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Challenges and opportunities in the implementation of new meat inspection systems in Europe

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ABSTRACT

Background: The traditional meat inspection system is often found to be inefficient. Meat inspection in European countries is in a phase of modernisation to reflect improvements in livestock health and advances in understanding meat safety. The key point of progress is to replace the traditional meat inspection with risk-based meat inspection, including the elements of a meat safety assurance system (MSAS).

Scope and approach: Modernisation of meat inspection was launched by the European Food Safety Authority's (EFSA) opinions and recommendations in the period 2011–2013 and consequent amendments to the EU meat inspection legislation in the period 2014–2019. For this study, the EU-funded RIBMINS COST Action conducted a comprehensive survey using an in-depth questionnaire to estimate the level of implementation of new risk-based meat inspection systems in Europe, stakeholders' confidence in the new systems and the main identified obstacles.

Key findings and conclusions: The implementation of new meat inspection systems is still ongoing, as they have been fully implemented in just 61%, 42% and 38% of the surveyed countries in the pig, bovine, and poultry sectors, respectively. The main identified obstacles are existing trade agreements with 3rd countries, costs of implementation, inadequate food chain information and resistance from meat inspectors. Improvement of all components of the current meat inspection systems is a prerequisite for further modernisation.

1. Introduction

From its beginnings (Salmon, 1889), meat inspection evolved with a view to remain relevant. It has been an effective hurdle for foodborne diseases during the last 150 years, in particular allowing detection of bovine tuberculosis (bTB) and trichinellosis in pigs (Ostertag, 1892). However, as the control of these zoonoses has improved, other meat-borne hazards, such as *Salmonella* spp., have gained prominence (EFSA, 2011; EFSA, 2012). Thus, the question from a food safety perspective is: what would be the most fit-for-purpose meat inspection of tomorrow?

Over the past 30 years, as reported by Huey (2012), it has become apparent to most national and international authorities and organisations, such as the Codex Alimentarius of the Food and Agriculture Organization and the World Health Organization of the United Nations, that the procedures that have served public and animal health well for over a century are in need of a radical overhaul. A major push was the White paper on food safety (EC, 2000a), which laid down the principles

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for the General Food Law (EC, 2002), such as food safety as a farm-to-fork concept and responsibilities for producing safe food being allocated to food business operators (FBOs). Major drivers for this evolution have been the biological hazards, such as *Salmonella* spp., *Campylobacter* spp. and enterohaemorrhagic *Escherichia coli* (EHEC), followed later by a prion-related disease (bovine spongiform encephalopathy) (Smulders et al., 2008). Collection and analysis of pre-harvest information about the animals and their herds through food chain information (FCI) was introduced to simplify *post-mortem* procedures (EC, 2004).

An updated meat inspection approach should contribute to better public health protection (Antunovic et al., 2013), because the traditional meat inspection system was often ineffective, resulting in foodborne outbreaks of disease (EC, 2000b; Smulders et al., 2008). For example, non-visible hazards, such as *Salmonella* spp. and *Campylobacter* spp., are not mitigated effectively by the means of traditional inspection, consisting of palpation and incision. Consequently, the European Food Safety Authority (EFSA) recommended changes to better protect consumers from meat-borne diseases. The EFSA opinions were adopted between 2011 and 2013 (EFSA, 2011; EFSA, 2012; EFSA, 2013), and consequent changes in the EU meat inspection legislation were adopted between 2014 and 2019 (EC, 2014; EC, 2017; EC, 2019a; EC, 2019b).

The key point of progress suggested by EFSA was to adjust the traditional meat inspection concept, so it becomes a meat safety assurance system (MSAS). The focus of modernisation so far has been on replacing traditional inspection with risk-based meat inspection in which meat of low risk animals is visual-only inspected (VOI), while meat of high risk animals is subject to palpation and/or incision (Alban et al., 2021; EFSA, 2011; Riess & Hoelzer, 2020). VOI avoids cross-contamination between carcasses via knives and hands at the abattoirs. The move to visual-only *post mortem* inspection has – for the diseases and conditions considered – a negligible negative impact on disease control (Alban et al., 2021; Stärk et al., 2014) and can easily be adopted in pig abattoirs (Ghidini et al., 2018). However, the practical implementation of a MSAS is complicated and involves fine-tuning, feasibility and impact testing, and development of individual guidelines by the EU Member States (MS) and other European countries, in line with the updated EU legislation (Buncic et al., 2019). Meat inspection in European countries should constantly be updated in a cost-efficient way to reflect improvements in livestock health, and advances in technology and the understanding of meat safety (Blagojevic et al., 2021). So far, the degree of implementation of the new meat inspection systems has not been evaluated in the EU/European economic area (EEA).

The aim of this study was to systematically survey the level of implementation of the new risk-based meat inspection systems for pigs, bovine animals and poultry in Europe. Moreover, the stakeholders' confidence in the new systems, changes in the inspection workload and main obstacles to the new systems were determined.

2. Approaches followed

As the survey has been focused on challenges and opportunities (mostly qualitative data), the approach followed was preparation of a questionnaire structured from different question types and that enabled free comments. Such an approach produces numerical results, where it is possible, and also benefits from qualitative estimation of prevailing answers by respondents from the enabled free comments. The survey included EU and the European free trade agreement (EFTA) MS, as implementation of the new meat inspection rules (EC, 2014; EC, 2019a; EC, 2019b) is mandatory for them. Some non-EU countries are also interested in complying with the EU meat inspection legislation to ensure trade with the EU and to improve the cost-effectiveness of their own meat control systems. This is especially important for countries foreseeing EU membership. Therefore, information was collected from the following 26 European countries:

- EU member countries (n = 19): Belgium, Croatia, Czechia, Denmark, Estonia, Finland, France, Germany, Ireland, Italy, Latvia, Lithuania, Poland, Portugal, Romania, Slovakia, Slovenia, Spain and Sweden;
- EFTA countries participating in the EEA (n = 1): Norway;
- EFTA countries with a bilateral trade agreement with the EU (n = 1): Switzerland;
- EU candidate countries (n = 4): Albania, Montenegro, Serbia and Turkey;
- Potential EU candidate countries (n = 1): Bosnia-Herzegovina.

A comprehensive survey using an in-depth questionnaire was prepared using SurveyHero® cloud-based software and questionnaire tool (enuvo GmbH, Zurich, Switzerland). The questionnaire contained 12 questions and was structured in five sections, namely:

Section I – Comparison of the meat inspection systems (traditional vs. new);
Section II – Barriers and obstacles in implementation of the new meat inspection systems;
Section III – An analysis of strengths, weaknesses, opportunities and threats (SWOT-like analysis) of the traditional and new meat inspection systems;
Section IV – Matters related to the organization of the official controls in the COVID-19 pandemic;
Section V – Other comments.

The question types utilised were: single selection of pre-provided answers; multiple selection of pre-provided answers; ranking and scoring questions; SWOT-like analysis and; open questions enabling free comments.

The level of implementation of the new meat inspection elements in the different European countries (Section 3 below) was evaluated taking into consideration the application of EU Regulation No. 218/2014 (EC, 2014) for pigs, and Commission Implementing Regulation 2019/627 (EC, 2019b) for bovines and poultry. The approach used was "single selection of pre-provided answers", with comments enabled. The questions separately covered the following livestock populations: indoor-raised pigs, outdoor-raised pigs, sows and boars, bovines, poultry, and other. The subsequent questions enabled estimation of the coverage of each animal population by the new meat inspection system using the approach of "multiple selection of pre-provided answers". Here, only the countries that had implemented the new meat inspection systems for one or more animal species were included (n = 16/26).

The level of confidence of different stakeholders, namely competent authority (CA) personnel, meat inspectors (MIs) and food business operators (FBOs), in the traditional and new meat inspection systems for different livestock populations (Section 4) was evaluated using a scale from 1 to 4 (1 = unsatisfactory, 2 = substantial improvements are needed, 3 = minor improvements are needed, 4 = satisfactory), and comments were enabled.

The perception of inspection workload within the new meat inspection systems compared to the traditional system related to the meat inspection of the three animal species (pigs, bovines and poultry; Section 5) was analysed in relation to different stakeholders (CA, MI and FBO) and in relation to plants of different sizes (small, medium and large). The approach used was "multiple selection of pre-provided answers", with comments from stakeholders enabled.

The question of whether the new meat inspection systems had been formally evaluated after implementation with respect to food safety impact, economics and feasibility (Section 6) was posed in two parts: (i) related to the effect of a single activity that had been changed and; (ii) related to the entire food chain level, implying the total effect on the meat after cooling. These questions required "single selection of pre-provided answers", and comments were enabled.

The question about possible barriers and obstacles to implementation of a new meat inspection system (Section 7) was posed separately

for each livestock population. A pre-set list of six possible barriers and obstacles to implementing new meat inspection systems, chosen after in-depth discussion by experts within the RIBMINS network, was offered to respondents. They ranked, according to importance, the six proffered barriers and obstacles. Additionally, respondents were able to add reasons not listed in the questionnaire and provide a comment.

A comparison of the traditional and new meat inspection systems was made using four SWOT-like questions related to the stakeholders (Section 8) – what they liked about the system; what they struggled with; what they should be aware of and; what the system was not covering. The questions were raised separately for the traditional and new meat inspection systems, and divided into pig, bovine and poultry sectors.

The question related to challenges in the organization of official controls due to the COVID-19 pandemic (results mentioned in Section 3 below) was posed in a free form that allowed text input from the respondents.

The questionnaire was answered exclusively for each country by its appropriate RIBMINS national contact point (NCP). NCPs, based on their great expertise in the field, had earlier been established for each country within the RIBMINS network of experts. Each NCP had one month to answer the questionnaire. Each NCP was obliged to consult the separate associations representing the MIs (usually employed by the CA for red meat abattoirs – bovine, pig and ovine, or by the FBO for poultry abattoirs), FBOs or abattoirs, as well as the veterinary CA in their country, in order to ensure the answers provided were both accurate and representative. The questionnaires were sent to all the 33 NCPs involved in the RIBMINS network. Seven of them were estimated not to be able to produce a comprehensive picture of the situation in their country. So, in total, 26 questionnaires were considered. The NCPs were supported in answering the questionnaires by their networks of national RIBMINS experts (more than 170 experts and scientists in total). The results of the survey, together with the most prevailing comments received from the respondents, are presented below.

3. Level of implementation of new meat inspection systems in different European countries

The survey found the status of implementation between countries varied, and the transition process is still ongoing in the three meat production sectors, i.e., pigs, bovines and poultry (Fig. 1).

Implementation of the new meat inspection systems was the highest in the pig sector (61% of the countries have implemented the new systems), and lower in the bovine and poultry sectors (42% and 38%, respectively). This could be related to the different years the respective regulations came into force: 2014 for pigs (EC, 2014), and 2019 for bovines and poultry (EC, 2019b). For the EU candidate and potential candidate countries this is expected, as they are mostly in the process of approximation or transposition of the mentioned EU regulations. But even in surveyed EU member countries, new meat inspection systems were found to be fully implemented in the pig sector in only 14 of 19 countries, and in the bovine and poultry sectors in 10 of 19 countries. The EU Regulation No. 218/2014 (for pigs) and the EU Commission Implementing Regulation 2019/627 (for bovines and poultry) became bindingly applicable from 1 June 2014 and 14 December 2019, respectively. The COVID-19 pandemic clearly should not be a reason for lack of implementation, as it appeared in Europe after these dates, so the standards for bovines and poultry should already have been implemented in 2019. Also, the mitigation efforts appear to have been successful, as the CAs in 18 of 24 surveyed countries (75%) reported no major disruptions of the official controls due to the COVID-19 pandemic during spring, 2020 (Section IV of the survey). Due to the derogations in Commission Regulation (EU) 2020/466 (EC, 2020a) as last amended by Commission Regulation (EU) 2020/1341 (EC, 2020b), CAs have been more flexible in designating who does what and focusing on the essential tasks of the official controls. Still, no flexibility has been offered by these two regulations regarding implementation of EU Regulation No. 218/2014 and EU Regulation 2019/627 in a way that new meat inspection systems do not have to be in place. Obviously, there are other longer-term practical reasons that are creating barriers and obstacles in implementation of new meat inspection systems, and it is just the right moment to point them out and consider possible corrective measures.

3.1. Pig meat inspection

The EU Regulation No. 218/2014 (EC, 2014) introduced VOI as the *post-mortem* procedure for low-risk pigs. This new pig meat inspection system was fully implemented in 16 countries (61%), whilst seven countries (27%) had not implemented it (Fig. 1). Of the seven countries that were still using the traditional system, five countries were from the group of non-EU countries that referred to their possible partial implementation of this EU legislation in the near future. Additionally to these seven, one country had "fully implemented new meat inspection system in some, but not all abattoirs" and two countries had "incompletely implemented the new system in most abattoirs". Implementation in surveyed countries was most frequent for indoor-raised pigs (89% of the affirmative countries) and slightly less frequent for sows and boars and outdoor-raised pigs (79% and 63%, respectively). The prevailing reasons

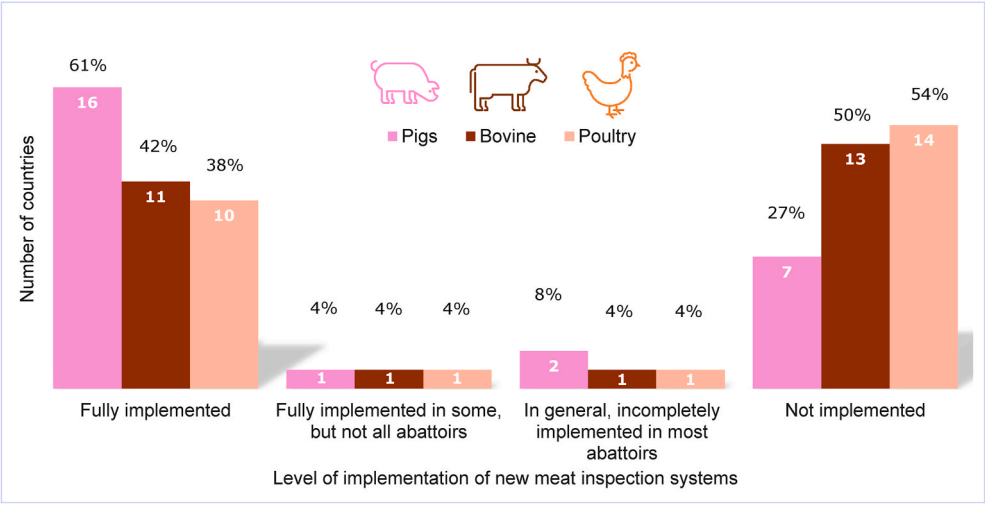

Fig. 1. Distribution of answers to the question: "Has the new meat inspection system been implemented in your country in line with EU Regulation No. 218/2014 (for pigs), and in line with EU Commission Implementing Regulation 2019/627 (for bovines and poultry)?" (n = 26 European countries).

for not having VOI in place were: export requirements (i.e. pigs, sows and boars from non-controlled housing and slaughtered in US-authorised abattoirs); regionally higher risks (i.e. endemic *Mycobacterium avium*); *Cysticercus cellulosae* surveillance programs in force and; African swine fever outbreak. The constraints related to export were previously reported by Alban et al. (2021). *Mycobacterium* lesions in pigs are mostly located in submaxillary and mediastinal lymph nodes, and a change in the likelihood of detecting *Mycobacterium* lesions could be expected using VOI (Blagojevic et al., 2015). Therefore, these answers are properly in accordance with the risk-based meat inspection defined in EU Regulation No. 218/2014 (EC, 2014): *"when the epidemiological or other data from the holding of provenance of the animals indicate a possible risk to public health, animal health or animal welfare, additional post-mortem procedures using incision and palpation may be included"*.

3.2. Bovine meat inspection

For bovines, the VOI system under EU Regulation 2019/627 (EC, 2019b) uses a risk-based meat inspection approach, considering the animal's age, the production system (outdoor/indoor), the official tuberculosis status (country or region) (Section II, Section 3, Article 18) and evidence indicating a risk to human health, animal health or animal welfare. This evidence, for example, could be epidemiological data, or other data from the holding of provenance of the animals (Section II, Section 3, Article 24).

Regarding implementation of the new meat inspection system (EC, 2019b), 11 countries (42%) answered "fully implemented", and 13 countries (50%) answered "not implemented" (Fig. 1). Of these 13 countries still using traditional bovine inspection, five were the same EU candidate and potential candidate countries that also reported unchanged pig inspection systems. These countries reported being in the process of approximation or transposition of the EU Regulation 2019/627 (EC, 2019b). The EU member countries and surveyed EFTA countries reported different explanations for not moving to the new system, as follows: tuberculosis eradication scheme; liver fluke problems (in pasture-based production); 3rd country export requirements and; mandatory liver incisions to gather information on whether *Fasciola hepatica* or *Dicrocoelium dendriticum* occur on farms (as was previously underlined by Foddai et al., 2015).

Among the countries that had implemented the new bovine meat inspection system, one country had "fully implemented the new meat inspection systems in some, but not all abattoirs" and one country had "incompletely implemented the new systems in most abattoirs" (Fig. 1). The reasons for not having full VOI in place were: diaphragm muscle was cut twice for detection of *Taenia saginata* cysticercus, a hazard that Calvo-Artavia et al. (2012) pointed out should be detected under a risk-based meat inspection approach and; abandoned *post-mortem* examination of cattle less than 20 months old and reared without access to pasture during their whole life in an officially tuberculosis-free region, because of no findings of cattle with live cysticerci over a 2-year period, in accordance with the new EU legislation.

3.3. Poultry meat inspection

For poultry (Fig. 1), the level of non-implementation of the new meat inspection system was slightly higher (54%, or 14 countries) than for bovine (50%, or 13 countries). The prevailing reason (five countries) noted concerns in using technological systems as a tool to support post-mortem inspection, such as the VISION system described by Yang et al. (2009). The results of that research proved its usefulness, with significant benefits to increase efficiency and reduce the effect of human error in the poultry processing industry. Other reasons were export agreements with 3rd countries that did not allow meat inspection to be limited to a representative sample of birds and; the specific adaptations made to the EU Regulation 2019/627 (EC, 2019b). Regarding the last point, the mentioned regulation requires that all poultry carcasses are inspected at *post-mortem*, additional *post-mortem* checks are conducted on representative samples (2% of flocks, 2% of discarded carcasses) and only veterinarians are involved in the meat inspection system.

4. Comparison of stakeholders' confidence in traditional and new meat inspection systems

Stakeholders (CAs, MIs and FBOs) tended to have higher confidence in the new systems than in the traditional system (Fig. 2). While the overall view was that the new systems ensured food safety to a higher degree than the traditional systems, the large standard deviations in Fig. 2 are reflective of the level of disagreement between countries. While stakeholders were more confident in the new systems for all species (average relative confidence across all species: 1.11, with SD = 0.06 between species), the highest number of individual answers in favour of the new systems was received from the pig sector (relative confidence: 1.16), followed by the poultry (1.10) and bovine (1.02) sectors.

The main reservations for pigs pertained to the ability of the new system to detect *Trichinella* spp. and to fulfil 3rd country export requirements. Consequently, many countries have retained a surveillance system for *Trichinella* spp. for all pigs, regardless of their housing status. Also, there were concerns that spinal abscess might be missed if VOI is undertaken.

For bovines, the stakeholders were roughly equally confident in the new and in the traditional systems. Reservations towards the new system were noted regarding detection of bTB and cysticercosis. Thus, many countries have retained parts of the traditional system to ensure detection of these diseases. The practical implementation of the age differentiation for *post-mortem* examination in the new system was perceived as difficult in some countries, which led to lower confidence in the new system.

For poultry, the traditional system was considered as demanding in large facilities with high line speeds, especially if flocks with high condemnation rates were slaughtered. Stakeholders welcomed the use of technological tools to support poultry meat inspection, as allowed by the new regulation, but noted that costs might be a hurdle for implementation. The lower risk of cross-contamination due to the decreased number of incisions and the greater ability to detect common foodborne pathogens like *Salmonella* spp. or *Campylobacter* spp. were the main reasons for the stakeholders' higher confidence in the new systems. Also, the ability to run higher line speeds, especially in the poultry sector, was perceived as positive.

The political will to implement the new regulations, along with the necessary financial commitment by the local authorities to implement the changes, had a large impact on the way respondents perceived the new meat inspection systems. In countries with systemic issues (e.g. local authorities lacking staff and highly fragmented jurisdictions), the confidence that a new system could be implemented successfully was lower. A robust FCI system is a prerequisite for the new meat inspection systems, but confidence in the local authorities to establish this varied. The involvement of abattoir staff in meat inspection raised some concerns, particularly among veterinarians employed by CAs, regarding the staff's ability to judge neutrally. Veterinarians also felt threatened by the new regulations in countries where job opportunities for veterinarians were scarce. Based on these data, it is to be expected that lower income countries will meet larger resistance in the implementation of the new meat inspection systems.

5. Changes in the inspection workload within the new meat inspection systems compared to the traditional system

Overall, countries that had implemented the new systems reported reduced or equal workload for all included occupational groups in almost all settings, with a few exceptions (Fig. 3). An increased workload was observed only for FBOs with large pig abattoirs or with medium-

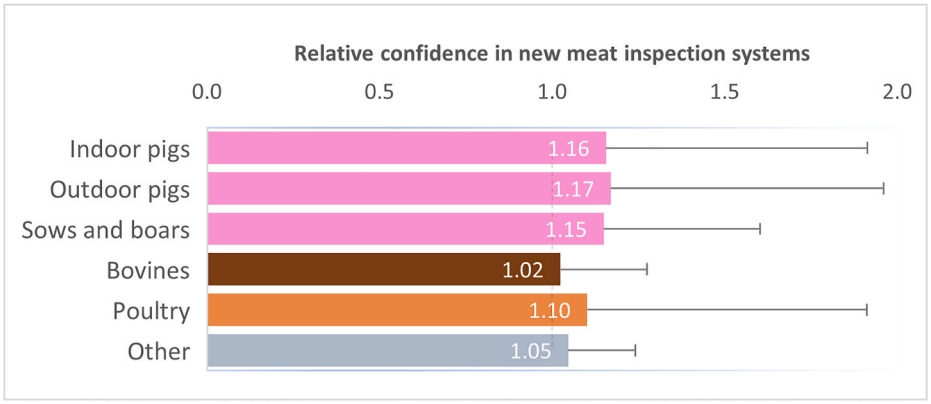

Fig. 2. Relative confidence of the stakeholders (competent authority personnel, meat inspectors and food business operators) in the new vs. the traditional meat inspection systems in surveyed European countries (n = 14) was calculated by dividing the average confidence (values on a scale from 1 to 4) in the new system by the average confidence in the traditional system. Values > 1.0 represent higher confidence in the new system. "Other" includes solipeds, small ruminants, wild boar or rabbits. Error bars: standard deviation between countries.

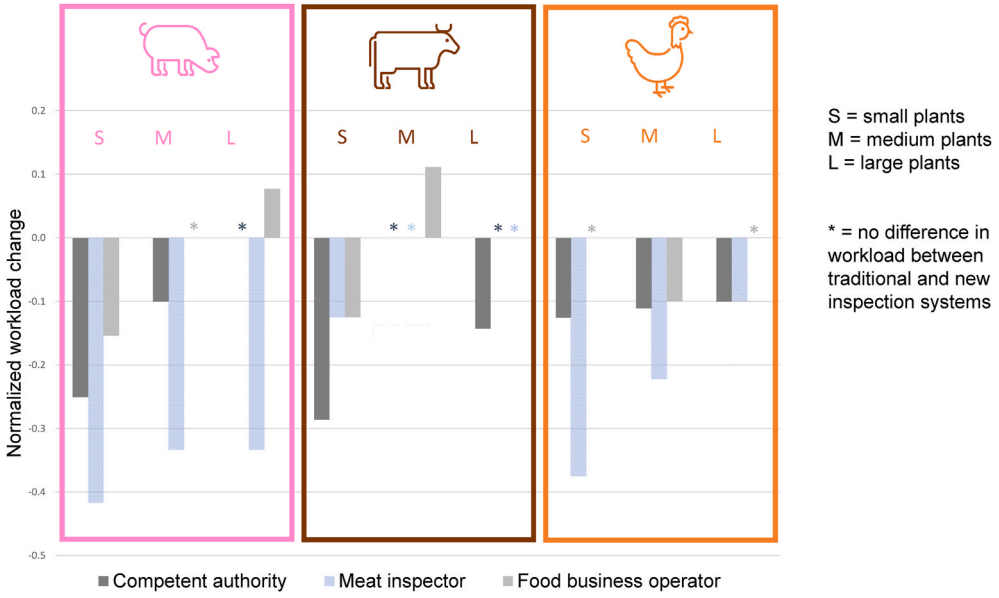

Fig. 3. Normalised changes in workload related to meat inspection of the individual animal species in surveyed European countries (n = 14). To identify overall trends in workload changes, the increase/decrease/no change in workload was transformed into +1/−1/±0, respectively, and the sum of all values was normalised by dividing by the number of valid responses. Only answers from countries that had partially or fully implemented the new meat inspection system were considered.

sized bovine abattoirs.

A future increase in the workload tended to be forecasted and overestimated by countries where the new meat inspection systems were not yet implemented. This erroneous assumption could be a contributing factor for the late adoption of new meat inspection systems in some of these countries. While the workload for FBOs, who carry the main responsibility for meat safety in a MSAS (Blagojevic et al., 2021), was estimated to remain unchanged, an increase in the workload for CAs and MIs was expected in these countries, in particular in bovine and poultry abattoirs. Interestingly, the foreseen increase in workload upon implementation contrasts starkly with the overall reduction in workload reported by countries that have already implemented the new systems.

Sources of the reported increased workload for FBOs were more paperwork and a lack of trained personnel. Also, electronic reporting of results was perceived as more complicated than the actual inspection in the new systems.

6. Evaluation of the efficiency of new meat inspection systems at individual and food chain levels

Within this survey, no country reported that a comprehensive evaluation of the impact of the new meat inspection procedures had been undertaken. This might be expected for bovines and poultry, as the EU Commission Implementing Regulation 2019/627 is being applied from 14 December 2019, but the same applies for pigs, where the EU Regulation No. 218/2014 is being applied from 1 June 2014. Additionally, no official reports or scientific publications that covered such evaluations were identified during the course of the current study. In some countries, specific issues have been looked into, but the cost-efficiency of the systems has not been addressed.

However, the introduction of new approaches for meat inspection should be followed closely. The new systems should provide at least the same level of safety as the traditional system. Transparency into meat safety measures is important for farmers, FBOs and CAs. Monitoring systems may need to be adapted to regional settings, but the main outputs should be strictly specified. It is important that data are collected and structured in a well-designed way. Then, the task could even be automated to generate, e.g., weekly reports on condemnations and incidence rates of relevant lesions. Such reports would provide valuable inputs for risk management at abattoirs and for farmers, who would receive adequate feedback, as according to Guardone et al. (2020), meat inspection conducted at the abattoir by the OVs continues to play a fundamental role.

7. Barriers and obstacles to implementing the new meat inspection systems

Whilst Session 3 considers reasons expressed by the countries that do not have VOI in place, this Session considers barriers and obstacles faced both by countries that have and do not have VOI in place. Although VOI of pigs has been a legislated procedure for pigs since June 2014 (EC, 2014), there have been massive barriers to its implementation (Fig. 4). Existing trade agreements were rated generally as the predominant barrier, especially for indoor finisher pigs. This is because trade between the EU and 3rd countries requires negotiations to ensure acceptance of equivalence between the exporting and importing countries' ways of undertaking meat inspection, which can take years (Alban et al., 2021). The second most common barrier (for indoor finisher pigs) was the cost of implementation related to launching and training, as well as requirements for extra equipment, like mirrors on the slaughter line. Such costs could be difficult for smaller abattoirs to cover. An inadequate FCI system was listed as the third most common barrier. The general implementation of FCI has taken years longer than expected in EU Regulation No. 853/2004 (EC, 2004), and meaningful FCI, enabling applicable risk-based decisions, is still missing in some countries. Resistance from some MIs, who work under the responsibility of the CAs, and who believed that the new meat inspection procedures will lead to poorer food safety, was mentioned as the fourth most common barrier. The fifth most common barrier was lack of clear and feasible requirements specified by the CA regarding criteria for VOI. A full understanding of the changes by the people involved in daily inspection requires detailed communication (Bækbo et al., 2015). In one of the surveyed countries, the resistance was mitigated slowly by a gradual change from traditional meat inspection to VOI (Alban et al., 2021).

For outdoor finisher pigs, the top-five obstacles and barriers were the same as those for indoor finisher pigs, but the order was slightly different; cost of implementation was rated as the most frequent obstacle, whilst trade concerns came in as reason number two (Fig. 2). For sows and boars, the main barrier was resistance from MIs, followed by costs of implementation, trade concerns, inadequate FCI, and lack of clear and feasible requirements. One of the responding countries argued that lesions can be found on every second sow, making it less of a priority to implement VOI. Another responding country highlighted that the former EU Regulation No. 854/2004 (EC, 2004) had only allowed changes to meat inspection of finisher pigs raised under controlled housing conditions. This had hampered exporting countries from applying for acceptance of equivalence for sows and outdoor-raised pigs until 2014, when VOI of pig meat became the standard for all pigs, irrespective of age and housing conditions. Consequently, that country is still undertaking traditional inspection of outdoor-reared pigs if slaughtered at abattoirs authorised for export.

For bovines, the main barriers were costs of implementation, followed by trade concerns, inadequate FCI, resistance from MIs, and concerns for animal health and welfare. This should be seen in relation to the new EU legislation allowing the omission of cutting of the masseter muscles and some lymph nodes, if certain requirements are met (EC, 2019b). Some bovine cysticercosis cases could be missed if the masseters are not incised. However, the requirement for incisions of the heart muscle is retained, which should ensure adequate monitoring for bovine cysticercosis. Similarly, bTB could be missed if the lymph nodes are not incised. Still, the probability of a bovine being infected with bTB is negligible if raised in a country officially free from bTB. In line with this, young bovine males, raised indoors and slaughtered below two years of age, have a very low prevalence of *Taenia saginata* cysticercus, as shown by Calvo-Artavia et al. (2012). This parasite is considered to contribute only a very low burden to human disease (WHO, 2015). One country mentioned that monitoring of some diseases is undertaken to follow the epidemiological situation. For that reason, the CA has not yet released new inspection procedures. In another country, bTB is still present along with liver flukes – two important animal health conditions – for which incisions are still needed.

For poultry, the main barrier was resistance from MIs, followed by inadequate FCI, costs of implementation, trade agreements, and lack of clear and feasible requirements. One comment was that VOI systems in the pipeline need to be accepted by the EU Commission and trade partners before the abattoirs invest in these systems.

Other general comments were related to the specific challenges of small abattoirs with scarce resources. Moreover, camera-based vision systems have not been tested and, therefore, have not been introduced. In some countries, the obstacle has been a complex political structure coupled with a lack of political readiness to improve meat inspection, leading to a slow and inefficient process of harmonisation and implementation of relevant legislation.

8. SWOT-like analysis of the traditional and new meat inspection systems

A SWOT-like analysis was undertaken for the traditional and the new meat inspection systems, and the predominant answers related to pig inspection are presented in Table S1. For bovines and poultry, similar answers were given. Where they diverged from answers given for pigs, they are highlighted in the text below.

Several countries mentioned that the traditional system of inspection in pigs was recognised as a well-known system with an associated high degree of confidence, mainly because of the presence of impartial OVs (so this was counted among strengths). According to one responding country, there is a lack of trust from the inspectors' side in the FBO's own checks, and there are challenges related to the FCI (so these were

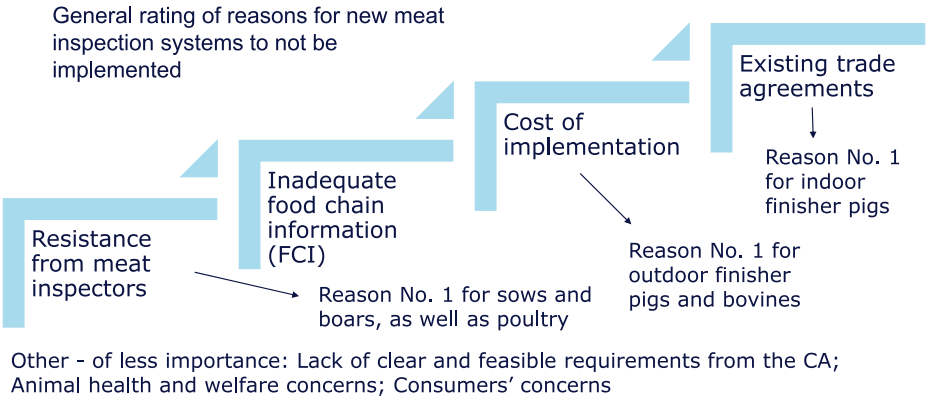

Fig. 4. Categorisation of identified barriers and obstacles to implementation of new meat inspection systems in surveyed European countries (n = 24 for the indoor finishing pig sector; n = 20 for the outdoor pig sector; n = 19 for the sow and boar sector; n = 22 for the bovine sector; n = 18 for the poultry sector). FCI = food chain information; CA = competent authority.

weaknesses). However, respondents also expressed their opinion that the focus should be on food safety using a risk-based approach and that time, training, and communication are needed to make the new systems work fully (opportunities). Standardisation and continuous education for veterinarians working in VOI is of ultimate importance (opportunities – or threats if not in place), as was also mentioned by Ghidini et al. (2018).

For bovines, respondents noted that meat inspection is also used to monitor freedom from certain animal diseases (opportunities). This was pointed to by Foddai et al. (2015), who documented that in an official bTB-free country, the ability to substantiate freedom from bTB will remain high, even if VOI is undertaken. However, some cases of cysticercosis could be missed when the masseter muscles are not incised (weaknesses). Similarly, fluke infestation could be missed if the liver is not incised.

For poultry, countries highlighted that the traditional system was well automated and did not require expensive equipment (strengths). With the high line speed, it was difficult to sort out carcasses requiring partial condemnation in the traditional system (threats). Moreover, machinery can cause cross-contamination. Regarding the new system, concern was expressed related to increasing the line speeds (threats). Also, exchange of information between the different actors is required to make the new system functional. If technological systems are introduced, their functionality needs to be verified (opportunities). Moreover, trade agreements can prohibit the full implementation of the new meat inspection system (threats).

9. Future trends in meat inspection

The ongoing updating of all parties involved in meat inspection is necessary to understand the scientific and practical reasons for change. The MIs' experiences and opinions about the changes must be adequately considered (Laukkanen-Ninios et al., 2020) from both the scientific and risk management perspectives. This could help to overcome any resistance to modernisation (Bækbo et al., 2015). Future research and risk assessments to inform risk managers, ultimately leading to the improvement of public health and greater cost-efficiency, are necessary. New EFSA scientific opinions and national risk assessment bodies provide the basis for legislative changes at the EU or national levels. One recent change is EFSA's opinion on delayed meat inspection (EFSA, 2020), which is to be considered by the European Commission.

One of the key elements of the new meat inspection is the FCI concept that serves to categorise animal batches into risk groups, which is important for meat inspection intensity (visual-only vs. palpations/incisions). Although the concept was launched more than 15 years ago, it still suffers from many drawbacks, such as insufficient and inaccurate information (Felin et al., 2016; Wagenberg et al., 2012). Thus, on its own, it often does not fulfil its main purpose. Therefore, it is essential to further investigate and adjust ways of utilising FCI to categorise animals into different risk groups. Measures like health classification of feeder pigs can have beneficial effects on performance and meat inspection findings (Heinonen et al., 2021).

The implementation of new technologies that would facilitate new meat inspection systems, such as mirrors or cameras, is costly. Therefore, financial support by governments to small FBOs for investments is required. Further European and global harmonisation, including the level of modernisation of meat inspection procedures and the lesion code system, would facilitate trade. Finally, we need verification that the meat inspection changes will improve public and animal health and welfare and/or cost-efficiencies. Thus, the new meat inspection systems will become a component of the overall European risk-based MSAS (Blagojevic et al., 2021).

10. Conclusions

The results show variation in the status of meat inspection reforms between countries and that the transition process of introducing the new meat inspection systems in Europe is ongoing. The most frequently identified hurdles to implementing the new meat inspection systems were existing trade agreements with 3rd countries, costs of implementation, inadequate FCI and resistance from MIs. Indoor-raised pigs were identified as the animal population for which the new inspection system is the most comprehensively implemented to date. The stakeholders are more confident in the new systems than in the traditional system. Overall, countries that have implemented new meat inspection systems reported reduced or equal workload related to the inspection compared to the traditional system.

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Appendix A. Supplementary data

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