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Food chain information for broilers: Results of a Europe-wide survey on status quo, usability and suggestions for improvement

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ABSTRACT

A modern risk-based meat safety assurance system (RB-MSAS) for poultry includes information systems to better adapt to risks for meat safety. Food Chain Information (FCI) according to Regulation (EC) No 853/2004 includes data on animal health, laboratory test results and further information that is relevant for consumer protection. FCI has to be transferred from the farm to the abattoir where the data analysis leads to adaptations of the slaughter process and/or meat inspection. As the EU regulation describes the required FCI imprecisely and without recommendations for meaningful reactions to specific information, implementation differs between European countries and even between abattoirs within one country. To assess the status quo of transfer, use and the usefulness of FCI in Europe, we conducted a survey on FCI for broilers among European stakeholders. The answers of 32 respondents, working in 14 different European countries as official veterinarians/meat inspection officers, food business operators/quality assurance managers, or in other positions in broiler meat hygiene, were included in the analysis. Overall, 75% (24/32) of the respondents stated they find FCI helpful for decision-making. All respondents (56%, 18/32) with electronic access to FCI find the transmission procedure practical. Most respondents get information about previous ante-mortem (81%, 26/32) and post-mortem (91%, 29/32) inspection results for flocks from the same holding of provenance. Likewise, most respondents receive data on mortality rate (88%, 28/32) and veterinary medications with a withdrawal period that have been administered during the fattening period (84%, 27/32). Overall, 53% of the respondents indicated that the entire fattening period would be the optimal relevant period for recording the administration of veterinary medications with a withdrawal period. In addition to this information, the respondents desired to have more data about further treatment (28%, 9/32) and data from the private veterinarian responsible for the farm (25%, 8/32). Knowledge of these data especially led to various measures being initiated at the abattoir, according to the respondents. In contrast, some specific production data were reported as also an important part of FCI, even though these data have little impact on the measures to protect human health that are taken in the slaughter process or at post-mortem inspection. All respondents transferred information about findings in the abattoir back to the farmers: these data were ante-mortem (72%, 23/32) and post-mortem (100%, 32/32) inspection results as well as further information (28%, 6/32).

Our study shows that FCI for broilers is already widely successfully established as part of the RB-MSAS in Europe. Important information, like the ante- and post-mortem inspection results, is mostly available. Recommendations for improvement and for data to be included based on our study and literature are, inter alia: electronic data transfer; on-farm mortality; diseases occurring on-farm, especially those shortly before slaughter; all data on treatment with veterinary medications; EFSA's harmonised epidemiological indicators and; specific production data. Further studies are needed to gain a deeper understanding of correlations between ante-mortem data for the flock and findings at post-mortem inspection. Specific measures to be taken as a result of incoming information need to be stipulated in order that FCI is used more efficiently as a risk assessment tool in RB-MSAS.

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1. Introduction

The development of post-mortem meat inspection led to the recently introduced risk-based meat safety assurance system (RB-MSAS) that is flexible, dynamic, longitudinally integrated and includes a variety of preventive and control measures at farms and abattoirs (Blagojevic et al., 2021). Food Chain Information (FCI), as regulated in Regulation (EC) No 853/2004, Annex II, Section III (EC, 2004), is an important component in RB-MSAS (Blagojevic et al., 2021; Ferri et al., 2023). For broilers and all other species of poultry, only visual meat inspection takes place when no specific risks are present (EC, 2019b). The European Food Safety Authority (EFSA) identified *Campylobacter*, *Salmonella*, and bacteria that carry extended-spectrum β-lactamase and AmpC β-lactamase (ESBL/AmpC) genes as high priority hazards in the inspection of poultry meat (EFSA, 2012a). Broilers are mostly asymptomatic carriers of these pathogens, along with other potential hazards such as dioxins or antimicrobial residues. Therefore, no abnormalities on the carcasses are visible during post-mortem inspection, and the carcasses are further processed without detection of these food safety hazards (Blagojevic et al., 2021; EFSA, 2012a). The required FCI should help food business operators (FBOs) and official veterinarians (OVs) to be aware of these invisible hazards and other specific risks related to the incoming batch. Based on the FCI, they can react adequately to mitigate the risk of cross-contamination and ensure effective meat inspection. Possible reactions are increasing the number of official auxiliaries, reducing the slaughter line speed and implementing logistic slaughter with subsequent cleaning and disinfection of the slaughter line (Löhren, 2012).

FBOs who are responsible for abattoirs receive FCI either in the form of a paper-based declaration or through electronic data exchange (EC, 2004). In many European countries, official statutory FCI documents exist and must be transferred by the farmer to the FBO who transfers the prepared information to the OV. The information content differs substantially between the European countries and partly differs also between abattoirs (EFSA, 2012a).

FCI as mandated requires the following data (EC, 2004) (shortened here for brevity):

a) animal health status of the holding of provenance or region;
b) animal health status of the flock;
c) veterinary medications or other treatments administered within a relevant period and with a withdrawal period longer than zero days;
d) occurrence of diseases that can affect meat safety;
e) test results, if relevant for protection of public health or for meat safety;
f) relevant reports about previous ante- and post-mortem inspections of animals from the same holding;
g) production data, needed in case they might indicate the presence of disease;
h) name and address of the private veterinarian responsible for the farm.

Information in b) to h) is requested from farmers and must be transmitted to the FBO and, in parallel or subsequently, to the OV (EC, 2004).

In 2012, EFSA published its “Scientific opinion on the public health hazards to be covered by inspection of poultry meat” and included an analysis on the usefulness of FCI (EFSA, 2012a). FCI was recommended as a useful tool providing information on veterinary medications, diseases occurring and *Salmonella* testing on-farm. However, EFSA concluded FCI was imprecise, inconsistent, lacked thresholds and did not contain defined measures that would result from receipt of specific data, and therefore, improvements were strongly recommended but not precisely described in the opinion (EFSA, 2012a). Studies on FCI depict the lack of specification for how FCI should be analysed and utilised (Blagojevic et al., 2021) and the insufficient harmonisation of FCI in the EU member states (EU MS) (Antunović et al., 2021; Löhren, 2012). An example is the relevant period (according to the above point c), which is the time span before slaughter in which each application of veterinary medications or other treatments with a withdrawal period longer than zero days must be documented. There is no Europe-wide definition of the length of this relevant period, and every country determines it individually. Additionally, the required FCI is not scientifically established but mostly based on common sense (Lupo et al., 2013). Studies on meaningful specific FCI content, possible thresholds, and subsequent measures as a result of FCI received are scarce.

To fill this gap, we conducted an online survey on the status quo of FCI for broilers regarding the transmission process, usefulness, transmitted parameters, thresholds and subsequent measures among European stakeholders in broiler abattoirs and other persons working in the field of broiler meat hygiene. The aims were to assess the current situation with regard to similarities and differences between the European countries and to evaluate meaningful information and consequences of FCI. Additionally, specific suggestions were gathered for optimising FCI and subsequent measures in the case of specific information and presented these.

2. Materials and methods

2.1. Development and structure of the questionnaire

A survey was planned and designed by Working Group 2 (WG 2) of the EU COST Action Network entitled "Risk-based meat inspection and integrated meat safety assurance – RIBMINS” [CA18105]. WG 2 deals with controls and risk categorisation at farm level and, thus, works on the status quo and optimisation of FCI. A subgroup within WG 2 created the questions and selectable answers, which received positive evaluation from two social scientists at the Agricultural Economics Research Institute (AGRERI) of the Hellenic Agricultural Organization (ELGO-DIMITRA) in Athens, Greece and ethic approval by the Central Ethics Committee of Freie Universität Berlin, Germany (ZEA-Nr. 2022-008).

The questionnaire (Supplemental material 1) was written in English language. The NCPs were encouraged to translate the survey into their national languages, if necessary, to exclude errors due to language difficulties as far as possible. The questionnaire was implemented in the cloud-based software SurveyHero® (enuvoGmbH, Zurich, Switzerland), and consisted of two sections with a total of 29 questions. Three questions were on general information, and 20 higher-level questions were on FCI with six sub-questions for more specific answers that were only available if the related questions were answered with “yes”. Single choice, multiple choice and open questions were used, covering the following topics: general information (country, professional role, abattoir capacity/estimated number of average broilers slaughtered per hour: <3000 per hour, 3001–10,000 per hour or >10,000 per hour), status quo of transmission of FCI and gathered information, feasibility of FCI, proposals for improvements of FCI, and subsequent measures according to the FCI received.

2.2. Distribution of the survey

The link to the online survey was distributed via email by the RIBMINS Science Communication Manager to the 33 national contact points (NCPs) of the different European countries participating in the RIBMINS network. The NCPs sent the survey via email to persons working in the field of broiler slaughter, i.e., official veterinarians or meat inspection officers (later together referred to as OVs), to food business operators and quality assurance managers (later together referred to as FBOs) and to other experts in broiler meat safety systems. The NCPs decided independently on the number of participants to be invited from their country. NCPs were instructed to select participants representative of their country’s structure concerning the size and number of broiler abattoirs. Moreover, at least one OV and one FBO were to be addressed.

Anonymity was guaranteed for all respondents according to

Regulation (EU) 2016/679 (EC, 2016b). The survey was available between 6th November 2020 and 16th December 2020.

2.3. Data analysis

A total of 32 persons answered the survey completely, and their answers were included in the final analysis. All respondents worked in European countries. For analysis, the countries were divided into non-EU countries and EU MS including the United Kingdom (UK) as the Brexit transition period was still ongoing and the UK was still subject to EU regulations at the time the survey was conducted. Analyses of the survey results were conducted descriptively with IBM SPSS Statistics for Windows, version 28 (Armonk, New York, USA) and by using Microsoft Excel (Microsoft Corporation, 2019; Version 2211). Descriptive statistics included contingency tables concerning all questions in the survey about FCI. Additionally, significance of associations between groups was calculated in IBM SPSS. Due to the small number of respondents, Fisher's exact test, or for contingency tables larger than 2 × 2, the Fisher-Freeman-Halton test was calculated. A P-value of less than 0.05 was considered significant for both tests. The answers to the questions were screened for significance regarding the respondents' different roles (OV/FBO/other), their working country (EU/non-EU) and the capacity of the abattoir (<3000 broilers slaughtered per hour/3001–10,000/>10,000).

3. Results and discussion

3.1. General information

The 32 respondents worked in 14 different countries, including ten EU MS with 26 respondents and four non-EU countries with six respondents. In total, 69% (22/32) of the respondents were OVs. FBOs formed the second largest group with 25% (8/32) of respondents. Two respondents (6%) belonged to none of the two pre-classified professional groups and were classified as "others". The respondents assigned themselves to an abattoir slaughtering less than 3000 broilers per hour (25%, 8/32), 3001–10,000 broilers per hour (47%, 15/32) or more than 10,000 broilers per hour (28%, 9/32).

Although 32 persons from 14 countries may be considered few, NCPs should select and contact directly individuals who are particularly experienced in the area of FCI. Therefore, the answers are deemed to be considered to have a very high quality and relevance. Thus, the information provided by our participants was extremely pertinent, even though responses were not received from an FBO and an OV from every participating country. Moreover, three of the four countries which had the highest numbers of poultry slaughtered per year in Europe in 2020 and 2021 (EC, 2023) were represented in the survey. All three pre-defined size categories of abattoirs were represented several times. The contribution of the respondents' assigned countries and abattoir capacities indicates that our results reflect a representative picture in terms of the EU's structural aspects.

The answers provided by two groups of people, OVs and FBOs, could have differed with respect to three aspects: (i) availability of specific FCI data, (ii) differences in finding FCI helpful and the transmission procedure practical or (iii) differing conception of optimal values (for the critical threshold for the mortality rate that should be associated with a higher condemnation rate as well as for the relevant period for treatments administered to the current flock). Interestingly, none of the answers of the two compared groups OVs and FBOs did show a statistically significant difference ($p > 0.05$ for all aspects). This indicates that OVs and FBOs have similar views on the handling of FCI data which is beneficial for a harmonised procedure. The question of whether access to additional information is available in case of abnormalities was significantly correlated ($p = 0.03$) with the working country of the respondents (EU MS vs. non-EU countries). Altogether, 30 respondents (94%, 30/32) stated they do receive additional information, while the two respondents (6%, 2/32) who did not have this information came from non-EU countries. It becomes clear that all respondents from EU MS have access to additional information in contrast to respondents from non-EU countries. However, the calculation is based on only six people from non-EU countries, which weakens the assessment of this significance.

3.2. Transmission procedure

Asked about the transmission procedure of FCI, most of the respondents (88%, n = 28) answered they receive paper-based FCI, while 56% (18/32) receive it electronically. Fourteen respondents (44%) had access to both transmission procedures, while four respondents (13%) received the FCI only electronically, and 14 respondents (44%) received only paper-based FCI. In total, 78% (25/32) of the respondents found the given transmission procedure feasible. All respondents who stated the transmission procedure is not feasible receive only paper-based FCI (22%, 7/32). This meant there was a statistically significant difference ($p = 0.006$) between the transmission procedures and the participants' perceptions of whether the transmission is practical. This clearly indicates that electronic transmission of FCI is to be recommended for feasibility reasons, as already pointed out by Windhaus et al. (2007).

3.3. Status quo of food chain information

3.3.1. Animal health status of holding of provenance or region

The respondents stated that information about recent outbreaks of notifiable diseases in their region is mostly available via the regional veterinary service (75%, 24/32), followed by national disease databases (66%, 21/32) and the World Organisation for Animal Health (41%, 13/32). Additionally, 44% (14/32) of the respondents proposed further options, e.g., national networks and publications in the media. Overall, 69% (22/32) of the respondents used more than one source to get information about recent outbreaks of notifiable diseases. We deduce from the respondents' answers that they are aware of the importance of these diseases and the need to detect them at the abattoir as the last possibility for intervention. As notifiable diseases can have a major impact on animal health as well as on a country's disease status (EC, 2016a), this information is of great importance at regional, national and international level. Both for operational reasons and for adaptations to post-mortem inspection, this information is highly relevant, as the respondents indicated.

3.3.2. Animal health status of the current flock

Animals, especially an entire broiler flock, cannot be easily declared as "healthy" or "not healthy". Diverse information must be considered for proper understanding of the broiler flock's health status. In this context, the flock mortality rate during fattening is numerical data that is easily accessible to farmers, FBOs and OVs. Overall, 88% (28/32) of the respondents had access to the total on-farm mortality rate, indicating the importance of this information.

Asked for a proposed optimal critical threshold for the mortality rate associated with pathological findings on broiler carcasses that are detectable by post-mortem inspection measures, 63% (20/32) of the respondents stated this threshold should be less than 5%, followed by five respondents (16%) who answered it should be between 6% and 10%, and two respondents (6%, both OVs) who stated that more than 10% would be the optimal critical threshold. The exact optimal critical threshold for the mortality rate associated with pathological findings on the carcasses and, thus, impacting on meat safety, has not yet been identified, and only a few studies have dealt with this subject. Lupo et al. (2009) detected a lower condemnation rate in broiler carcasses in flocks with a mortality rate of less than 2.5% compared to flocks with a mortality rate of more than 2.5%. In a following study on the same data, Lupo et al. (2013) detected a higher condemnation rate following a high mortality rate during the last seven days of fattening. Junghans et al.

(2022) showed that a high cumulative mortality rate of broiler flocks tended to be associated with the occurrence of polyserositis and was significantly associated with other pathological findings and/or haematoma and/or injuries detected at post-mortem inspection. However, the association of the total on-farm mortality rate, or the mortality rate in the last seven days before slaughter, with the condemnation rate or with specific findings detectable by post-mortem inspection has not been investigated further. This should be a task of future studies.

In total, 44% (14/32) of the respondents had regular contact with the private veterinarian responsible for the farm, and 59% (19/32) had access to data from the private veterinarian regarding the animal health status. All these latter respondents (n = 19) reported they have access to the on-farm mortality rate and the veterinary medications administered during fattening. From the respondents with access to data from the private veterinarian, 74% (14/19) received information on specific diseases reported to food safety authorities. An additional four respondents (21%) answered that they have access to other information from the farm, and for one respondent, this is very detailed information including feed and water intake, light and temperature management. Further data mentioned in other information were animal welfare issues (n = 2) and occurring diseases (n = 1). Haslam et al. (2008) showed higher total condemnation rates when a diagnosed disease existed in broilers. Health disorders, especially those that occurred shortly before slaughter, were shown to have a great impact on the condemnation rate of the batch at the abattoir (Lupo et al., 2009, 2013).

It can be that a high on-farm mortality rate and/or the occurrence of specific diseases in a broiler flock are associated with a deficient flock health status resulting in a higher-than-normal condemnation rate for the batch of carcasses at the abattoir. Therefore, knowledge of the on-farm mortality rate and of the occurrence of diseases, both especially shortly before slaughter, could help to optimise the processing steps at the abattoir and subsequently increase meat safety. These data should, therefore, consequently be transmitted as FCI with the batch.

3.3.3. *Veterinary medications or other treatments*

The respondents indicated that periods from zero days to the entire fattening period are laid down as the relevant periods for their countries. Discrepancies in the logic of the answers were detected, e.g., different values from different respondents from the same country, even in countries where the relevant period is mentioned in the official FCI form. There seemed to be problems with some respondents understanding this question correctly. Similar results were found among German veterinarians and farmers in another study where the concept of the relevant period was not clear to the participants (Popp et al., 2017). Due to this inconsistency, the results of this question could not be analysed.

In a further question, respondents were asked about what they considered to be the optimal relevant period. As the question (Supplemental material 1, Question B.6) was formulated in a comprehensible way, we assume the respondents' answers were generated according to their intentions to answer; therefore, we analysed the suggested relevant periods. The entire fattening period was considered as relevant by 53% (17/32) of the respondents. The other answers were spread along the possible answer range of between 0 days (6%, 2/32) and 21 days (13%, 4/32) (Fig. 1). For broilers with their compared to other food animals' short lifespan, the entire fattening period seems, in our opinion, to be the most reasonable timespan. When this period is applied, the farmers must communicate every administration of veterinary medications with a withdrawal period as obligatory part of the FCI.

Access to data on administered veterinary medications with a withdrawal period is important for RB-MSAS, as the administration of antibiotics to broilers can lead to a risk of residues in the carcasses (Ghimpeteanu et al., 2022). Besides, the use of antibiotics for the whole lifetime of a flock was identified as relevant for the incidence of ESBL/AmpC-producing bacteria (Blagojevic et al., 2021). The administration of antibiotics is also a sign for an occurring disease and possibly following post-mortem findings. In their study, Junghans et al. (2022) showed that the treatment of broiler flocks with antibiotics was associated with significantly higher condemnation rates at slaughter than in non-treated flocks. Additionally, significant positive correlations between antibiotic treatments and occurrences of the post-mortem findings 'ascites' and 'polyserositis' were identified (Junghans et al., 2022). In contrast, Alban et al. (2013) showed higher frequencies of specific post-mortem abnormalities in pigs when less antibiotic usage occurred on farm.

Data received on non-antibiotic treatments was on: veterinary medicinal products apart from antibiotics (75%, 24/32); feed additives (75%, 18/32); antiparasitic medicines (75%, 18/32); vaccines (58%, 14/32) and; other veterinary treatments (33%, 8/32). Some of these non-antibiotic veterinary products also have a withdrawal period. Feed

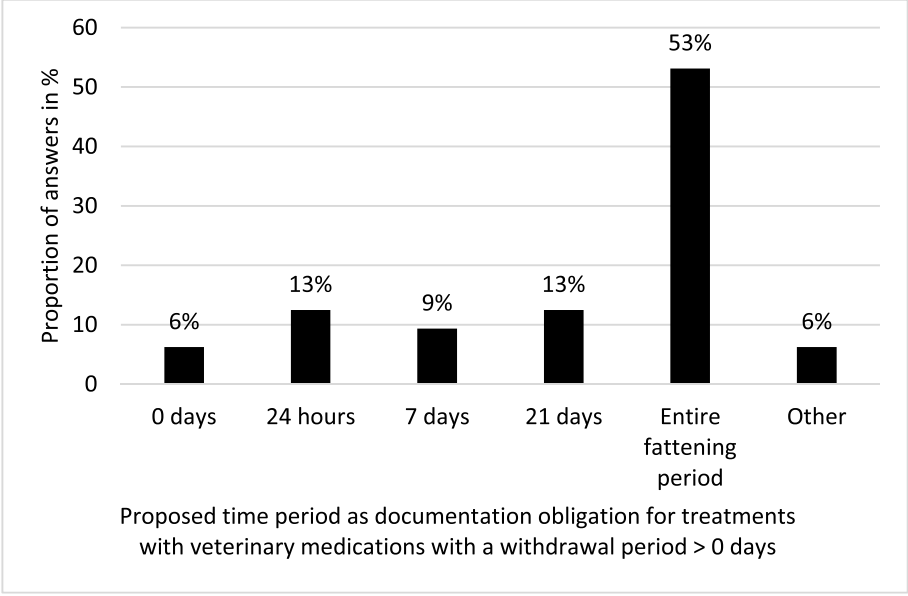

Fig. 1. Proposed time period as documentation obligation in the food chain information for treatments with veterinary medications with a withdrawal period >0 days (n = 32).

additives and antiparasitic medicines can be of interest for FCI, as they can draw attention to specific abnormalities or, in contrast, the absence of non-antibiotic treatments could lead to higher condemnation rates caused by the detection of specific pathological conditions.

3.3.4. Relevant reports about previous ante-mortem and post-mortem inspections of animals from the same holding

The ante-mortem inspection of broilers was reported to take place at the farm (22%, 7/32, all from EU MS), at the abattoir (53%, 17/32, 13 from EU MS and 4 from non-EU countries) or both (25%, 8/32, 6 from EU MS and 2 from non-EU countries). Ante-mortem inspection at the farm must be performed by OVs (EC, 2019a). This type of ante-mortem inspection gives a good overview of the health status of a flock because the animals can be inspected when they are exhibiting their natural behaviour and motion (Löhren, 2012). Additionally, insight into the flock's data is easily and quickly gained during the farm visit. After ante-mortem inspection at the farm, the OV issues an official health certificate that is valid for 72 h (EC, 2019a). At the abattoir, this certificate is checked together with FCI for irregularities especially with regard to meat safety, and exemplarily, ante-mortem inspection of the broilers is performed by an OV or official auxiliary under supervision of an OV in a visual manner (EC, 2019b). If ante-mortem inspection of broilers is performed at the abattoir only, OVs visually inspect every batch, assessing the animals' behaviour, health, welfare and cleanliness. In addition to findings that can have an impact on meat safety, animal welfare is given special consideration at this stage. However, animal health and, therefore, meat safety are in the focus of ante-mortem inspection. During this inspection, the animals sit close together in crates, and therefore, it is difficult to detect clinical signs (Allain et al., 2018). Only the first row of birds in the crates can be inspected (Löhren, 2012). Additionally, cross-checking whether the correct information is supplied in the FCI received is not possible (Löhren, 2012). Ante-mortem inspection at the abattoir is less time consuming than ante-mortem inspection at the farm, but at the abattoir, this inspection is very close (time-wise) to slaughter, and decisions on measures based on specific findings must be made quickly.

A total of 81% (26/32) of the respondents had access to previous ante-mortem inspection results from the same holding. All 17 respondents from countries where ante-mortem inspection took place only at the abattoir had access to previous results, as no transmission step between the farm of origin and abattoir was required. Six respondents (19%) received no results from previous ante-mortem inspections, among them four OVs and two FBOs from five EU MS and one non-EU country. The respondents reported they have access to specific ante-mortem data: dead-on arrival rate (100%, 26/26); clinical signs of disease (88%, 23/26) and; visible lesions caused by injury (81%, 21/26). Other ante-mortem results were animal welfare problems (n = 2) and the cleanliness of animals (n = 1). Asked separately in the survey about whether they receive data on the cleanliness of broiler flocks, 63% (20/32) of the respondents stated they have access to this data. Another five respondents (16%, 5/32) requested that data on cleanliness of broiler flocks be additional information for improving FCI, highlighting the importance of this data. Dirty broilers with faeces, residues of litter and other dirt on their feathers can lead to contamination of the abattoir staff as well as equipment, especially when stunned electronically in the hang-on processing and when flapping wings before stunning (Wilkins et al., 2003). In addition, in the scalding and plucking processes, scalding water and the plucking fingers can lead to cross-contamination of following flocks (Wilkins et al., 2003). As there is no possibility of cleaning dirty broilers before slaughter at the abattoir, the birds should be as clean as possible and if dirty batches are delivered, other measures like logistic slaughter at the end of the working day should be taken into account. Still, no correlation was visible between clean or dirty broiler flocks and the condemnation rate (Lupo et al., 2009) but dirtiness together with other clinical indicators can be used to assess animal welfare problems (Saraiva et al., 2016).

Overall, 91% (29/32) of the respondents had access to data from previous post-mortem inspections of animals from the same holding. In contrast, two FBOs and one OV, all from EU MS, did not have access to this kind of information. Specific post-mortem data that was received, according to respondents' answers, were meat safety and meat quality data: total condemnation rate (90%, 26/29); partial condemnation rate (76%, 22/29); disease implying pathological findings (59%, 17/29, specified as ascites, pericarditis, arthritis and other) and; low carcass quality (55%, 16/29). Several other answers specified that other types of post-mortem data are received; these data concerned animal health, consumer health, meat safety and animal welfare. No specific pathological post-mortem finding was mentioned very often, so we could draw no conclusion for any specific item of post-mortem information that is very important for the FCI of the next flock. Nevertheless, previous post-mortem data are important, as subsequent batches could have similar condemnation rates and similar specific abnormalities that would be particularly important for meat safety, but such data can also be of concern for meat quality or animal welfare. In a French study, a flock's condemnation rate, categorised as higher or lower than 0.44%, had a high impact on the following flock's condemnation rate (Lupo et al., 2013). In conclusion, we believe it is important that the relevant people have unfettered access to previous ante-mortem and post-mortem data as required FCI; this was true for most of the participants in our study.

3.3.5. Production data and further information

In total, 66% (21/32) of the respondents asked for further information in addition to the legally required FCI. One person did not explain the kind of additional information they requested. For the other respondents, it covered: the official farm number (100%, 20/20); the farm location (100%, 20/20); the flock size (80%, 16/20); the production system (conventional/organic; 80%, 16/20); the husbandry system (indoor/outdoor; 65%, 13/20); the quality assurance system applied (15%, 3/20); information on heat treatment of the feed (15%, 3/20) and; other individual answers (30%, 6/20) with a large variety of information about average weight, flock density, transportation, and production data.

3.4. Consequences from received food chain information

The respondents were asked to give information about the measures they initiated in the abattoir in the event of specific data being in the FCI. This data (e.g., on-farm mortality rate) was predefined and measures (e.g., reduction of line speed) could be chosen; multiple answers were allowed.

Fig. 2 gives an overview of the number of answers regarding information that did not lead to any subsequent measure regarding the slaughter process and the inspection of the carcasses. Here, especially general and production data were mentioned, e.g., quality assurance system (n = 16), flock size (n = 14), husbandry system (n = 14) and production system (n = 11). Some of the data may also be relevant in the context of risk monitoring, for example, a higher prevalence of *Campylobacter* is possible in broiler flocks with outdoor access (Allen et al., 2011; Engvall, 2001; Heuer et al., 2001; Newell et al., 2011). In particular, however, these data contain important information for organisational purposes. For example, it is essential to know the size of the incoming batch in order to estimate the slaughter duration and to take into account the abattoir-specific slaughter capacity. Altogether, these data are of little relevance for risk assessment, which is the actual intention of having FCI in the framework of RB-MSAS (Blagojevic et al., 2021).

In Fig. 3, possible measures initiated by the respondents after receiving specific data are given. The measures that were most commonly chosen are listed on top. Ante- and post-mortem findings were most often chosen as leading to especially substantial measures with high impacts on time and effort (Fig. 3, light to dark red), e.g., a

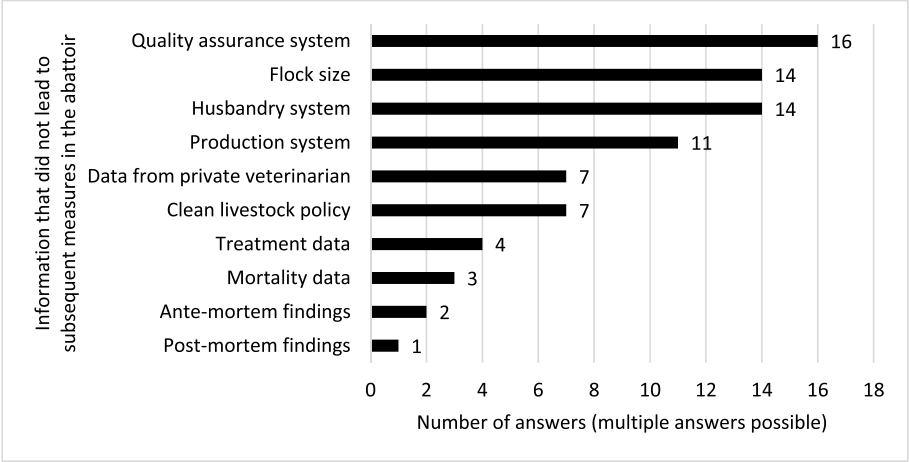

Fig. 2. Gathered information that did not lead to subsequent measures in the abattoir (n = 32, multiple answers possible).

reduction of line speed. Obviously, it is important that these data are transferred in the FCI. Regarding post-mortem findings, many different subsequent measures were reported, like raising awareness (n = 23), intensification of meat inspection with more personnel (n = 17), additional tests (n = 14) and channelling of the processed products (n = 16). In the case of knowledge about treatment data, residue testing was often applied by the respondents (n = 19).

Other information with many chosen consequences was mortality rate data, data from the private veterinarian and treatment data. Thus, these data should be regarded as relevant for FCI. Frequent subsequent measures arising from these relevant data were raising awareness, logistic slaughter and preselection of herds before slaughter. On-farm mortality was already identified as important FCI (see section 3.3.2). The classifications of data from private veterinarians and treatment data as important information were reinforced by the answers respondents gave to the question about additional information to which the respondents would like access (Fig. 4). For this question, ten different answer options were provided in the questionnaire, and free text could be inserted by the respondents. Half of the participants (50%, 16/32, 12 from EU MS, four from non-EU countries) stated they had nothing to add, or they did not give a textual answer, which implies they do not ask for additional information. Specific answers like mortality data (n = 4), ante-mortem (n = 5) and post-mortem findings (n = 3) were only mentioned by a few respondents, all coming from EU MS. As shown before (see sections 3.3.2 & 3.3.4), most respondents receive information on the on-farm mortality rate and ante- and post-mortem findings, so they do not have to request them additionally. Both treatment data (n = 9, all from EU MS) and data from the private veterinarian (n = 8, six from EU MS, two from non-EU countries) were of great interest, implying that data concerning veterinary medications administered to the animals within a relevant period and with a withdrawal period longer than zero days were not enough for meaningful FCI. One respondent added that not only treatment data but also the indication for the treatment would be of interest. Those data about clinical diseases and all treatments administered to the flock could be an important indication of specific meat safety risks that are present.

Feedback to the farmer as another consequence, not given as answer in the consequences question but required in Regulation (EU) 2019/627 (EC, 2019b), was stated to be given by all respondents. All (100%, 32/32) of the respondents mentioned they send to the farmer

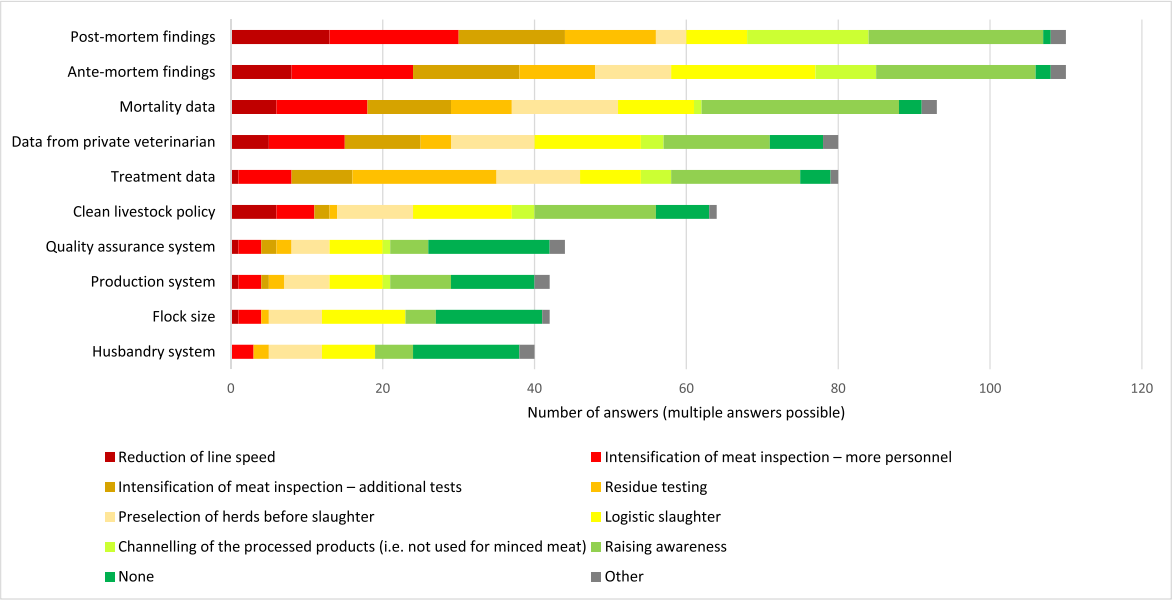

Fig. 3. In-abattoir measures of specific information, ranked in order of the main impact on slaughter (n = 32, multiple answers allowed). The colour gradation goes from dark red (high impact of time and effort) to green (low impact of time and effort) and grey (not applicable).

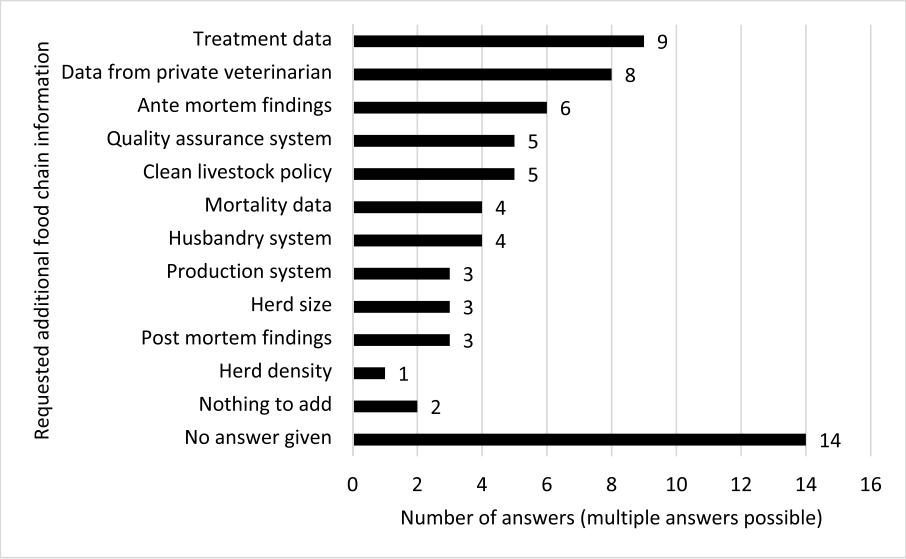

Fig. 4. Requested additional food chain information for broilers (n = 32, multiple answers possible).

post-mortem findings and 72% (23/32) send ante-mortem inspection results. Six respondents (28%) additionally transferred other information, like aspects of animal welfare (n = 3) and results of laboratory tests (n = 1). Information fed back to the farmer is helpful for meat safety as well as for animal health and welfare, as improvements on the farm can be established for the following broiler flock(s) after specific findings at the abattoir (Blagojevic et al., 2021; Buzdugan et al., 2021; Saraiva et al., 2016). To the best of our knowledge, no study shows the farmers' specific consequences arising from information that is fed back from OVs to the holding of provenance.

3.5. Usefulness of food chain information for decision-making

A total of 75% (24/32) of the respondents stated FCI is helpful for decision-making regarding meat safety. One respondent (3%) found FCI is not helpful and 22% (7/32) said it is rarely helpful. The respondent stating FCI is not helpful specified that there is a lack of details in the FCI as declared in the EU legislation, which is in accordance with other studies and EFSA publications (Antunović et al., 2021; EFSA, 2012a; Gomes-Neves et al., 2018). That respondent added that further information like mortality, feed and water intake as well as results of dissections and treatments would be helpful, and that FCI cannot replace control of the animals at the farm. This stands in contrast to Löhren (2012), who suggested that FCI detailing the daily growth rate, daily feed and water intakes, reports of all veterinary visits, laboratory tests and veterinary indications for any flock medications could, in the end, replace ante-mortem inspection on the farm. For male turkey broilers, flocks with fewer apparent clinical signs during ante-mortem inspection at the abattoir showed a lower risk of condemnation (Lupo, Le Bouquin, et al., 2010). From our point of view, ante-mortem inspections of broiler flocks will continue, as the visual inspection of the flock by an OV is essential to get trusted relevant information about the flock's health status and also about animal welfare of the living birds. In this respect, the ante-mortem inspection by the OV remains crucial to ensure meat safety and animal welfare.

Interestingly, the 24 respondents who found FCI helpful worked in all pre-defined categories of abattoir capacities (4, 12 and 8 in <3000 broilers slaughtered per hour, 3001–10,000 and > 10,000, respectively). The one respondent who negated the helpfulness of FCI assigned themselves to a highest capacity abattoir. FCI was stated to be rarely helpful by seven respondents from small (<3000 broilers slaughtered per hour, n = 4) and medium (3000–10,000 broilers slaughtered per hour, n = 3) capacity abattoirs. This distribution was statistically significant ($p = 0.043$). At the same time, statistical significances were found for the questions on accessibility to the mortality rate ($p = 0.002$), treatments within a relevant period with a withdrawal period longer than zero days ($p < 0.001$) and treatments apart from antibiotics ($p = 0.011$). In all three cases, most of the negative answers about possible access to the information were given by respondents who worked in small capacity abattoirs with less than 3000 broilers slaughtered per hour. Thus, compared to high capacity abattoirs OVs and FBOs working in small abattoirs seem to receive less information, which can be seen as the reason why they stated FCI is less helpful for decision-making.

3.6. Overall discussion and suggestions for improvement

In our survey, general satisfaction (75%, 24/32) regarding the usefulness of FCI for broilers for decision-making regarding meat safety was reported. Specific information can lead to adaptations in the slaughter process and meat inspection for improved risk control, decreased microbial load and, thus, increased meat safety. There is already important information required and used as FCI, e.g., animal health status of the holding of provenance or region; veterinary medications within the relevant period and with a withdrawal period longer than zero days; ante- and post-mortem findings as well as contact data of the private veterinarian. This should be continued with additional improvements to the content (e.g., inclusion of concrete mortality rate data), thresholds (e.g., for the mortality rate associated with a specific lesion or for a general increased condemnation rate) and risk-based standardised decisions that are necessary, as was mentioned by other authors and EFSA (Antunović et al., 2021; Blagojevic et al., 2021; EFSA, 2012a; Gomes-Neves et al., 2018; Löhren, 2012). For broilers, other poultry species and pigs, FCI is more applicable than for bovines and sheep due to the common integrated systems for the former categories/species (Ferri et al., 2023).

Table 1 contains suggestions for improved FCI for broilers. These are compiled from the conclusions of our study and other results from the scientific literature. Conclusions of this study include our strong recommendation for electronic transfer of FCI, which will enable easy data access. Paper-based transmission can remain an additional means of transmission. In our opinion, relevant data according to EU regulation should be more detailed and should specify which data are to be transmitted. For the respondents, on-farm mortality data is highly relevant, and thus, we conclude that the total mortality rate and the

Table 1
Suggestions for improving broiler food chain information.

Component	Suggestions for improvement	Source
Transmission process	Electronically, additionally paper-based possible	Our study
Additional information	Mortality rate: total and last seven days in form of a precise number	Our study; Junghans et al., 2022; Lupo et al., 2009; Lupo et al., 2013
	Average bird weight, age of the broilers	Buzdugan et al., 2020; Haslam et al., 2008; Langkabel et al., 2015; Lupo et al., 2009
	Stocking density	Hall, 2001; Junghans et al., 2022
Relevant period	Harmonisation of the relevant period in EU MS to the entire fattening period	Our study
Treatments	Add all treatments in the entire fattening period with indications and withdrawal periods where applicable	Our study; Löhren, 2012
Test results	All results for *Salmonella* and *Campylobacter*, optional ESBL/AmpC [a] *E. coli,* Harmonised Epidemiological Indicators, antibiotic resistance	Blagojevic et al., 2021; Bonardi et al., 2021; Buncic et al., 2019; EFSA, 2012a; Ferri et al., 2023
Catching	Catching method: by hand or machine	Delezie et al., 2006; Knierim & Gocke, 2003; Langkabel et al., 2015; Lupo, Bougeard, et al., 2010

[a] Extended-spectrum β-lactamase and AmpC β-lactamase.

mortality rate in the last seven days before slaughter should be included in FCI.

In addition, studies showed the effect of weight at transport and at slaughter. Higher weight led to higher rates of ascites, "hard breast" (Buzdugan et al., 2020), lesions (Langkabel et al., 2015) and a higher total condemnation rate (Lupo et al., 2009). Total carcass rejections increased with broiler age (Haslam et al., 2008). The question of the farm-to-abattoir transfer of information about expected slaughter weight and broiler age was not part of this survey, but these data are highly likely to be important information for economic and technological reasons. Therefore, we recommend estimated weight at slaughter and broiler age both be included in FCI, because subsequent measures might be needed in the case of older broiler batches with their expected higher condemnation rates and in the case of specific condemnation reasons.

For stocking density, some studies indicated an influence on the post-mortem results. While Meluzzi et al. (2008) did not find a correlation between stocking density and lesion incidence, Hall (2001) found a higher prevalence of wing and leg bruising, breast blisters, hock burn and back scratches in birds from holdings with a stocking density of 34 kg per m^2 than for those with 30 kg per m^2. In a German study, the stocking density had a significant influence on post-mortem findings "not suitable for production/general disease", "hepatic changes" and "underdevelopment/emaciation" (Junghans et al., 2022). Thus, in our opinion, three farm management parameters are required in FCI: start date of the fattening period; estimated live weight at slaughter and; stocking density.

We advise that the relevant period for veterinary medications administered with a withdrawal period longer than zero days be harmonised to the entire fattening period in all EU MS, as proposed by the majority of the survey's respondents. All relevant people, including FBOs and OVs should require data on all treatments of the broiler flock. The data required are: administered medicinal product; start date; number of days of administration; withdrawal period if applicable (proposed by us due to the results in this study), and; the indication for treatment (proposed by Löhren et al. (2012) and by us).

FCI needs to include all available test results on *Salmonella*, *Campylobacter* and ESBL/AmpC *E. coli*, since these are the high priority hazards defined by EFSA, and on harmonised epidemiological indicators (HEIs) for poultry (EFSA, 2012a; 2012b). In addition, Blagojevic et al. (2021) recommended on farm-monitoring of antibiotic resistant bacteria, which we also recognise to be a meaningful investigation. Different authors proposed integrating the results in the RB-MSAS and transferring them with FCI (Blagojevic et al., 2021; Bonardi et al., 2021; Buncic et al., 2019; Ferri et al., 2023) so that OVs will benefit and be able to use FCI and HEIs in their roles as risk managers in a RB-MSAS (Ferri et al., 2023).

In addition, the method for catching broilers should be a necessary part of the FCI. Studies showed that good catching led to fewer traumatic condemnations and less stress in broilers (Langkabel et al., 2015; Lupo, Bougeard, et al., 2010). A lower incidence of wing haemorrhages occurred when broilers were caught using a machine (Delezie et al., 2006), while significantly lower injury rates after mechanical catching with a specific catching machine were found (Knierim & Gocke, 2003). In our opinion, the broiler catching options "by hand" or "by catching machine" with the name of the machine need to be included in the FCI.

Official thresholds or predefined management procedures resulting from specific FCI cannot be decided on yet, because the results of our study did not clearly connect specific subsequent measures to a specific piece of information. Further studies focussing on parameters of broiler flocks with relevance to post-mortem findings are needed to evaluate this topic.

For risk-based meat inspection purposes, a standardised form as proposed by Allain et al. (2018) is clearly a requirement. Most of the suggestions resulting from our survey's outcome and other scientific research could be included in this form, which will be an improvement of FCI.

For full implementation of RB-MSAS, a system is needed that uses data from FCI and HEIs to identify risks and propose subsequent measures. Two groups of authors published possible implementations. Allain et al. (2018) proposed a four-step alert system for risk-based meat inspection in poultry abattoirs where alert criteria for FCI includes a formal irregularity, i.e., a lack of specific information or of the entire FCI. Another aspect is mortality, i.e., a high mortality rate in the last two weeks before slaughter or a total mortality rate that is higher than an individually defined threshold. The alert would inform an expert group that would subsequently determine the consequences (Allain et al., 2018). Lupo et al. (2009) created and tested a model with six variables – production type, frequency of farmer's visits during the starting period, health disorders during rearing period, on-farm mortality, mortality during transport and slaughter-line speed – that helped to classify broiler batches into condemnation groups based on the predicted condemnation rate. This model for a harmonised method of risk-based meat inspection for broilers would allow OVs to focus on the examination of carcasses in which specific pathological findings, or a high number of them, are suspected. In our opinion, those models should be evaluated for implementation in abattoirs with adaptations to local national or abattoir-specific conditions. This can be a crucial step further on the way to a standardised RB-MSAS.

A limitation of our study is the low number of respondents (n = 32), but with their excellent qualifications to answer the survey they realistically depict the status quo of FCI in Europe together with possible suggestions for improvement.

4. Conclusions

FCI is one of the most important risk assessment tools in RB-MSAS. Our study proved the successful establishment of FCI for broilers, as, e.g., the successful transmission of some important FCI data, like ante- and post-mortem findings, was shown. However, the survey results also showed the potential for FCI to be optimised in the areas of data transmission, specification of required information, thresholds, and subsequent measures to be applied. Various suggestions on specific data

to be transmitted in the FCI were brought forth in this study. Still, further research is necessary, especially for the links between FCI and the meaning for carcass findings and for meat safety. Further research is also needed to develop meaningful subsequent measures in the abattoir procedures after specific information is received in the FCI. Nonetheless, FCI must be implemented for all broilers and can be harmonised without delay. The successful consolidation of FCI requires: (i) specific legislation to mandate harmonised, transmitted FCI data, (ii) technical implementations for easy electronic FCI data exchange that is two-way between farmers and FBOs and OVs, (iii) close collaboration of operators and decision makers, (iv) training of stakeholders on the meaning and application of FCI and (v) abattoir-specific strategies for specific subsequent measures because of information received in the FCI. Finally, we confirm that flexible handling and adaptation to new situations are necessary, so FCI will need to be adaptive and reviewed regularly at the EU level.

Ethical approval

Ethical approval for the study was obtained from the Central Ethics Committee of Freie Universität Berlin, Germany under ZEA-Nr. 2022-008 on April 14th, 2022.

Positive evaluation was performed by two social scientists from the Agricultural Economics Research Institute (AGRERI) of the Hellenic Agricultural Organization (ELGO-DIMITRA), Athens, Greece.

CRediT authorship contribution statement

Susann Langforth: Investigation, Formal analysis, Data curation, Writing – original draft, Visualization. **Verena Oswaldi:** Investigation, Formal analysis, Data curation, Writing – review & editing. **Rudi Isbrandt:** Writing – review & editing. **Smaragda Sotiraki:** Conceptualization, Methodology, Writing – review & editing. **Sofia Anastasiadou:** Conceptualization, Methodology, Writing – review & editing. **Truls Nesbakken:** Conceptualization, Methodology, Writing – review & editing. **Diana Meemken:** Conceptualization, Methodology, Writing – review & editing, Supervision, Project administration. **Nina Langkabel:** Investigation, Writing – review & editing, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Due to the anonymity given to the participants of this study, survey respondents were assured raw data would remain confidential, and so these are not available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.foodcont.2023.109844.

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