






A comprehensive analysis of inspection and audit reports in animal-derived food production by local competent authorities: A study from Emilia-Romagna, Italy (2020–2024)

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ABSTRACT

Food safety is essential to public health and is ensured through official controls that verify compliance across the food supply chain. This study examines the frequency and nature of non-compliances identified through inspections and audits in Emilia-Romagna, Italy, from 2020 to 2024. A survey explored challenges faced by veterinarians in official controls. Over 540,000 inspections and 40,000 audits were performed in ≈3000 production activities handling products of animal origin. Inspection non-compliance rates remained low, from 1.7 % in 2020 to around 2.3–2.4 % in later years. Few inspections led to enforcement actions: 89 legal referrals, 151 administrative penalties, and 55 product seizures. Audits showed higher non-compliance rates (4.6 %), particularly in poultry slaughterhouses (8.5 %) and meat processing facilities (7.2 %), though rarely resulting in sanctions. The study underscores methodological and functional differences between inspections and audits, the former being more effective in identifying operational issues, and the latter in detecting systemic deficiencies. While audits revealed more non-compliances, this quantitative difference lacks consistent support from broader literature and deeper analysis, suggesting both tools have complementary strengths shaped by context and methodology. The Complaint Index highlighted imbalances in inspection frequency, pointing to sectors where resources could be better allocated. However, limitations such as fragmented data systems hinder comprehensive risk-based planning. Official veterinarians' survey responses indicated a need for improved training, better checklists, and time optimization. The findings advocate for a transition from broad risk categories to targeted, risk-based inspections, supported by digital tools to enhance the efficiency and effectiveness of official controls.

1. Introduction

Food business operators (FBOs) are legally obligated to ensure the effective implementation of food safety regulations, as established by European legislation (EC, 2002, pp. 1–24). Concurrently, official

controls conducted by competent authorities (CAs) are essential to verify compliance with statutory requirements and to ensure that operational practices align with current regulatory frameworks (EC, 2017). These official controls encompass assessments of both structural and managerial compliance, as delineated in sector-specific provisions (EC, 2004,

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pp. 55–205). CAs are responsible for guaranteeing that personnel assigned to perform official controls possess adequate training and are regularly updated on food safety principles and operational protocols. The systematic documentation of control activities, including the procedures undertaken, outcomes observed, and corrective measures implemented, is critical to enable consistent analysis and interpretation of findings across different inspectors (Italian Republic, 2016).

A structured communication system between CAs and FBOs is necessary to support the periodic analysis of non-compliance factors and to foster continuous improvement in production processes (EC, 2017). Furthermore, the evaluation of inspection and audit reports, when integrated with robust feedback mechanisms from FBOs, facilitates the identification of recurrent issues, the strategic planning of targeted interventions, and the prompt implementation of corrective actions. These practices collectively contribute to mitigating the risk of future non-compliance (Rossi et al., 2020).

The European Union (EU) has established a comprehensive regulatory framework that sets uniform standards for food safety, hygiene, and official controls across all Member States (MSs). This framework ensures that food products circulating within the internal market meet consistent safety and quality standards. (EU) Regulation 2017/625 serves as the principal legal instrument governing official controls throughout the EU. It mandates that such controls be planned and executed with a frequency proportionate to the level of risk associated with specific production activities (EC, 2017). While each MS retains the autonomy to implement its own management systems and procedural approaches, it is required to delegate control functions to designated CAs and to provide them with the necessary resources to carry out their duties effectively. These authorities must conduct official controls in accordance with documented procedures, thereby ensuring full transparency and operational consistency in the enforcement of food law.

In Italy, official controls are carried out by local CAs, which operate under a regionally coordinated management system (EC, 2024). However, a national plan developed by the Ministry of Health, the “Piano di Controllo Nazionale Pluriennale”, establishes the minimum levels of control, the methodologies for conducting inspections, and the criteria for evaluating outcomes and identifying non-compliances. At the regional level, the Regional Integrated Plan (Piano Regionale Integrato, PRI) of Emilia-Romagna outlines the criteria used to classify the specific risk levels associated with different food production establishments. It also defines the procedures for conducting official controls and for reporting the results (Italian Republic, 2022). Regional manuals provide standardized procedures for the implementation of official controls and for the assessment of non-compliances. Checklists are employed as operational tools to support inspection activities and to ensure that findings are properly documented and traceable.

Manuals and checklists are tailored to each specific type of production activity and are structured around common investigation areas (IAs). These areas encompass key operational domains such as establishment registration and approval, facilities and equipment, sanitation plans and pest control, personnel hygiene and training, water supply procedures, by-products and waste management, raw materials and semi-finished products, labelling, traceability, recall and withdrawal procedures, storage and transportation, as well as own-check plans and Hazard Analysis and Critical Control Points (HACCP) systems (Italian Republic, 2022).

For each IA, specific requirements have been defined in accordance with the applicable regulatory framework (EC, 2004, pp. 55–205). This structured approach ensures consistency in the implementation of official controls and facilitates the systematic evaluation of compliance across diverse FBOs.

This regional control system has been in use for several years, and there is a recognized need to analyze its strengths and weaknesses. In the context of continuous improvement, a decision was made to collect feedback from official veterinarians (OVs) through a questionnaire designed to capture their experiences, which vary depending on the

types of establishments present within their operational districts. The aim was to obtain an informed, albeit subjective, perspective on the factors influencing official control activities, including inspections and audits. Audits and inspections are not mutually exclusive but rather complementary tools in the regulatory framework (EU) Regulation 2017/625 and national guidelines (CSR 212/2016) clearly delineate their respective roles. Audits are intended to verify whether planned arrangements are effectively implemented (validation) and whether they are adequate to achieve defined objectives (effectiveness verification) (EU, 2017, pp. 1–142; Italian Republic, 2016). This includes a systematic review of unresolved non-compliances and unmet targets. Inspection is the control of one or more specific requirements (through verifications) in order to establish compliance with legislation. Compliance is relevant only to the precise moment in which it is performed. Inspection is normally unannounced, except in cases that require it, as foreseen by Art. 9(4) of (EU) Regulation 2017/625.

It is important to emphasize that risk-based control frequencies must be adaptable to specific circumstances, based on a critical analysis of identified issues. In particular, the frequent occurrence of non-compliances in certain IAs and production sectors highlights systemic weaknesses in food safety management systems, as also noted by other authors (Kiviniemi et al., 2025). The repeated failure to meet food safety standards suggests that the root causes of these issues have not been adequately addressed, or that the systems intended to manage them are flawed. This situation may necessitate a more tailored risk reassessment for each individual establishment.

The analysis of findings obtained through official controls, along with the insights of the OVs responsible for their implementation, can serve as a valuable tool for improving the management of control systems and non-compliance responses. This may lead to the development of more effective procedures tailored to the specific characteristics of the production context. To this end, the present study examined the frequency of non-compliances identified during inspections and audits across various sectors and production activities in establishments handling food of animal origin in the Emilia-Romagna Region during the period 2020–2024.

2. Materials and methods

2.1. Establishments and risk categorization

This study included all establishments located in the Emilia-Romagna Region that handle, prepare, or produce food of animal origin. Emilia-Romagna, situated in northeastern Italy, is particularly renowned for its production of meat-based and dairy products. The establishments were officially approved by the local CA in accordance with (EC) Regulation 853/2004 (EC, 2004, pp. 55–205) and classified following the criteria outlined in the SANCO document (EC, 2022a).

Regional CAs are required to maintain and update the S.INTE.S.I.S. database (Integrated System for Trade and Imports), hosted on the NSIS platform of the Italian Ministry of Health (Italian Republic, 2012a). This system facilitates the monitoring of production activities within the food sector and supports more effective management of official controls and authorization procedures. Each establishment may be associated with one or more production activities. Notably, no establishments classified under Section XVI (Highly Refined Products) were present in the Emilia-Romagna.

Risk levels assigned by local CAs were based on three main criteria, as defined by regional guidelines (Italian Republic, 2022) and consistent with FAO recommendations (FAO, 2008): i) type of product (scored 1–6); ii) production process management (scored 0.1–1); and iii) production volume (high = 1.2; low = 1) (Table S1).

The study encompassed approximately 1735 establishments, associated with approximately 3000 production activities. The most represented categories included meat product production (19.0 %), dairy product manufacturing (18.5 %), cold storage warehouses (13.1 %), and

repackaging and reprocessing centres (11.8 %), the latter performing activities such as deboning of cured hams, slicing and dicing of cured meats, and grating of cheeses. All production activities were classified into high, medium, or low risk categories (Fig. S1).

2.2. Inspections and audits

For the execution of inspections and audits, local CAs utilize standardized tools such as manuals, checklists, and official reports developed by the regional CA. These tools provide structured guidance on how to organize and document findings. Both inspection and audit procedures rely on a unified reporting form to record observed evidence. This form includes 32 verification points grouped into 14 IAs: establishment registration and approval; structure and equipment; cleaning and sanitation conditions; pre-operational and operational sanitation; personnel and processing hygiene; staff training; pest control; animal by-products, waste, and water supply; traceability, recall and withdrawal; storage and transport; raw materials and semi-finished products; finished products and labelling; own-check/HACCP plan; and HACCP plan implementation.

At the conclusion of each official control, the local CA provides the FBO with a copy of the report, either in paper or digital format. Inspections are scheduled annually by the local CA, these are the Local Health Units based on the risk category assigned to each production activity. Each category corresponds to a minimum number of verifications to be conducted across all establishments with that production activity: 60 for high-risk, 46 for medium-risk, and 32 for low-risk activities. These thresholds refer to the total number of verifications required per category, not per individual facility. For example, if a local CA oversees several high-risk production activities, such as slaughterhouses, it must ensure that at least 60 verifications are carried out collectively across those facilities over the year. This is in addition to the continuous presence of OV's in certain facilities, such as slaughterhouses, where daily ante- and post-mortem inspections are mandatory. Moreover, the inspection frequency may be adjusted based on non-compliances identified in previous years.

Audit frequency is determined according to national guidelines (Italian Republic, 2016), which specify the percentage of production activities to be audited, but do not define the number of verifications to be conducted. Consequently, local CAs determine both the number and the specific IAs to be assessed during the planning phase. Annual audit plans include 33 % of activities in Section 0 and 20 % of activities in Sections I to XV, regardless of the assigned risk category (high, medium, or low) (EC, 2022a). Audits and inspections are both components of the official control system and are carried out during the same annual cycle, but they are conducted separately and serve different purposes. Audits are typically conducted by a team/group of OV's, and are not conducted simultaneously with inspections at the same facility. The objective is to ensure that all production activities are audited at least once within a 3- to 5-year cycle.

Non-compliances considered significant for food safety, particularly those related to traceability, recall and withdrawal, and HACCP are considered when reassessing risk classification and planning future inspections (FAO, 2008). To ensure consistency in compliance assessment, a four-level evaluation scale is used: compliant, compliant to be improved, potentially not-critical, and critical for consumers' food safety (Italian Republic, 2016, 2022). Depending on the severity of the non-compliance, enforcement actions may include administrative or criminal measures and product batch seizures for issues deemed critical for consumers' food safety. For potentially not-critical non-compliances, FBOs are required to implement corrective actions.

2.3. Data collection

In Italy, the reporting of official controls, including inspections and audits, is regulated by an agreement between the State, the Regions, and

the Autonomous Provinces. According to this agreement, data must be submitted by the end of February each year (Italian Republic, 2016). Data were collected annually by the local CA for each operational district and organized into spreadsheets. These were then sent via email to the regional CA, which standardized the data before forwarding them to the Ministry of Health.

For the purposes of this study, data were evaluated for the period 2020–2024. The analysis focused exclusively on establishments involved in the processing of food of animal origin.

2.4. Questionnaire

To better understand and analyze the challenges encountered by inspectors in the implementation of official control activities, a structured questionnaire-based survey was conducted. A preliminary version of the questionnaire was pilot-tested with three OV's to assess the clarity and comprehensibility of the questions. Based on their feedback, the final version of the questionnaire was revised and made available online (Appendix A). It was then distributed via email to all OV's involved in food control activities in the Emilia-Romagna Region. Respondents were given two weeks to complete the questionnaire. After this period, a reminder was sent and the response window was extended to increase participation. Participation was voluntary and anonymous, and confidentiality of responses was ensured. Informed consent was obtained in advance, with participants being provided with detailed information about the study objectives and the aggregated use of the data. The questionnaire was divided into five sections and included multiple-choice, open-ended, and Likert-scale (Jamieson, 2004) questions covering the following areas: i) professional characteristics (e.g., types of establishments monitored, nature of activities, staff rotation, time allocation for controls); ii) training and information (e.g., perceived adequacy of objectives, criteria, and procedures); iii) effectiveness and resources (e.g., evaluation of inspection/audit effectiveness, adequacy of resources, clarity of manuals and checklists); iv) improvements and suggestions (e.g., proposals for improvement, balance between inspection and audit activities); v) demographic and professional information (e.g., age, seniority, operational district). Participants were encouraged to respond to all questions to ensure a comprehensive collection of perspectives on the official control system. Contingency tables were constructed to analyze the effect of seniority on the judgments expressed in the questionnaire responses. It is important to clarify that, under Italian legislation, OV's are required to obtain a national specialization, which includes approximately 3150 h of practical training. They also participate in the Regional Programme of Continuing Education in Veterinary Medicine, and their had comparable roles across the veterinary public services of the Emilia-Romagna Region. Consequently, in this context, the concept of "seniority" primarily reflects the officers' familiarity with the internal organization of professional duties.

2.5. Data analysis and Calculation of the Complaint Index (ComIn)

Inspections and audits addressed the same areas of investigation, albeit with differing objectives and frequencies. To assess the frequency of non-compliances, we calculated the proportion of non-compliant findings for each investigation area and overall, along with their corresponding 95 % confidence intervals (CIs). The CIs were derived using the binomial distribution (binom.test function), reflecting the proportion of non-compliances relative to the total number of verifications. Differences in questionnaire responses across seniority groups were assessed for each categorical variable using the Fisher's exact test (fisher.test function). The graphs were generated using the ggplot2 package (Wickham, 2016). All statistical analyses were conducted using R software (version 4.3.0).

In order to assess whether the relationship between control frequency and the detection of non-compliances across the various investigation areas is appropriately balanced, a Complaint Index (ComIn) was

calculated using the model proposed by Lueckl et al. (2019). The ComIn model enables the establishment of dynamic alert thresholds and the implementation of early warning systems based on observed trends.

ComIn = rate of non-compliances [%] – control rate [%]

Where.

- For each production activity, the rate of non-compliances is defined as the ratio between the number of non-compliances recorded in that specific activity and the total number of non-compliances identified across all production sectors.
- The control rate is calculated as the ratio between the total number of inspections conducted in a specific production activity and the total number of inspections carried out across all sectors.

Accordingly, a positive ComIn value indicates the need for corrective actions or increased monitoring to ensure compliance with regulatory standards. Conversely, a negative ComIn value suggests that the frequency of controls may have exceeded what is necessary, given the low proportion of products, processes, or services failing to meet the established standards or legal requirements.

3. Results

3.1. Non-compliances identified during inspections and audits

Between January 2020 and December 2024, a total of 582,833 official verifications, including inspections and audits, were conducted in establishments involved in the production and processing of food of animal origin. In total, 14,287 production activities were assessed through inspections and 2418 through audits (Table 1). The number of non-compliances recorded was 12,237 (2.3 %) in inspection reports and 1956 (4.6 %) in audit reports (Fig. 1, Table 2). The graphical representation illustrates the relationship between the number of verifications performed and the frequency of non-compliances detected.

Although the same IAs were assessed, notable differences in the frequency of non-compliances emerged between inspections and audits (2.3 % vs. 4.6 %). However, these discrepancies were not uniformly distributed across all production activities. In several sectors, audits revealed a significantly higher incidence of non-compliances compared to inspections. For instance, this was observed in: repackaging centres (2.6 % vs. 5.2 %); slaughterhouses for domestic ungulates (1.6 % vs. 5.2 %) and poultry (2.6 % vs. 8.5 %); red meat cutting plants (2.7 % vs. 4.4 %) and game meat facilities (1.3–1.5 % vs. 9.5–7.7 %); meat preparation plants (2.6 % vs. 3.8 %) and processed meat product facilities (2.0 % vs. 7.2 %); live bivalve mollusk purification centres (2.0 % vs. 4.4 %). In the dairy sector, audits also identified a higher frequency of non-compliances, with rates of 5.7 % in cheese and dairy product plants compared to 2.8 % during inspections, and 4.5 % in cheese aging facilities versus 1.3 % in inspections.

Conversely, inspections revealed a greater incidence of non-compliances in milk heat-treatment plants (2.7 % vs. 0.3 %). Similar patterns were observed in: egg shelling facilities (1.5 % vs. 12.5 %);

animal fat processing plants (0.2 % vs. 7.6 %); casings processing plants (2.8 % vs. 7.0 %).

3.2. Analysis of non-compliances by investigation area (IA)

A detailed analysis of the findings recorded across the various Investigation Areas (IAs) during audits and inspections is summarized in Figs. 2 and 3 respectively. Comparing the non-compliances identified for each IA and production activity provides insight into the most frequently encountered issues and allows for hypotheses regarding the factors that may have prompted increased scrutiny during audits.

The highest frequencies of non-compliances observed during audits were related to: the adequacy of HACCP plans (19.4 %); cleaning and sanitation programs (9.8 %); pest control (7.1 %); adequacy of structures and equipment (6.2 %); implementation of HACCP plans (4.1 %), and staff training (4.0 %) (Fig. 2).

All of these findings resulted in formal prescriptions aimed at improving procedures and production conditions. Administrative sanctions were issued in only five cases involving dairy product processing facilities and in one case involving a meat product establishment.

Regarding inspection-based controls, the most frequent non-compliances were associated with: structural and equipment conditions (5.3 %); HACCP plans (4.3 %); cleaning and sanitation (3.4 %); pest control (3.3 %); staff training (2.4 %), and personnel and processing hygiene (2.0 %) (Fig. 3).

3.3. Critical non-compliances and temporal trends

A focused analysis of non-compliances classified as critical for food safety is presented in Table S2. Significant irregularities were identified in relation to the structural and equipment conditions of slaughterhouses for domestic ungulates, red meat cutting plants, game meat processing facilities, meat product manufacturing plants, dairy production establishments, fishery product facilities, repackaging centres, and cold storage warehouses. In dairy processing establishments, major issues were observed concerning the condition of raw materials and semi-finished products, traceability, and cleaning and sanitation practices. Poor storage conditions for raw and semi-finished products, along with inadequate pest control, were also reported in slaughterhouses for both domestic ungulates and poultry. These inspections resulted in 151 administrative sanctions, 89 legal referrals to judicial authorities, and 55 product seizures. In contrast, audits led to only 6 administrative sanctions (Table 3). A temporal analysis of the frequency of critical non-compliances provides insight into the effectiveness of CA-issued prescriptions and the corrective actions implemented by FBOs. Fig. S2 presents data for two key IAs: i) structure and equipment, and ii) raw materials and semi-finished products. An exception was noted in 2020, with a significantly lower frequency of non-compliances, likely due to operational restrictions imposed during the COVID-19 pandemic. In subsequent years, particularly in 2023 and 2024, improvements were observed, with a reduction in non-compliance rates compared to the previous biennium. However, in 2023, an increase in irregularities was recorded in dairy product establishments (IX/PP) concerning structural

Table 1

Inspections and audits carried out by the official veterinarians in production activities that handle food of animal origin in the Emilia-Romagna Region (2020–2024).

Years	Inspections				Audits			
	Activities (%)	Verifications	Non-compliances ^a	% (95 % CI)	Activities (%)	Verifications	Non-compliances ^a	% (95 % CI)
2020	2796 (94.4)	107,919	1864	1.7 (1.6–1.8)	364 (12.3)	6927	261	3.8 (3.3–4.2)
2021	2893 (96.0)	122,033	2853	2.3 (2.2–2.4)	578 (19.0)	11,337	540	4.8 (4.4–5.2)
2022	2934 (94.5)	109,610	2629	2.4 (2.3–2.5)	506 (16.3)	7170	379	5.3 (4.8–5.8)
2023	2861 (91.4)	105,137	2563	2.4 (2.3–2.5)	499 (15.9)	8273	440	5.3 (4.8–5.8)
2024	2803 (89.8)	95,699	2328	2.4 (2.3–2.5)	471 (15.1)	8728	336	3.8 (3.4–4.3)
Total	14,287 (93.2)	540,398	12,237	2.3 (2.2–2.3)	2418 (15.8)	42,435	1956	4.6 (4.4–4.8)

^a Sum of the non-compliances potentially not-critical and critical for consumers' food safety.

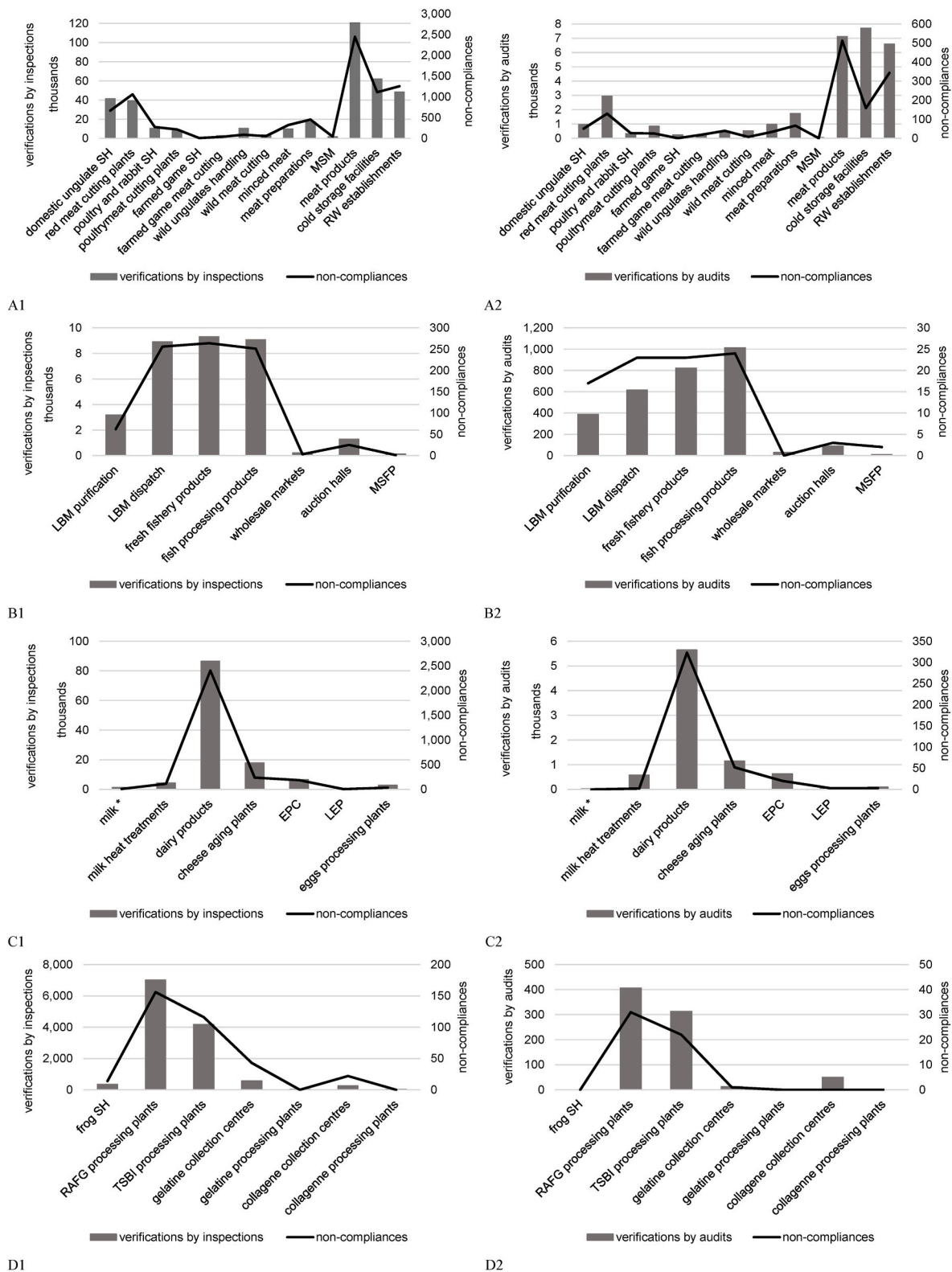


Fig. 1. Non-compliances detected during inspections and audits carried out by official veterinarians (2020–2024). The graphs illustrate the results of the checks carried out during inspections (A1, B1, C1, D1) and audits (A2, B2, C2, D2), and the respective non-compliances found in the respective production activities. EPC = egg packing centres; LBM = live bivalve molluscs; LEP = liquid egg plants; MSFP = mechanically separated fishery products; MSM = mechanically separated meat; RAFG = rendered animal fats and greaves; RW = re-wrapping and re-packaging establishment; SH = slaughterhouses; TSBI = treated stomach, bladders and intestines; * collection and standardization.

Table 2
Inspections and audits carried out by the official veterinarians in sections/production activities that handle food of animal origin (2020–2024).

Section	Activities ^a	Risk category ^b	Inspections			Audits		
			Verifications	Non-compliances ^c	% (95 % CI)	Verifications	Non-compliances ^c	% (95 % CI)
0	Cold storage facilities	M/L	61,980	1112	1.8 (1.7–1.9)	7701	158	2.0 (1.7–2.4)
	Re-wrapping and re-packaging establishments	H/M	48,284	1254	2.6 (2.5–2.7)	6579	343	5.2 (4.7–5.8)
I	Slaughterhouses	H	41,322	668	1.6 (1.5–1.7)	962	50	5.2 (3.9–6.8)
	Cutting plants	H	39,101	1059	2.7 (2.5–2.9)	2942	129	4.4 (3.7–5.2)
II	Slaughterhouses	H	10,393	274	2.6 (2.3–3.0)	319	27	8.5 (5.6–12.1)
	Cutting plants	H	8172	215	2.6 (2.3–3.0)	834	25	3.0 (1.9–4.4)
III	Slaughterhouses	H	1261	8	0.6 (0.3–1.2)	229	0	0.0 (0.0–1.6)
	Cutting plants	H	2753	35	1.3 (0.9–1.8)	189	18	9.5 (5.7–14.6)
IV	Cutting plants	H	3508	54	1.5 (1.2–2.0)	508	39	7.7 (5.5–10.3)
	Game-handling establishments	H	10,409	88	0.8 (0.7–1.0)	450	7	15.5 (6.3–31.8)
V	Minced meat establishments	H	9730	320	3.3 (2.9–3.7)	965	33	3.4 (2.4–4.8)
	Meat preparation establishments	H	17,121	452	2.6 (2.4–2.9)	1732	66	3.8 (3.0–4.8)
	MSM establishments	H	1589	41	2.6 (1.9–3.5)	38	0	0.0 (0.0–9.2)
VI	Processing plants	H/M/L	120,580	2447	2.0 (2.0–2.1)	7119	512	7.2 (6.6–7.8)
VII	Purification centres	H	3176	62	2.0 (1.5–2.5)	387	17	4.4 (2.6–6.9)
	Dispatch centres	H/M	8901	256	2.9 (2.5–3.2)	615	23	3.7 (2.4–5.6)
VIII	Fresh fishery products plants	H/M	9301	264	2.8 (2.5–3.2)	822	23	2.8 (1.8–4.2)
	Processing plants	H	9060	251	2.8 (2.4–3.1)	1013	24	2.4 (1.5–3.5)
	Wholesale markets	M	216	3	1.4 (0.3–4.0)	29	0	0.0 (0.0–11.9)
	Auction halls	M	1281	25	1.9 (1.3–2.9)	88	3	3.4 (0.7–9.6)
	MSFP	M	116	1	0.9 (0.0–4.7)	8	2	25 (3.2–65.1)
IX	Collection centres	L	1305	9	0.7 (0.3–1.3)	19	0	0.0 (0.0–17.6)
	Standardization centres	L	31	0	0.0 (0.0–11.0)	0	0	–
	Heat treatment plants	H	4267	114	2.7 (2.2–3.2)	574	2	0.3 (0.0–1.2)
	Processing plants	H/M	86,451	2406	2.8 (2.7–2.9)	5642	323	5.7 (5.1–6.4)
	Cheese aging plants	L	17,886	239	1.3 (1.1–1.5)	1146	52	4.5 (3.4–5.9)
X	Packing centres	L	6624	188	2.8 (2.5–3.3)	630	20	3.2 (1.9–4.9)
	Liquid egg plants	M	393	6	1.5 (0.6–3.3)	24	3	12.5 (2.7–32.4)
	Processing plants	M	2786	35	1.3 (0.9–1.7)	90	3	3.3 (0.7–9.4)
XI	Slaughterhouses	H	342	14	0.4 (0.2–0.7)	0	0	–
XII	Processing plants	L	7011	156	0.2 (0.2–0.3)	406	31	7.6 (5.2–10.7)
XIII	Processing plants	L	4167	116	2.8 (2.3–3.3)	313	22	7.0 (4.5–10.4)
XIV	Collection centres	L	572	43	7.5 (5.5–10.0)	12	1	8.3 (0.2–38.5)
	Processing plants	L	30	0	0.0 (0.0–11.6)	0	0	–
XV	Collection centres	L	249	22	8.8 (5.6–13.0)	50	0	0.0 (0.0–7.1)
	Processing plants	L	30	0	0.0 (0.0–11.6)	0	0	–
Total			540,398	12,237	2.3 (2.2–2.3)	42,435	1956	4.6 (4.4–4.8)

^a Mechanically separated meat; Mechanically separated fishery products.

^b High, Medium, Low.

^c Sum of the non-compliances potentially not-critical and critical for consumers' food safety.

and equipment conditions. This production sector had shown a temporary improvement in non-compliances related to raw materials and semi-finished products in 2022, highlighting a lack of consistent and effective interventions.

3.4. Analysis of survey responses

Fig. S3 presents the responses from 82 of the 154 OVs invited to participate in the study, representing a 53.2 % response rate among those involved in food control activities in the Emilia-Romagna Region.

The distribution of OVs across districts is uneven (Table 4). Romagna has the highest number, with 47 professionals (31 % of the regional total), 22 of whom responded to the survey (27 % of respondents). Modena and Parma follow, accounting for 21 % and 19 % of OVs, and 17 % and 16 % of respondents, respectively. At the other end, Imola has just 2 OVs (1 %), both of whom responded, while Ferrara has 8 (5 %), with 6 participants. Bologna and Reggio Emilia, representing 11 % and 10 % of OVs, contributed 10 % and 13 % of responses. Piacenza, with 6 % of OVs, had a comparable response rate: 6 out of 9 veterinarians (7 %).

Overall, the control system developed by a regional working group (Italian Republic, 2012b) and implemented since 2012 received a generally positive evaluation, although several critical issues were identified. A notable proportion of respondents expressed the need for enhanced training on the objectives, criteria, and procedures for

conducting inspections and audits (Q9, 20.0 %), indicating that the mandatory qualification courses organized by the regional CA were perceived as insufficient (Q10, 24.0 %; Q11, 85.0 %). The overall assessment of current inspection and audit procedures suggested the need for adjustments (Q12, 23.0 %; Q13, 20.0 %), and a majority of respondents supported the use of separate checklists for inspections and audits (Q17, 57.0 %). Responses to Q23 highlighted three main areas for improvement: i) inspection and audit procedures (42.6 %); ii) training (24.1 %); and iii) increasing the number of inspectors (33.3 %). According to Q24, while current procedures were generally considered clear (46.0 %), respondents emphasized the need for greater understanding of FBOs' own-check systems (16.0 %) and for more effective evaluation of corrective actions taken to address non-compliances (24.0 %). A significant concern raised by OVs was the perceived inadequacy of time resources, which hindered the proper execution of inspection procedures (Q26, 67.0 %). Additionally, some respondents reported experiencing pressure from FBOs (Q19, 9.0 %). Many OVs had already participated regularly in audit activities (Q20, 67.0 %) and recognized their value (Q14, 33.0 %). However, inspections were often reported as challenging due to: lack of cooperation from FBOs (Q21a, 87.0 %); regulatory complexity (Q21b, 65.0 %); external emotional pressures (Q21c, 56.0 %); and insufficient technological resources (Q21d, 61.0 %). Similar challenges were reported for audits, with comparable response rates: Q22b (lack of cooperation, 89.0 %); Q22c (regulatory complexity,



Fig. 2. Heatmap of non-compliances identified during audits carried out by official veterinarians (2020–2024). The figure illustrates the distribution of non-compliances across different production activities involving food of animal origin (y-axis), categorized by investigation areas (x-axis). Color intensity indicates the frequency of non-compliances observed. White cells denote investigation areas where no audits were conducted. Investigation areas are coded as follows: 1 = Registration and approval; 2 = Structure and equipment; 3 = Cleaning and sanitation condition; 4 = Pre-operative/operative cleaning/sanitization conditions; 5 = Personal hygiene and workplaces; 6 = Training; 7 = Pests; 8 = Animal by-products, waste and water supply; 9 = Traceability, withdrawal, recall; 10 = Storage and transport; 11 = Raw materials, semi-finished products; 12 = Finished product and labelling; 13 = Own-check plan/HACCP; 14 = Own-check plan/HACCP implementation.

65.0 %); Q22d (emotional pressure, 88.0 %); and Q22e (technological limitations, 67.0 %).

A significant association was observed between seniority and the scores assigned to Q8 (workload), Q9 and Q11 (training on inspection and audit protocols), and Q20 (participation as a member of audit teams) (Fig. 4 and Table S5). Regarding the timeline assigned to complete checks for each production activity, perceived adequacy increases with seniority, with the highest perception of unreasonableness among OV's with 5–15 years of experience. In the analysis of confidence in training on inspection objectives and procedures across seniority groups, the most experienced group (>26 years) consistently reports higher confidence, significantly more than all other groups. The least experienced group (<5 years) is significantly more likely to rate training as marginally or almost adequate, and less likely to rate it as fully adequate. The transition from 5 to 15 to 16–25 years also shows significant improvements in perceived adequacy, especially in the “marginally adequate” and “adequate” categories. The least experienced group (<5 years) and the 5–15 years group show a strong consensus on the necessity of further theoretical and practical training at the company level for conducting inspections and audits (≈74 %), while the 16–25 years group presents a more balanced view, with a notable portion (33 %) indicating training is “almost necessary”. The most experienced group (>26 years) shows the least perceived need, with 31 % considering training “unnecessary” and only 37.5 % rating it as “necessary”. Regarding participation in audit teams, the <5 years group differs significantly from all others, especially in the “never” category, indicating lower participation. The >26 years group shows very high frequent participation, with statistically significant differences

compared to less experienced groups. The 16–25 years group shows more variability, with some rare participation, distinguishing it from both less and more experienced groups.

3.5. Complaint Index (ComIn) analysis

Figs. 5 and 6 summarizes the Investigation Areas (IAs) and productive activities where adjustments in inspection and audits frequencies are recommended, based on ComIn values from Table S3 and S4. Full details are available in the supplementary materials. For inspections, higher frequencies are recommended for: IA 9 (traceability, withdrawal, recall) in re-wrapping and re-packaging establishments; IA 6 (training) in poultry and rabbit slaughterhouses; IA 12 (finished product and labelling) in meat preparation; IA 13 (own-check plan/HACCP) in meat products; IA 11 (raw materials, semi-finished products) in live bivalve mollusk dispatch; and IAs 1, 2, 3, 5, 7, and 11 in dairy products.

For audits, increased attention is needed for: IA 4, 9, and 12 in re-wrapping and re-packaging establishments; IA 6 in domestic ungulate slaughterhouses, and poultrymeat cutting plants; IA 10 (storage and transport) in meat preparation; IA 2, 5, 7, and 11 in dairy products; IA 1 (registration and approval) in cheese aging plants, and nearly all IAs (12 out of 14) in meat product. Conversely, over-control (ComIn > -5 %) was noted for: IAs 9, 11, and 12 in domestic ungulate slaughterhouses; IAs 11 and 14 in meat product facilities; IAs 4, 10 and 13 in dairy products, and nearly all IAs (13 out of 14) in cold storage facilities.

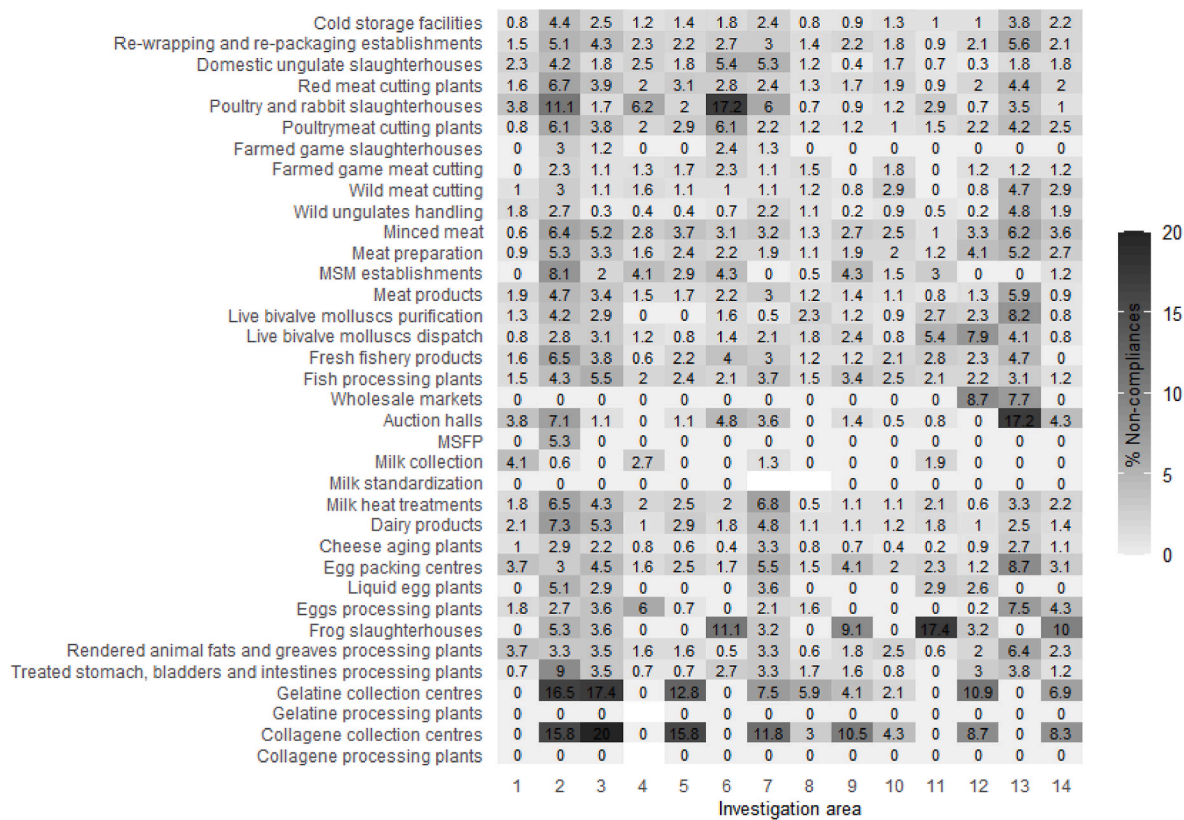


Fig. 3. Heatmap of non-compliances identified during inspections carried out by official veterinarians (2020–2024). The figure illustrates the distribution of non-compliances across different production activities involving food of animal origin (y-axis), categorized by investigation areas (x-axis). Color intensity indicates the frequency of non-compliances observed. White cells denote investigation areas where no inspections were conducted. Investigation areas are coded as follows: 1 = Registration and approval; 2 = Structure and equipment; 3 = Cleaning and sanitation condition; 4 = Pre-operative/operative cleaning/sanitization conditions; 5 = Personal hygiene and workplaces; 6 = Training; 7 = Pests; 8 = Animal by-products, waste and water supply; 9 = Traceability, withdrawal, recall; 10 = Storage and transport; 11 = Raw materials, semi-finished products; 12 = Finished product and labelling; 13 = Own-check plan/HACCP; 14 = Own-check plan/HACCP implementation.

4. Discussion

Non-compliances identified through official controls reflect failures of products, processes, or systems to meet legal requirements or established standards. These are typically classified by severity: minor non-compliances, such as labelling inaccuracies or incomplete documentation, require corrective attention but do not trigger regulatory action; major non-compliances, including inadequate process controls or hygiene deficiencies, necessitate timely corrective measures; critical non-compliances, such as the presence of pathogens or serious regulatory violations, pose direct threats to food safety and legal compliance.

The study found that audits identified a higher rate of non-compliances (4.6 %) than inspections (2.3 %), especially in sectors like poultry slaughterhouses and meat product processing. However, these audit-detected non-compliances rarely led to serious consequences, only a few administrative sanctions were issued, and no legal actions or product seizures occurred. In contrast, inspections, though detecting fewer non-compliances overall, were more effective in certain sectors (e.g., milk heat-treatment, egg shelling, animal fat, and casings processing). Among over 540,000 inspection reports, only a small number led to judicial referrals (89), administrative sanctions (151), or product seizures (55) mostly related to microbiological hazards in bivalve mollusks and meat products.

Although audits provide a comprehensive evaluation of FBOs management systems and their adherence to quality assurance principles, their limited frequency often constrains their effectiveness in addressing product-specific food safety risks. Typically, pre-scheduled in coordination with FBOs, audits are primarily designed to assess the adequacy

of hazard control measures and the overall robustness of internal food safety systems. While this structured and collaborative approach is valuable for evaluating systemic compliance and documentation-related issues, it may limit the capacity of audits to detect immediate or situational deficiencies. In contrast, inspections, often unannounced and operationally focused, are better suited to identifying real-time non-compliances, such as hygiene lapses or procedural inconsistencies. By offering a “snapshot” of current conditions, inspections emphasize the physical state of facilities, equipment, and employee practices at the time of the visit, enabling the detection of immediate hazards.

Several factors influence the effectiveness of inspections, including inspection history, frequency, and whether the inspection is pre-announced. Kosola et al. (2022) found that severe non-compliances were 2.4 times more likely to be identified during unannounced inspections compared to pre-announced ones. Their study also revealed that minor non-compliances often precede more serious violations - facilities with minor issues in previous inspections had a 16.8 % non-compliance rate in subsequent visits, compared to 5.3 % for those previously in full compliance. These findings underscore the importance of addressing even minor infractions promptly. Moreover, reduced inspection frequency has been associated with declining inspection scores, highlighting the need for consistent oversight. Human factors also play a critical role in inspection outcomes. Ibanez and Toffel (2019) estimated that mitigating inspector biases, such as fatigue or the influence of prior inspection outcomes, could lead to the detection of approximately 11 % more violations annually across the United States.

These findings are consistent with those of Turku et al. (2018), who reported that inspections are more effective in identifying immediate

Table 3
Measures adopted during inspections and audits by the official veterinarians (2020–2024).

Section	Activities ^a	Inspections			Audits ^b
		Administrative sanctions	Judicial authority reports ^{>}	Seizures	Administrative sanctions
0	Cold storage facilities	16		8	
	Re-wrapping and re-packaging establishments	9	1		
I	Slaughterhouses	43		9	
	Cutting plants	14		3	
II	Slaughterhouses	14	2	4	
	Cutting plants		1		
III	Slaughterhouses				
	Cutting plants				
IV	Game-handling establishments	1		1	
	Cutting plants				
V	Minced meat establishments	2			
	Meat preparation establishments	5	3	2	
	MSM establishments				
VI	Processing plants	17	10	10	1
	Purification centres		12	3	
VII	Dispatch centres	3	56		
	Fresh fishery products plants	1		1	
VIII	Processing plants	2		1	
	Wholesale markets			1	
	Auction halls				
IX	MSFP				
	Collection centres				
X	Standardization centres				
	Heat treatment plants				
	Processing plants	20	4	10	5
XI	Cheese aging plants			1	
	Packing centres	3			
XII	Liquid egg plants				
	Processing plants				
XIII	Slaughterhouses				
	Processing plants	1			
XIV	Processing plants			1	
	Collection centres				
XV	Processing plants				
	Collection centres				
Total	Processing plants				
		151	89	55	6

Fields left blank indicate a value of zero.

^a Mechanically separated meat; Mechanically separated fishery products.

^b No judicial authority reports and seizures were taken.

Table 4
Characteristics of official veterinarians (OVs) operating in the Emilia-Romagna Region who responded to the survey.

Local Health Units	OVs working district (n)	%	OVs respondents (n)	%
Bologna	11	7 %	8	10 %
Ferrara	8	5 %	6	7 %
Imola	2	1 %	2	2 %
Modena	33	21 %	14	17 %
Parma	29	19 %	13	16 %
Piacenza	9	6 %	6	7 %
Reggio Emilia	15	10 %	11	13 %
Romagna	47	31 %	22	27 %
Total	154	100 %	82	100 %

operational deficiencies (e.g., hygiene, maintenance), whereas audits are more adept at uncovering systemic weaknesses in management systems (e.g., HACCP implementation, product recall procedures). These differences stem from variations in methodology, duration, prior notification, and intended objectives.

Together, audits and inspections offer a comprehensive view of both the structural and functional dimensions of food safety compliance. An integrated and balanced approach that leverages the strengths of both methods is essential for ensuring the effectiveness and credibility of official food control systems. As Powell et al. (2013) argue, the effectiveness of both audits and inspections ultimately depends on whether

the findings are translated into timely and effective corrective actions.

A study on official controls in Finland demonstrated that the use of standardized checklists and reporting templates significantly enhances the consistency and effectiveness of these controls (Läikkö-Roto et al., 2015). The system currently employed in the Emilia-Romagna Region was generally well-received; however, the responses to the questionnaire administered to OVs involved in official controls, as analyzed in this study, highlight the need to revise and adapt the checklists used for conducting inspections and audits. While respondents emphasized the importance of maintaining a systemic approach that evaluates all IAs, they also pointed to specific areas requiring improvement. Respondents expressed the need for more in-depth training for inspectors operating across different production sectors. Attention was also drawn to the planning of control activities, particularly regarding the time required to carry out inspection tasks, which directly affects the efficiency of official controls. In this context, observations made by auditors from the European Commission's Food and Veterinary Office regarding official controls in dairy production establishments, though not specific to Emilia-Romagna, are particularly relevant (EC, 2022b). These observations highlighted inefficiencies in the official control system for milk and dairy product safety, partly due to staffing shortages and the ineffectiveness of procedures intended to enforce FBO compliance. Specific shortcomings were noted in areas such as own-check sampling, labelling, traceability, and the implementation of HACCP-based procedures. Similar concerns and shortcomings that could affect the efficiency of official controls were also reported in literature. A study conducted in

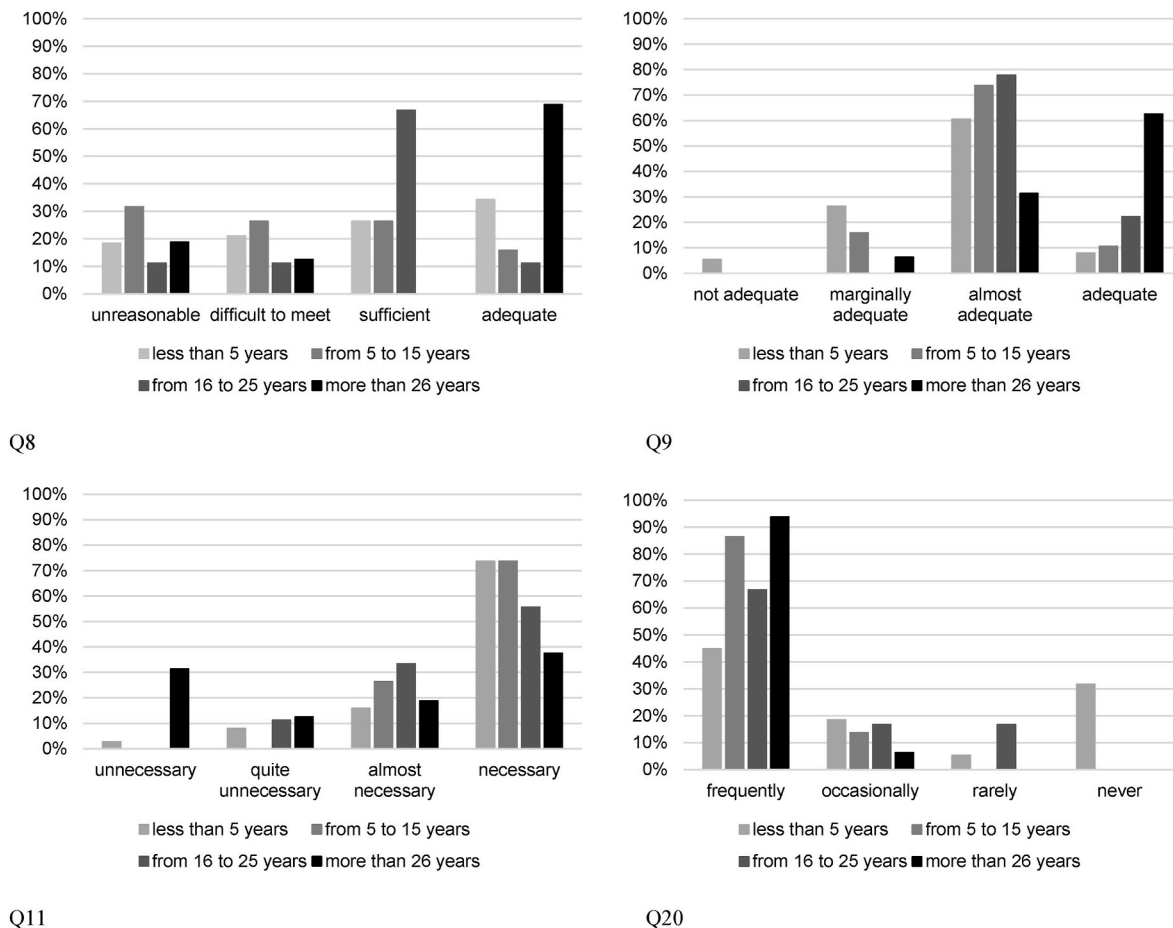


Fig. 4. Association between seniority and questionnaire responses among official veterinarians. Q8, timeline assigned to complete the checks in a production activity; Q9, confidence in training on inspection objectives and procedures; Q11, further theoretical and practical training required; Q20, participation as a member of audit teams.

Sweden found that establishments with a high frequency of non-compliances (FnC) exhibited a greater proportion of false negative non-compliances compared to those with lower FnC rates (Berking et al., 2019). Supervisors participating in the study noted that most false negatives occurred in control areas characterized by high FnC. This suggests that inspectors often failed to detect all instances of non-compliance in more complex domains, such as HACCP systems and food information and labelling, which are inherently more challenging to assess than simpler areas like personal hygiene and staff training. Berking et al. (2019) also identified insufficient experience among food control inspectors as a key factor contributing to false negative findings. The term “insufficient experience” needs clearer analysis. The 2023 research by (Gomes-Neves et al. 2023) revealed that Italian OVs identified universities as their main training source by 61.7 % which exceeded the general average of 18 %. OVs receive extensive training which covers multiple competencies including national and EU legislation knowledge as well as good manufacturing practices principles and quality management methods and auditing and compliance verification and data management and applied biostatistics. The training program includes supervised practical experience for OVs at abattoirs and cutting plants and farms. The National Veterinary Authority requires all officials to complete continuing education courses (ECM).

Inspections in complex settings need inspectors who understand production processes and process-specific hazards and have substantial practical experience to achieve effectiveness. The survey results from OVs in this study support these findings (e.g., Q23, Q24, Q26). The introduction of new inspection personnel leads to decreased quality and

effectiveness in official food control activities according to Lääkkö-Roto et al. (2015).

A plausible explanation of outcomes of our study would be instead that effective inspections in complex settings require inspectors to possess comprehensive knowledge of production processes, process-specific hazards, and substantial practical experience. These findings align with responses from OVs who participated in the present study’s questionnaire (e.g., Q23, Q24, Q26). Supporting this, Lääkkö-Roto et al. (2015) observed that the introduction of new inspection personnel may compromise the quality and effectiveness of official food control activities.

A recent Finnish study aimed at identifying recurring issues among FBOs who repeatedly violate food safety legislation highlighted critical shortcomings in areas such as own-check performance, food information accuracy, and the cleanliness of facilities, surfaces, and equipment (Kiviniemi et al., 2025). The analysis underscored the inadequacy of current control methods in preventing repeated non-compliances, pointing to a lack of awareness among FBOs regarding legal requirements and food hygiene risks. Moreover, one in five inspectors reported insufficient time to conduct thorough inspections and provide meaningful guidance to FBOs. In this context, it is important to consider inspectors’ perceptions of external pressures, both from FBOs and emotional stressors. OVs acknowledged that FBOs do not always fully implement their own own-check plans, often due to economic pressures and market dynamics. These include cost-driven decisions in the selection of raw material suppliers and labor, which may conflict with food safety objectives. Similarly, the analysis of non-compliances in the Emilia-Romagna Region identified staff training in production processes

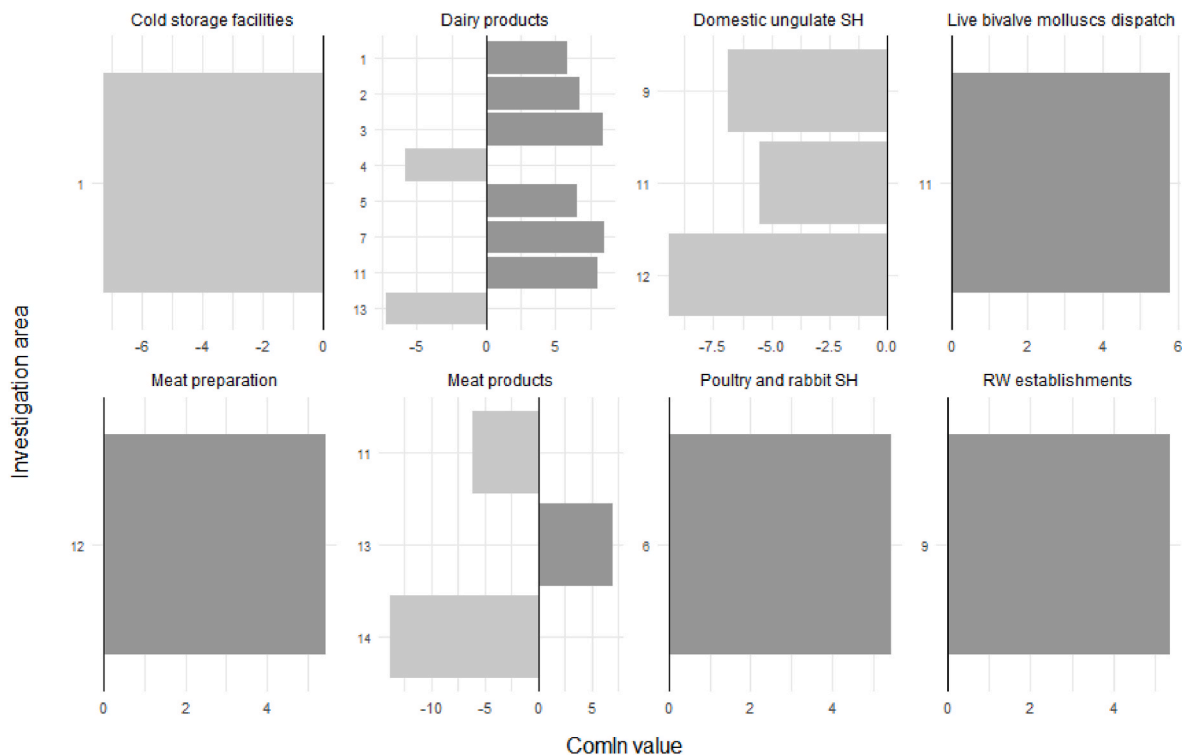


Fig. 5. Complaint Index (ComIn) for non-compliances identified during inspections across different production activities. The figure highlights the production activities and investigation areas where significantly positive or negative ComIn values were observed (thresholds $>5\%$ or $<-5\%$). Dark grey bars indicate areas with a positive ComIn, suggesting a need for increased control due to higher expected frequency of non-compliance. Light grey bars represent areas with a negative ComIn, potentially indicating over-control or excessive inspection relative to observed issues. Investigation areas are coded as follows: 1 = Registration and approval; 2 = Structure and equipment; 3 = Cleaning and sanitation condition; 4 = Pre-operative/operative cleaning/sanitization conditions; 5 = Personal hygiene and workplaces; 6 = Training; 7 = Pests; 8 = Animal by-products, waste and water supply; 9 = Traceability, withdrawal, recall; 10 = Storage and transport; 11 = Raw materials, semi-finished products; 12 = Finished product and labelling; 13 = Own-check plan/HACCP; 14 = Own-check plan/HACCP implementation.

as one of the most frequently cited issues. Notably, regional approaches to this matter vary considerably across Italy: while some regions issue only general guidelines, others provide detailed and prescriptive instructions (Pattono et al., 2023).

Considering all these factors, the quantitative data suggesting a higher overall incidence of non-compliances identified through audits compared to inspections is not consistently supported by the broader literature. Instead, the evidence points to a more nuanced relationship, in which audits and inspections demonstrate distinct strengths in detecting specific types of non-compliance, depending on contextual and methodological variables.

A recent study by Salines et al. (2023) surveyed 18 European countries to identify the criteria used to categorize slaughterhouses based on food safety risk. The findings revealed that only 14 countries systematically apply such categorization. Among the criteria considered, establishment size and production volume influence the frequency of microbiological testing, which may also increase due to international trade requirements. However, only 36 % of the surveyed CAs actually use microbiological testing results for risk categorization. Notably, none of the countries have yet integrated Harmonised Epidemiological Indicators (HEIs) into their risk categorization systems, despite recommendations from the European Food Safety Authority (EFSA). In Italy, all slaughterhouses are classified as high-risk, and the frequency of inspections and audits is determined by national regulations. This classification directly influences the number of OVs assigned to each local CA.

To improve the planning of official control activities and optimize inspector performance, the application of the ComIn indicator appears to be a valuable tool. Results from our analysis underscore the need to increase the frequency of audits in the meat products sector, where 12 out of 14 IAs analyzed exhibited positive ComIn values. Similarly, in the

dairy sector, the findings point to a need for more effective control measures, particularly in relation to infrastructure, hygiene practices, and raw material management. In contrast, cold storage facilities showed negative ComIn values across nearly all IAs, with the exception of the HACCP plan, suggesting that inspections in these establishments may have been conducted more frequently than warranted by the actual risk level. These findings support the utility of ComIn as a strategic tool for rationalizing inspection efforts, fostering a risk-based approach, and identifying areas where oversight should be intensified. Importantly, the data reveal that a high frequency of inspections does not necessarily align with the actual distribution of food safety risks. While ComIn has demonstrated its potential to identify production activities that may be either under- or over-inspected relative to their risk profile, certain limitations in its practical application must be acknowledged. To maximize its effectiveness, the indicator should ideally be used to compare non-compliance rates and inspection frequencies across similar production systems or facility types. This would allow for the identification of establishments requiring more frequent and targeted inspections to address persistent or systemic issues. However, such comparative analysis is currently hindered by the absence of a centralized information system capable of aggregating and integrating official control data from the various local CAs. At present, data collection remains fragmented and inconsistent across regions, limiting the ability to conduct comprehensive, system-wide evaluations. This represents a significant barrier to the practical implementation of a fully risk-based approach and underscores the need to develop information systems that enable effective management of official control data. In this regard, the experience of the city of Barcelona serves as a noteworthy example: the implementation of a digital system has been shown to significantly enhance inspection effectiveness, leading to a higher detection rate of

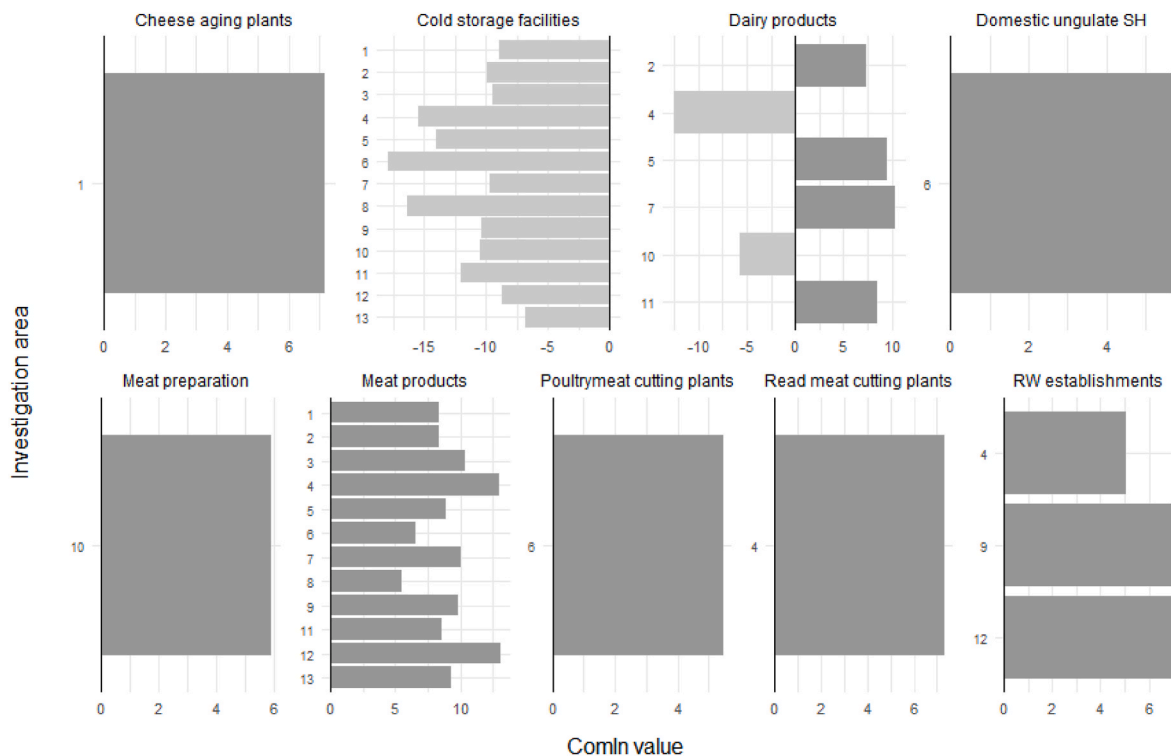


Fig. 6. Complaint Index (ComIn) for non-compliances identified during audits across different production activities. The figure highlights the production activities and investigation areas where significantly positive or negative ComIn values were observed (thresholds $>5\%$ or $<-5\%$). Dark grey bars indicate areas with a positive ComIn, suggesting a need for increased control due to higher expected frequency of non-compliance. Light grey bars represent areas with a negative ComIn, potentially indicating over-control or excessive inspection relative to observed issues. Investigation areas are coded as follows: 1 = Registration and approval; 2 = Structure and equipment; 3 = Cleaning and sanitation condition; 4 = Pre-operative/operative cleaning/sanitization conditions; 5 = Personal hygiene and workplaces; 6 = Training; 7 = Pests; 8 = Animal by-products, waste and water supply; 9 = Traceability, withdrawal, recall; 10 = Storage and transport; 11 = Raw materials, semi-finished products; 12 = Finished product and labelling; 13 = Own-check plan/HACCP; 14 = Own-check plan/HACCP implementation.

non-compliances compared to traditional methods (Grau-Noguer et al., 2024). In Italy, the Campania Region has made strides in this direction through the GISA portal, which ensures more effective and coordinated control across the entire agri-food supply chain. GISA integrates a wide range of functional modules, including the management of official controls, food alerts, slaughter operations, and both regional and local annual planning (Mandato et al., 2018).

The efficiency and effectiveness of controls, as well as the corrective measures adopted in response to non-compliances, are critical aspects that CAs must systematically evaluate. This is essential for optimizing human resource management and enhancing the capacity to promptly identify and address critical issues within production systems. It also facilitates collaborative interventions with FBOs to address root causes. In this context, the present study has made it possible to assess which IAs require increased control frequency and which appear to be subject to excessive oversight.

5. Conclusions

The study highlights a critical need for evolving official food safety controls from systematic approaches based on generic risk categories to more targeted, risk-based inspections. This transition should focus on specific risks identified within production sectors exhibiting significant issues.

While audits revealed a higher overall incidence of non-compliances compared to inspections, particularly in sectors like poultry slaughterhouses and meat processing facilities, these audit findings rarely resulted in serious enforcement actions such as administrative sanctions, legal actions, or product seizures. Conversely, inspections, though identifying fewer non-compliances overall, were more effective in

leading to enforcement actions, mostly related to critical food safety issues.

This suggests that inspections are more effective in identifying immediate operational issues (e.g., hygiene, maintenance), while audits are better suited for uncovering systemic weaknesses in management systems (e.g., HACCP implementation, product recall procedures). The effectiveness of both tools is influenced by their methodology, duration, and prior notification. Own-monitoring systems within food supply chains are inherently complex, requiring appropriate professional competencies from both FBOs and OVAs responsible for evaluating their performance. The survey of OVAs revealed a significant need for enhanced training on the objectives, criteria, and procedures for conducting inspections and audits, indicating that current mandatory qualification courses are perceived as insufficient. A significant concern among OVAs was the perceived inadequacy of time resources for conducting thorough inspections. Other challenges reported by OVAs included lack of cooperation from FBOs, regulatory complexity, external emotional pressures, and insufficient technological resources. The application of the ComIn proved to be a valuable tool for optimizing the planning of official control activities and allocating inspector resources. The study found that fragmented data systems across local CAs hinder comprehensive, system-wide evaluations and the implementation of a fully risk-based approach. Ultimately, the effectiveness of both audits and inspections depends on the findings being translated into timely and effective corrective actions by FBOs.

CRediT authorship contribution statement

Alfonso Rosamilia: Writing – original draft, Data curation, Conceptualization. **Maria Luisa Bartzak:** Formal analysis, Data

curation. **Claudia Travaglio**: Formal analysis, Data curation. **Silvia Vianello**: Formal analysis, Data curation. **Stefano Benedetti**: Investigation, Data curation. **Francesca Vergani**: Investigation, Data curation. **Marco Pierantoni**: Investigation, Data curation. **Antonio Poeta**: Investigation, Data curation. **Chiara Guarnieri**: Formal analysis, Data curation. **Daniele Fabbri**: Investigation, Data curation. **Giovanni Del'Orfano**: Investigation, Data curation. **Paolo Gandolfi**: Investigation, Data curation. **Giuseppe Diegoli**: Supervision, Project administration. **Anna Padovani**: Supervision, Project administration. **Marcello Trevisani**: Writing – original draft, Validation, Data curation, Conceptualization.

Data availability statement

Due to the sensitive or confidential nature of the information collected survey respondents were assured some data would remain confidential and would not be shared.

Ethics statement

The authors have no ethical statement to declare.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used Microsoft Copilot in Office 365 in order to check and edit the text to improve readability. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

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.

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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.2025.111686>.

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