was assumed whenever it was not specified otherwise in the data source); ii) data referred to animals in their common slaughter age (this was assumed whenever it was not specified otherwise in the data source); iii) data referred to animals naturally infected with a specific hazard (i.e. studies in which animals were experimentally infected were excluded).

Captured literature was examined for any quantitative and/or qualitative description of how often detectable lesions are present in green offal (e.g. "enteritis is often present"). Reported quantitative findings were taken as reported in the original source(s) and then directly converted into the likelihood categories presented in Table 2. Reported qualitative findings were subjected to critical appraisal by the authors who then produced a consensus-estimate of the likelihood categories from Table 2. Consensus was reached by opting for a precautionary approach (i.e. more weight to higher likelihoods of lesion presence).

2.4.1.2 Data collection for assessing the likelihood of lesion detection

A structured process of expert elicitation was used to assess the likelihood of detection of specific lesions with the current and the visual-only green offal inspection protocols. Experts were approached through the authors' direct and indirect network, and from the initial pool of approached experts, those who were motivated and met the experience requirements were recruited. The following criteria regarding experience requirement were used for the selection of the experts: at least 10 years of experience in meat inspection in the UK; ≥100 thousands of cattle / ≥ 1 million of small ruminants / ≥ 1 million of pigs inspected in the course of his/her professional activity. After taking into account the nature of the abattoir industry in the UK, it was decided to recruit two groups of experts: one for cattle and small ruminants and one for pigs. Each group consisted of five experts.

The expert elicitation consisted of two rounds. In the first round, an online questionnaire was sent out to the experts. Questionnaires were designed using SurveyMonkey®. The questionnaires were developed to elicit the likelihood of detection of the combination of lesions associated with a selected hazard in the event that the lesions were present (Table 3). Experts were asked to provide their answers as qualitative categories (Table 2). Returned questionnaires were analysed and disagreements between the experts identified. In cases where estimates of the likelihood of detection between two experts differed by more than one score category, consensus was sought in a second round - by teleconference.

2.4.2 Animal welfare hazards

For animal welfare hazards/conditions, the assessment of a change in detection if current green offal inspection is switched to visual-only or completely omitted was done through the change in the likelihood of detection of conditions if present (Ld), before and after the changes. As opposed to public and animal health hazards, the parameter Lp was not used as by definition all affected animals present with lesions (i.e. Lp=1).

2.4.2.1 Data collection for assessing the likelihood of lesion detection

Five meat inspection experts from the existing pool of those approached regarding public and animal health hazards (three for cattle and small ruminants and two for pigs) assessed likelihood of lesion detection for animal welfare hazards. All selected hazards/conditions in cattle, small ruminants and pigs, were presented to the experts and they were asked about the likelihood of detection with current (all species) and visual-only (cattle and pigs) inspection of green offal. The same categories as for public and animal health hazards were used (Table 2). The likelihood of detection estimates from all experts for each hazard-species pairing were combined into a single, final estimate using the same protocol as in the previous elicitation.

3. Results

In total, fourteen public health, ten animal health, and seventeen animal welfare hazard-species pairings were selected for further assessment. The results of the assessment provide the changes in the likelihood of detection of hazard-specific lesions, when present, if current green offal inspection was downscaled to visual-only or completely omitted. Inputs and outputs of the assessment of changes in detection of the public and animal health hazards in cattle, small ruminants and pigs are shown in the Tables 4, 5 and 6, respectively. Table 7 presents the likelihood of detection of the selected animal welfare hazards in all three species. Full inputs with literature references are provided in the reports to the UK FSA (Alonso et al., 2011; Blagojevic et al., 2014).

The final, conditional likelihoods of hazard detection with the current or visual-only inspection of green offal were never higher than *low*, for all the hazard-species pairings considered. In cattle, the conditional likelihoods of detection of three hazards were *low* and for another three were *very low* with the current inspection of green offal, and would remain at the same levels if inspection is switched to visual-only. However, for foot-and-mouth disease (FMD) virus and *Mycobacterium bovis*, the conditional likelihood of detection would change from *low* to *very low* and from *very low* to *negligible*, respectively, if the inspection is switched to visual-only. In small ruminants, the conditional likelihoods of detection with the current green offal inspection are *low* for three hazards and *very low* for the remaining five hazards. In pigs, the conditional likelihoods of detection of four hazards are currently *low* and for three hazards are *very low* and these would remain at the same levels if the current inspection is switched to visual-only. As in cattle, the conditional likelihood of detection of *Mycobacteria* spp. (TB) with the current green offal inspection is *very low*, but would be *negligible* if the inspection is switched to visual-only. Evidently, with the total absence of green offal inspection, the conditional likelihood of detection would be *zero* for any hazard-species combination.

The likelihood of detection with the current inspection system is *high* for umbilical hernias and rectal prolapses without complications in pigs. In rectal prolapses with complications and in conditions with lesions in the peritoneum, the likelihood of detection is *high* in all species. A change from current to visual-only inspection would have a negative impact on the likelihood of detection in the case of rectal prolapse without complications and peritoneal lesions (*high* to *moderate*), both in pigs. Similar effect can be observed in lesions in rumen/reticulum and rectal prolapse without complications in cattle (both change from *moderate* to *low*). For petechiae on anus in cattle and pigs consistent with excessive use of electric prods, and for gastro-oesophageal ulceration in pigs, the likelihood of detection with the current inspection system is *low*, but would be *very low* in pigs if inspection is switched to visual-only.

4. Discussion

4.1 Selection of hazards

A conservative approach was applied with the aim of identifying all hazards relevant to public and animal health in the UK. The group of selected hazards included public health hazards that are endemic in the relevant species. Regarding animal health hazards, some were exotic and currently not present in the UK (FMD virus and Bluetongue (BT) virus in ruminants and classical swine fever (CSF) virus in pigs), while some are present, but relatively rare (zoonotic *Mycobacteria* in cattle that are TB non-reactors, small ruminants and pigs) or with unknown prevalence (*Mycobacterium avium* spp. *paratuberculosis* (MAP) in small ruminants). Although considered amongst the most important meat-borne public health hazards, human pathogenic *E. coli* and *Yersinia enterocolitica* were not selected in cattle and small ruminants because the former hazard does not cause detectable green offal lesions in the common slaughter age of these species, while the meat-borne human cases associated with the latter are strongly attributed to pork (EFSA, 2011). Comparisons with hazard identification performed in the context of recent FSA's projects (Hill et al., 2013, 2014) and EFSA scientific opinions on meat inspection (EFSA, 2011, 2013a, 2013b), revealed no additional hazards that should have been selected for further assessment.

With regard to animal welfare, the definition of what constitutes an "animal welfare hazard" is complex as it could be argued that any disease or condition that produces lesions compromises to a degree the welfare of the affected animals. Effort was made therefore to narrow down the number of conditions with macroscopical lesions in green offal in which there should be an element of human fault or culpability present.

4.2 Inputs for assessment of changes in detection

The likelihood of gross lesion presence in green offal if the hazard is present (Lp) was the cornerstone of this assessment for public and animal health hazards, and estimates for each of the selected hazard-species pairing were based on data from scientific literature. However, the scientific literature data on this topic was lacking to a great extent. Also, the majority of information found was of qualitative nature and therefore, the selection of categories of likelihood (i.e. from *negligible* to *high*) was performed with considerable uncertainty. Therefore, the precautionary principle was applied, resulting in the use of higher likelihoods of lesion presence in green offal. This is likely to be an over-estimation.

As no information was available in the scientific literature on the likelihood of detection of lesions present in green offal (Ld), expert opinion was used to obtain these estimates. Regarding public and animal health hazards, in order to minimise bias, case definitions (Table 3) in the three species were presented to the experts, omitting the name of the hazard that was assumed to be causing the lesions. There were minor differences (not presented here) in the estimates provided by the different experts and simple majority of the answers led to final estimate for each pairing.

For animal welfare hazards, no case definitions were necessary. They were grouped and presented to the meat inspection experts directly for assessment. Weakness of the elicitation on detection of animal welfare hazards was that only three experts for ruminants and two for pigs participated; on the other hand, the agreement among them was very good (not presented here).

4.3 Contribution of the current green offal inspection to public health, animal health and animal welfare

Given that the conditional likelihood of detection with the current green offal inspection was found to be *low* or *very low* for selected public and animal health hazards, it is clear that the risk management in abattoirs cannot rely only or mainly on this meat inspection task. Therefore, there is a general need for alternative means of detection of these hazards, regardless of the protocol used for green offal inspection. The contribution to public and animal health of the entire current post-mortem meat inspection as required by the EU legislation (EC, 2004) is already being questioned elsewhere (Anon., 2006; Stärk et al., 2014) and recommendations for complete revision are currently considered in the EU (EFSA, 2011, 2013a, 2013b). Additionally, this study focused only on non-suspect (“low risk”) animals according to the data and findings from FCI and ante-mortem inspection. In line with this, earlier research found that in slaughtered animals that were categorised as non-suspect by ante-mortem examination (i.e. low risk animals), macroscopic lesions were present in up to 1% of the animals and post-mortem inspection on average detected only 20% of present lesions (Harbers, 1991; Berends et al., 1993). In general, post-mortem meat inspection is considered to contribute more to the detection/control of animal than public health hazards (Edwards et al., 1997; Stärk et al., 2014). The results of this study did not confirm a distinct relevance of green offal inspection, i.e. the independent contribution of this meat inspection task to both animal and public health appears to be limited.

Because of the different approach used to estimate the likelihood of detection in animal welfare compared to public and animal health hazards, the two estimates are not directly comparable. This applies also to the overall contribution of green offal inspection, which ultimately depends not only on the effectiveness of this control but also on the prevalence of the detectable condition. However, on an individual case (if an animal welfare condition is present), the results suggest that the likelihood of detection in four welfare condition-species combinations through green offal inspection was *high*, while in three it was *moderate*. These are not uncommon conditions, which would suggest a potentially significant contribution of this inspection task in the detection of these conditions, and by extrapolation to other conditions with similar characteristics. This relative importance of green offal inspection has to be seen, however, in the context of other inspection steps such as post-mortem inspection of dressed carcase.

4.4 Impact of switching to visual-only green offal inspection and alternative means of control

Regarding the capacity of current and visual-only green offal inspection to detect the selected public and animal health hazards, a difference between the two inspection scenarios was observed only in three hazard-species pairings, and all of them are relevant to animal health only. As for animal welfare, the likelihood of detection of six conditions in cattle and pigs with current green offal inspection drops for one likelihood category if switched to visual-only.

The change in the likelihood of detection for TB could be expected considering that palpation of the mesenteric lymph nodes is an important detection method. These findings are consistent with those of two other studies which found minor changes in risk for animal health regarding TB in pigs and cattle with a change from current to visual-only inspection. However, these studies considered the entire post-mortem inspection process, including, for example, the inspection of head and lungs (Hill et al., 2013, 2014). A Danish risk assessment related to substitution of current with visual-only inspection of green offal in finisher pigs identified TB as the only relevant hazard, but without an increase of the related public health risk (Alban et al., 2009). As already stated, TB in cattle and pigs was considered here only as an animal health hazard due to the lack of evidence of meat-borne transmission to humans (EFSA, 2011, 2013a).

In terms of risk to animal health, the detection of a single TB-suspect lesion in any organ or body part will result in the implementation of the full inspection protocol on the affected carcase and organs. However, if the public health aspects of TB were considered, the requirement of the EU legislation (EC, 2004) is relevant. Namely, when TB-like/suspect lesions are detected in only one organ/system (localised TB), all non-affected parts and organs are passed as fit for human consumption. If lesions in more than one system are detected, the whole carcase (including the offal) is rejected (generalised TB). Finding TB-suspect lesions in organs other than green offal leads to re-categorization of carcases as suspect ("high risk") and would trigger subsequent detailed inspection of green offal that includes incision of the lymph nodes. Nevertheless, recent risk assessments (Hill et al., 2013, 2014), addressing the risk arising from moving to visual-only post mortem inspection of pigs and cattle in the UK, concluded that the TB risk would be negligible to public health.

Regarding alternative means of control of the hazards for which differences were found between current and visual-only green offal inspection, it is notable that green offal is neither the only nor the most common location of TB and FMD lesions. Cattle usually have characteristic TB lesions in organs other than green offal system, primarily in the lymph nodes of the lungs (mediastinal and bronchial) and head (mainly retropharyngeal); therefore, lesions can be detected through inspection of head and lungs (FAO, 2004; EFSA, 2013a). Available data show that during 2009 in the UK, 3 out of the 285 TB cases detected in cattle at slaughter had lesions in green offal (mesenteric lymph nodes); and always coupled with lesions in other organs/systems. Additionally, only <0.5% of TB reactors had visible TB lesions exclusively in green offal (MHS 2009 – unpublished data). Similarly, TB-infected pigs tend to have lesions primarily in submaxillary, bronchial and mediastinal lymph nodes, but most cases also involve the liver in a form of multifocal granulomas (FAO, 1994; EFSA 2011). Regarding FMD in cattle, post-mortem inspection of the head is of crucial value - ulcerative lesions on tongue, palate and gums can be detected (FAO, 2004; OIE, 2010).

A concern related to the current post-mortem inspection is the spread of microbial pathogens between different organs and carcases mediated by mandatory palpations and incisions. Cross-contamination can pose a higher risk for public health than the hazards targeted by manual examination (Pointon et al., 2000; Nesbakken et al., 2003). Therefore, it was suggested by EFSA to limit manual handling during post-mortem examination to "higher risk" pigs and cattle, identified through FCI analysis and ante-mortem inspection (EFSA, 2011, 2013a). Although currently there is not enough data to reliably assess this benefit of visual-only compared with traditional meat inspection (Hill et al., 2013), in the case of green offal inspection, concerns about cross-contamination are even bigger, as any manipulation of the stomach and intestines can lead to leakage/spillage of digesta/faeces and subsequent contamination of other parts of the carcase with important public health hazards.

When assessing the difference between current and visual-only inspection of green offal it should be kept in mind that simply reaching the lymph nodes to palpate them may enhance visual detection of lesions present. Furthermore, as of 1st June 2014, new legislation on meat inspection of pigs came into force in the EU (EC, 2014b) and accordingly, palpation of the lymph nodes is not mandatory anymore in presumably "low risk" pigs that were subject of this study.

4.5 Impact of complete removal of green offal inspection and alternative means of control

As already stated, contribution of currently mandatory green offal inspection to both public and animal health appears to be very limited. Hence, completely removing it would have a very limited impact on public and animal health if any. Additionally, it could be compensated with other pre-harvest, harvest and post-harvest control measures including other meat inspection tasks. These measures are briefly illustrated below.

Currently, the most relevant food-borne hazards in humans such as *Salmonella* spp., *Campylobacter* spp., human pathogenic *E. coli*, *Y. enterocolitica*, or *Clostridium perfringens* are common faecal contaminants of carcases and their control can be achieved through abattoir process hygiene (Blagojevic and Antic, 2014). The EU process hygiene criteria allows *Salmonella* presence on dressed meat carcases (EC, 2005, 2014a), and an abattoir process hygiene is considered as satisfactory if there are < 4% *Salmonella* positive carcases of ruminants and < 6% of pigs. In the case of *Campylobacter*, despite very high prevalence in faeces of slaughter animals, the prevalence on chilled red meat carcases is low due to extensive dying-off on relatively dry carcase surfaces (Norrung et al., 2009). The risk of *C. perfringens* for human health is primarily associated with post-harvest growth - poisoning is caused by ingestion of a large amount of vegetative bacteria ($>10^5$, usually 10^6-10^8 CFU/g of food; Lawley et al., 2008); therefore, carcase contamination is not a key issue in its control. With regard to *Toxoplasma gondii*, infected animals have lesions (mostly necrotic granulomata) in organs other than the green offal system, such as lungs, heart, kidneys and liver (Radostits et al., 2007) but the whole current meat inspection is considered ineffective (EFSA, 2011, 2013a, 2013b). Freezing of carcases to inactivate cysts of *Toxoplasma gondii,* could be used for higher risk animal batches if pre-harvest categorization is performed (EFSA, 2011).

Regarding animal health hazards, alternatives for detection of FMD in cattle and TB in cattle and pigs are discussed earlier and the situation is similar in small ruminants. For Bluetongue, inspection of head and respiratory system is an alternative to green offal. Also, for CSF, a variety of lesions can be seen during visual inspection of the carcase, head, lungs, spleen, heart, liver, kidneys, pleura and peritoneum (FAO, 2004; OIE 2010). MAP is a specific case, because paratuberculosis lesions are mostly present in green offal only. More rarely, lesions can be present on dressed carcases and its external surfaces in the form of emaciation. However, this might be unlikely in "low risk" animals. Nevertheless, the use of herd certification schemes or similar pre-harvest risk categorisation provides alternative control approaches to manage related risks (Kalis et al., 2004).

It is reasonable to expect that the removal of green offal inspection would reduce the detection of some specific animal welfare conditions but this could also be compensated through other control steps. Green offal organs are not externally visible (other than the end of the gastrointestinal tract) and the clinical signs associated with them are usually difficult to detect and not specific (dullness, diarrhoea etc.). However, the prominent external manifestation of six of the identified animal welfare pairings (rectal prolapses in all species, umbilical hernia in pigs and petechiae in the anus due to excessive use of electric prods in pigs and cattle) indicates that ante-mortem inspection could play an important role in their detection. Other conditions such as peritoneal lesions can be detected at carcase inspection.

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7. Tables

Table 1. Matrix for conditional likelihood of detection as the product of the likelihood of lesion presence (Lp) and likelihood of lesion detection if present (Ld).

Ld Lp	Negligible	Very low	Low	Moderate	High
Negligible	*Negligible*	*Negligible*	*Negligible*	*Negligible*	*Negligible*
Very low	*Negligible*	*Negligible*	*Very low*	*Very low*	*Very low*
Low	*Negligible*	*Very low*	*Very low*	*Low*	*Low*
Moderate	*Negligible*	*Very low*	*Low*	*Low*	*Moderate*
High	*Negligible*	*Very low*	*Low*	*Moderate*	*High*

Table 2. Definition of qualitative categories of likelihood for the impact assessment of changes in green offal inspection protocol.

Likelihood category[a]	Descriptors
Negligible	May occur only in exceptional circumstances or probability of event or sufficiently low to be ignored.
Very low	Would be very unlikely to occur.
Low	Could occur at some time.
Moderate	Might occur or should occur at some time.
High	Is expected to occur in most circumstances.

[a] In converting probability estimates from the literature into qualitative likelihood categories, the following ranges were used: negligible: <0.1%; very low: 0.1% - <5%; low: 5% - <25%; moderate: 25% - <75%; high: ≥75%.

Table 3. Description of pathological presentations of cases of selected public and animal health hazards (only lesions considered to be detectable at slaughter are listed).

Hazard	Species	Combination of detectable lesions
Bluetongue virus	cattle	Oedema, hyperaemia, erosions of the mucosa of reticulum and rumen; enlarged and haemorrhagic mesenteric lymph nodes; enteritis
Bluetongue virus	small ruminants	Oedema, hyperaemia, erosions and/or ulcerations of the mucosa of the forestomachs; vascular congestion, haemorrhages, oedema and haemorrhage of mesenteric lymph nodes; enteritis
Campylobacter spp. (thermophilic)	cattle	Catarrhal and/or haemorrhagic enteritis; thickened intestinal mucosa; swollen mesenteric lymph nodes
Campylobacter spp. (thermophilic)	small ruminants, pigs	Catarrhal and/or haemorrhagic enteritis
Classical swine fever virus	pigs	Button ulcers in intestines; enlarged and haemorrhagic lymph nodes
Clostridium perfringens	cattle, small ruminants, pigs	Haemorrhagic and/or necrotic enteritis; ulceration of the intestinal mucosa
Foot-and-mouth disease virus	cattle, small ruminants	Fluid-filled vesicles which extend to the forestomachs and intestines; enlarged mesenteric lymph nodes; dysentery or enteritis
Human pathogenic *Escherichia coli*	pigs	Dilation, oedema, hyperaemia and congestion of the stomach and intestine

Mycobacterium avium spp. *paratuberculosis*	cattle	Thickened and corrugated intestinal mucosa; enlarged lymph nodes
Mycobacterium avium spp. *paratuberculosis*	small ruminants	Enteritis; yellow pigmentation of intestinal wall which is thickened; caseation and enlargement of the lymph nodes
Mycobacterium spp. (TB)	cattle, small ruminants	Tuberculous granuloma in mesenteric lymph nodes which are enlarged
Mycobacterium spp. (TB)	pigs	Tuberculous granuloma in mesenteric lymph nodes, which are enlarged and characterized by white or yellow caseous foci
Salmonella spp. (non-typhoid)	cattle	Haemorrhage; abomasitis; (muco-) haemorrhagic and/or necrotic enteritis; swollen and/or haemorrhagic mesenteric lymph nodes
Salmonella spp. (non-typhoid)	small ruminants	Abomasitis; haemorrhagic and/or necrotic enteritis; swollen lymph nodes
Salmonella spp. (non-typhoid)	pigs	Haemorrhagic and/or necrotic enteritis; swollen and/or haemorrhagic mesenteric lymph nodes
Toxoplasma gondii	cattle, small ruminants, pigs	Enteritis; intestinal ulceration and necrotic granulomata
Yersinia enterocolitica	pigs	Mild enteritis and swollen mesenteric lymph nodes

Table 4. Likelihood of detectable lesion presence in green offal, likelihood that lesions are detected if present, and conditional likelihood of detection of lesions in green offal associated with selected public and animal health hazards in cattle.

Hazard	Synthesis of literature findings* for the likelihood of detectable lesion presence in green offal if hazard is present in animal (Lp)	Lp	Likelihood that present lesions are detected if present (Ld)		Conditional likelihood of detection
BT virus	Diarrhoea is sometimes observed and hyperaemia and oedema of the abomasal mucosa are sometimes accompanied by ecchymoses and ulceration.	VL	current inspection	M	VL
			visual-only inspection	L	VL
Campylobacter spp.	*Campylobacter* is very often present in clinically healthy cattle, but animals in their common slaughter age are rarely affected with clinical and/or pathomorphological disease. However, diffuse catarrhal to severe hemorrhagic enteritis of the jejunum and ileum may be seen during necropsy of infected cattle.	VL	current inspection	M	VL
			visual-only inspection	L	VL
C. perfringens	*C. perfringens* is a commensal organism in the intestine of cattle, but it can induce disease under the action of pre-disposing factors (manifested with hemorrhagic and/or necrotic enteritis and ulceration of the intestinal mucosa).	VL	current inspection	H	VL
			visual-only inspection	H	VL
FMD virus	Occasional cases show localization in the alimentary tract with dysentery or diarrhoea, indicating the presence of enteritis. In some cases, vesicles may extend to the forestomachs (pillars of the rumen) and intestines. Enlarged lymph nodes may be found after infection with the virus.	L	current inspection	M	L
			visual-only inspection	L	VL
MAP	Long incubation period and clinical disease is the “tip of the iceberg” in terms of the total number of infected animals. Found that 32 out of the 52 infected cattle had gross lesions in green offal.	M	current inspection	M	L
			visual-only inspection	M	L

Mycobacterium bovis	Found that 3 out of the 285 cattle at slaughter had lesions in mesenteric lymph nodes.	VL	current inspection	M	VL
			visual-only inspection	N	N
Salmonella spp.	Infection in adult animals is usually limited to a healthy carrier state, and this hazard is often isolated from hides and/or faeces of healthy animals. Occasionally, lesions (like subacute enteritis) may be seen in green offal of cattle in their common slaughter age.	L	current inspection	H	L
			visual-only inspection	M	L
T. gondii	The infection is very common but the clinical disease is rare. Enteritis may be evident in infected cattle.	L	current inspection	H	L
			visual-only inspection	H	L

*References can be found in reports to the FSA (Alonso et al., 2011; Blagojevic et al., 2014); BT - Bluetongue; FMD - Foot-and-mouth disease; MAP - *Mycobacterium avium* spp. *paratuberculosis*; N – Negligible, VL – Very low; L – Low; M – Moderate; H – High.

Table 5. Likelihood of detectable lesion presence in green offal, likelihood that lesions are detected if present, and conditional likelihood of detection of lesions in green offal associated with selected public and animal health hazards in small ruminants.

Hazard	Synthesis of literature findings* for the likelihood of detectable lesion presence in green offal if hazard is present in animal (Lp)	Lp	Likelihood that present lesions are detected if present (Ld)		Conditional likelihood of detection
BT virus	There may be hyperaemia of the ruminal pillars and reticular folds, and occasional erosions may be seen in the reticulum and omasum. Some animals show haemorrhage in the region of the omasal folds. Multifocal erosive and necro-ulcerative rumenitis, sometimes accompanied by thrombi formation and acute hyperaemia in the reticuli are found in some animals. In some cases, hyperaemia, haemorrhages and oedema are found throughout the internal organs.	L	current inspection	H	L
Campylobacter spp.	*Campylobacter* is very often present in clinically healthy animals, but there may be diffuse catarrhal to severe hemorrhagic enteritis of the jejunum and ileum seen in infected animals in common slaughter age.	VL	current inspection	M	VL
C. perfringens	*C. perfringens* is a commensal organism in the intestine of small ruminants, but it can induce disease under the action of pre-disposing factors (manifested with hemorrhagic and/or necrotic enteritis and ulceration of the intestinal mucosa).	VL	current inspection	H	VL
FMD virus	Signs may be much more subtle and fewer observable than in cattle. In some cases, vesicles may extend to the forestomachs and intestines. Enlarged lymph nodes may be found after infection with the virus.	VL	current inspection	L	VL
MAP	Gross necropsy lesions are often minimal despite severe clinical signs during life. Caseation and mineralization of the gastric and mesenteric lymph nodes may occur. The intestinal mucosa is frequently reddened in infected animals. Found that, from a total of	L	current inspection	H	L

	20 infected sheep (13 with clinical symptoms and 7 without), 15 sheep had gross lesions in intestines. Also, found that, 15 out of 27 infected goats had macroscopic lesions in green offal.				
Mycobacterium spp. - sheep	Sheep are highly resistant to TB. Granulomas may be found in any lymph node, but not particularly in green offal lymph nodes. Found that TB lesions are present in 5.2% of infected sheep, considering all organs (not green offal only).	VL	current inspection	L	VL
Mycobacterium spp. - goats	Goats are more susceptible than sheep. Granulomas may be found in any lymph node, but not particularly in green offal lymph nodes. In some goats intestinal ulceration and enlargement of the gastric and mesenteric lymph nodes may occur.	L	current inspection	L	VL
Salmonella spp.	Small ruminants are common carriers and symptomless shedders of *Salmonella*. Cases of clinical and/or pathomorphological salmonellosis are infrequent in animals in common slaughter age, but subacute enteritis may be seen.	VL	current inspection	M	VL
T. gondii	The infection is very common but the clinical disease is relatively infrequent. Disease in adults is rare. Necrotic enteritis may be evident.	L	current inspection	M	L

*References can be found in reports to the FSA (Alonso et al., 2011; Blagojevic et al., 2014); BT - Bluetongue; FMD - Foot-and-mouth disease; MAP - *Mycobacterium avium* spp. *paratuberculosis*; N – Negligible, VL – Very low; L – Low; M – Moderate; H – High.

Table 6. Likelihood of detectable lesion presence in green offal, likelihood that lesions are detected if present, and conditional likelihood of detection of lesions in green offal associated with selected public and animal health hazards in pigs.

Hazard	Synthesis of literature findings* for the likelihood of detectable lesion presence in green offal if hazard is present in animal (Lp)	Lp	Likelihood that present lesions are detected if present (Ld)		Conditional likelihood of detection
Campylobacter spp.	*Campylobacter* is very often present in clinically healthy pigs, but there may be diffuse catarrhal to severe hemorrhagic enteritis of the jejunum and ileum seen in infected pigs in common slaughter age.	VL	current inspection	M	VL
			visual-only inspection	M	VL
CSF virus	In chronic forms, button ulcers in the cecum or large intestine may be present. Enlarged and hemorrhagic lymph nodes are common.	M	current inspection	M	L
			visual-only inspection	M	L
C. perfringens	*C. perfringens* is a commensal organism in the intestine of pigs, but it can induce disease under the action of pre-disposing factors (manifested with hemorrhagic and/or necrotic enteritis and ulceration of the intestinal mucosa).	VL	current inspection	H	VL
			visual-only inspection	H	VL
Human pathogenic *E. coli*	Oedema and congestion of the stomach and intestines may be present occasionally in adult pigs.	L	current inspection	M	L
			visual-only inspection	M	L
Mycobacterium spp.	Pigs are especially susceptible to infection. TB lesions are often present in mesenteric lymph nodes.	L	current inspection	L	VL
			visual-only inspection	N	N
Salmonella spp.		L	current inspection	H	L

	Infection is usually limited to a healthy carrier state, but diffuse necrotic colitis and typhlitis, accompanied with enlarged mesenteric lymph nodes, may be seen in infected animals.		visual-only inspection	H	L
T. gondii	The infection is very common but the clinical disease is rare. Enteritis may be evident in infected pigs.	L	current inspection	H	L
			visual-only inspection	H	L
Y. enterocolitica	*Y. enterocolitica* is often present in clinically healthy pigs. Mostly without lesions in green offal. Occasionally enteritis may be seen.	L	current inspection	L	VL
			visual-only inspection	VL	VL

*References can be found in reports to the FSA (Alonso et al., 2011; Blagojevic et al., 2014); CSF - Classical Swine Fever; N – Negligible, VL – Very low; L – Low; M – Moderate; H – High.

Table 7. Comparison of the likelihood of detection of lesions associated with selected animal welfare hazards in cattle, small ruminants and pigs through current meat inspection activities (EC, 2004) or using visual-only inspection.

Hazard/condition	Species	Likelihood that present lesions are detected if present (Ld)	
Gastrointestinal parasitism (excessive)	Cattle	current inspection	L
		visual-only inspection	L
	Small ruminants	current meat inspection	L
	Pigs	current inspection	M
		visual-only inspection	M
Gastro-oesophageal ulceration	Pigs	current inspection	L
		visual-only inspection	VL
Lesions in peritoneum (e.g. peritonitis, but excluding haemorrhagic ones)	Cattle	current inspection	H
		visual-only inspection	H
	Small ruminants	current inspection	H
	Pigs	current inspection	H
		visual-only inspection	M
Lesions in rumen and reticulum (rumenitis, foreign bodies, etc.)	Cattle	current inspection	M
		visual-only inspection	L
Petechiae on anus consistent with excessive use of electric prods	Cattle	current inspection	L
		visual-only inspection	L
	Pigs	current inspection	L
		visual-only inspection	VL

Rectal prolapse with complications (injury, necrosis, etc.)	Cattle	current inspection	H
		visual-only inspection	H
	Small ruminants	current inspection	H
	Pigs	current inspection	H
		visual-only inspection	H
Rectal prolapse without complications	Cattle	current inspection	M
		visual-only inspection	L
	Small ruminants	current inspection	M
	Pigs	current inspection	H
		visual-only inspection	M
Umbilical hernia	Pigs	current inspection	H
		visual-only inspection	H

N – Negligible, VL – Very low; L – Low; M – Moderate; H – High.