frontiers in Animal Science

TYPE Original Research
PUBLISHED 18 February 2026
DOI 10.3389/fanim.2026.1688590

OPEN ACCESS

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RECEIVED 19 August 2025
REVISED 29 January 2026
ACCEPTED 29 January 2026
PUBLISHED 18 February 2026

CITATION
Berg C, Löfblad H, Eklund K and Gårdlund M (2026) Animal welfare infringements at slaughter in Sweden—a nationwide survey.
Front. Anim. Sci. 7:1688590.
doi: 10.3389/fanim.2026.1688590

Animal welfare infringements at slaughter in Sweden—a nationwide survey

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Introduction: Poor animal handling at slaughter not only affects animal welfare but also influences the meat quality and industry credibility. This paper presents the findings from a nationwide project initiated by the Swedish County Administrative Boards in 2022, which evaluated the compliance of slaughterhouses with animal welfare legislations. The main goals were to assess adherence to both EU and national regulations, identify common issues, improve inspection uniformity, and map the stunning methods used.

Methods: Animal welfare inspections at slaughter were carried out by the competent authorities. A standardised checklist covering 67 control points (32 administrative and 35 operational) was used. A total of 86 out of 129 registered slaughterhouses were inspected (21 large, 21 medium, and 44 small). During 2022, 102 inspections were conducted: 90 planned on-site and 12 follow-ups.

Results: Although the majority of the premises complied with majority of the control points, non-compliances were found in 84 out of 90 inspections. Many were related to administrative issues: 88% had incomplete standard operating procedures (SOPs) and 14% lacked at least one proper Certificate of Competence (CoC). Of the operational non-compliances, 8% were associated with handling issues, 27% to stunning equipment and procedures, and 13% to bleeding. Stunning-related non-compliance was found most often with electrical stunning, particularly among pigs (67%) and poultry (up to 43%). Small slaughterhouses had more administrative non-compliances, but better results on handling and bleeding compared with medium and large slaughterhouses. Stunning-related compliance was the lowest at small and large slaughterhouses and better at medium-sized slaughterhouses.

Discussion: Certain non-compliances may have directly influenced animal welfare in a negative manner. The results from this study could help national and international efforts to improve training and inspection focus and potentially revise legislations for greater clarity and enforceability. The size of this study and the similarities between the methods used in Sweden and in other countries render the findings relevant beyond Sweden, on a worldwide scale where similar practices and regulations apply.

KEYWORDS
abattoir, animal welfare, compliance, infringement, inspection, legislation, official control, slaughterhouse

Introduction

The time spent at the slaughterhouse constitutes only a very short period of an animal's life. Nevertheless, it is an immensely different environment compared to the farm, with a considerable number of animal welfare risks (Authie et al., 2013a, 2013, 2013, 2013; Grandin, 2010; Nicolaisen et al., 2023; Sundermann et al., 2023). Animal welfare at slaughter is important not just for the animals themselves but also important for consumers (Schneidewind et al., 2023), as proper animal handling and humane slaughter can be considered part of the societal contract that accepts the killing of animals for meat consumption, although the detailed perception of what is considered as humane may vary (Sinclair et al., 2023). It may also be considered important to the slaughterhouse personnel, who find animal welfare relevant for work satisfaction because they may feel sympathy toward the animals (Pastrana-Camacho et al., 2023), although their detailed knowledge of animal welfare regulations may be insufficient (Lipovšek et al., 2024). Studies show that factors such as species slaughtered, personnel gender, number of years working in the slaughter industry, and whether they have received training influence the attitude to animal welfare (Wigham et al., 2020) and, thus, the intention to comply with animal welfare legislations. In addition to this, there is a generally acknowledged association between the pre-slaughter handling of animals and the meat quality (Faucitano and Nannoni, 2023; Kittelsen et al., 2015; Malmfors and Wiklund, 1996; Ogun et al., 2022; Warriss, 1990), which illustrates why both slaughterhouse management and farmers may view animal welfare as important due to its link with the monetary outcome at slaughter. This encompasses anything from stress effects such as PSE (pale, soft, and exudative) in pigs or DFD (dark, firm, and dry) in cattle to unnecessary downgradings and rejections related to fractures, bruises, or other injuries that arise at lairage or at handling prior to stunning. Hence, good animal welfare is of high interest to the majority—if not all—of the involved parties. However, problems continue to be regularly reported by the media or the authorities, resulting in various types of sanctions (Schneidewind et al., 2023, 2024).

At the global level, the World Organisation for Animal Health (WOAH) has developed guidelines for animal welfare at slaughter (WOAH, 2024). Although not legally binding in relation to the individual slaughterhouse, the organisations' member states are obliged to incorporate these guidelines into their national legislation; thus, these standards are relevant in many countries (Abyaneh et al., 2020; Grandin, 2010). At the European Union (EU) level, the Council Regulation 1099/2009 (European Commission, 2009) is directly applicable to slaughterhouses in all member states and at slaughterhouses in non-EU countries that produce meat for export to the EU. In addition, all EU member states have been able to retain and apply stricter regulations at the national level, after a set formal procedure at the EU level (European Commission, 2009). Sweden is one of the countries that have done so, even if the main volume of the slaughter-related animal welfare legislation is EU-based. One example of the stricter legislation within Sweden is the total ban on slaughter without prior stunning (Djurskyddslag, 2018); another is the provision of detailed requirements related to maximum stocking density at slaughterhouse lairage (Jordbruksverket, 2019).

Food safety and the welfare of the animals at a slaughterhouse, from their arrival until death, are the responsibilities of food business operators (FBOs), i.e., the company running the facility (Conter et al., 2024; European Commission, 2009), which are inspected by the competent authorities (Berg and Axelsson, 2012; Guardone et al., 2020; Schott et al., 2016). The EU animal welfare legislation includes an article that requires all slaughterhouses, except for the smallest ones, to appoint a dedicated animal welfare officer (AWO) who is responsible for the routines within the FBO related to animal welfare, including communication with the competent authorities (European Commission, 2009). However, legislation per se does not necessarily guarantee good animal welfare. Economic factors may present challenges, and conflicts between official veterinarians and FBOs are viewed as a common barrier to improved animal welfare at slaughter (O'Connor and Gouveia, 2025).

Until the start of this project, there was insufficient knowledge available regarding animal welfare infringements at Swedish slaughterhouses. Furthermore, such nationwide and detailed surveys are nonexistent in many other countries, including various EU member states. The Swedish animal welfare inspections are generally carried out by the regional competent authorities. Although data from these slaughterhouse inspections may at least be partly digitalised, this information is not centrally processed beyond the point of information on the actual number of inspections carried out annually. Hence, there is only anecdotal information available on the status quo of compliance with the relevant regulations at slaughter. The 21 Swedish County Administrative Board's (CAB) National Animal Welfare Cooperation Group can decide to run the national focus project on a specific species or aspect of animal welfare. In 2021, a decision was made to dedicate the national project for 2022 to animal welfare at slaughter.

Certain aspects of animal welfare are difficult to regulate, whilst others are difficult to inspect, and unless there is a combined understanding of the requirements, a willingness to comply, and an efficient control system (Berg and Lundmark Hedman, 2020), risks may persist. Therefore, the industry organisations, the competent authorities, and the National Contact Point for Regulation 1099/2009 are continuously working with knowledge transfer and ongoing professional development around animal welfare at slaughter. Moreover, official veterinarians of the Swedish Food Agency (SFA) will perform daily inspections as part of their tasks, addressing both meat safety and animal welfare in accordance with EU requirements (Berg and Axelsson, 2012; Stärk et al., 2014) that cover both *ante-mortem* and *post-*

Abbreviations: AWO, Animal Welfare Officer, in accordance with EU Reg 1099/2009; CAB, County Administrative Board, i.e., the Swedish Regional Competent Authority; CoC, Certificate of Competence, in accordance with EU Reg 1099/2009; FBO, Food Business Operator, here usually referring to the slaughterhouse company; SOP, Standard Operating Procedures, in accordance with EU Reg 1099/2009; WOAH, World Organisation for Animal Health.

TABLE 1 Capacity classification used in this study (number of animals slaughtered per year) and proportion of inspections with at least one infringement.

Size	Definition	No. of establishments (n = 86)	No. of species-specific inspections, (n = 132)	Proportion of establishments with at least one animal welfare infringement recorded
Small	Red meat: <3,000 animals per species Poultry: <10,000 (excluded from the study)	44	72	98%
Medium	Red meat: 3,000–15,000 per species Poultry: 10,000–50,000	21	26	90%
Large	Red meat: >15,000 per species Poultry: >50,000	21	34	67%

mortem findings, originating from either the farm, transportation, or slaughterhouse. In addition, the CAB animal welfare inspectors, who predominantly focus on inspecting animal welfare on farms and for companion animals, will carry out revisions—which are more thorough—at the slaughterhouses, typically annually or once every 2 years for larger plants and less frequently for smaller ones (risk-based intervals).

After each animal welfare inspection, the CAB inspectors are expected to write a report in accordance with both the relevant EU regulation (European Commission, 2017) and the Swedish legislation (Jordbruksverket, 2022). In instances where severe non-compliances have been identified, or if the FBO has not voluntarily agreed to rectify relevant non-compliances, formal injunctions can be issued. Furthermore, infringements of the animal welfare legislation or court sentences for cruelty to animals can result in fines, corporate fines, or—in rare instances—prison sentences. To prevent future animal suffering, individuals can also be banned from keeping, owning, and handling animals (Djurskyddslag, 2018), which also applies to slaughterhouse owners and employees. However, a follow-up of such consequences was not included in this study. The aims of the project were to improve the uniformity of inspections, map the level of animal welfare compliance with national and EU legislations at slaughter, and to identify any areas potentially requiring an increased focus from the FBOs and the official control. Thus, this study was designed for the purpose of describing the current state of animal welfare legislative compliance at Swedish slaughterhouses. Our null hypothesis is that we would be unable to identify any infringements related to administrative requirements or identify any cases of infringements related to the handling, stunning, and bleeding of animals. Another null hypothesis is that we would not find any differences related to slaughterhouse capacity or any differences between stunning methods within species. We also aimed to map the stunning methods used at slaughterhouses of varying capacities that process different species and to raise awareness about both the legislation and animal welfare at slaughter among the Swedish slaughterhouses.

Knowledge about common infringements and animal welfare problems is a prerequisite for developing focused advice for slaughterhouse FBOs and for the risk classification made by the competent authorities, both of which aim to use the available resources wisely to improve animal welfare at slaughter. Similar issues have also been observed in other countries and regions; hence, these results are relevant within a wider context (Schneidewind et al., 2023, 2024). Furthermore, the results can indicate the need for national and EU legislations to be clarified and updated.

Materials and methods

Standardisation and coordination of inspectors' assessments

Before this project commenced, the CABs also had access to centrally developed checklists on the inspection of slaughterhouses, as is the case for many other types of animal premises. In addition to this, thorough assessment guidelines for the CAB official animal welfare inspectors (referred to below as 'inspectors') were developed before the data collection began, focusing on areas with a history of difficult assessments. The inspectors then gathered (partly digitally) for an introduction to the project and the assessment guidelines to be applied, as well as for a repetition of the standard inspection methodology for slaughterhouses. Prior to this, the project group had made pilot visits to a few slaughterhouses to test and evaluate the protocol and guidelines. Moreover, the national slaughterhouse FBOs' organisation and its members were provided with information about the project. Only slaughterhouses large enough to warrant official veterinary presence were included in the project, meaning that poultry slaughterhouses that slaughter less than 10,000 birds annually were excluded. The slaughterhouses included were classified as small, medium, or large (see Table 1).

The inspectors were asked to contact each slaughterhouse 1–2 weeks before the inspection, to liaise with the official veterinarians at the premises, and to receive a copy of the FBO's standard operating procedures (SOPs) in advance in order to facilitate the inspection. The inspections were then to be carried out as usual in accordance with the standard protocol (checklist) set by the Swedish Board of Agriculture (SBA), which covers all the animal welfare-related points as listed in the project from arrival until the animal has been declared dead, but excluding lairage (due to time constraints). The checklist covers 67 control points, 32 of which are related to documentation [such as SOPs, Certificates of Competence (CoCs), and recording of the stun parameters] whilst 35 cover practical on-site design and handling aspects (such as animal handling, equipment, stunning, and bleeding). For each control point, the slaughterhouse was categorised as 'compliant' or 'non-compliant', i.e., a dichotomous outcome. A copy of the official Swedish checklist for slaughterhouse inspections can be obtained

from the first author. The inspectors could write free-text comments when relevant. For the analyses in this paper, the control points were grouped into five main categories: SOPs, CoCs, handling (including driving), stunning (including restraint), and bleeding (including sticking/cutting and monitoring until the animal is dead).

Slaughterhouse inspections

All slaughterhouse inspections within the project were conducted in 2022. When possible, the inspections were carried out in the presence of the official veterinarian and the FBO's AWO. The dates of inspections (or follow-ups) were not pre-announced to the FBOs. All protocols and reports, including those from any follow-up inspections, were collected digitally by the project group and subsequently analysed. After each inspection, feedback on the results was provided to each individual slaughterhouse by the animal welfare inspectors, which would have occurred even without the involvement of the project.

The inspections were categorised as planned routine inspections, follow-up inspections on-site, or administrative follow-ups, where the FBO was asked to provide written statements, photographs, copies of purchase orders, or other indicators or proof of having corrected previously identified non-compliances. It was up to the individual inspector's discretion to decide whether to carry out a follow-up inspection or not based on how severe the inspector found the non-compliances (informally considered 'minor' or 'major'). After each inspection, the CAB inspectors wrote a report; in some cases, formal injunctions were issued, in the same manner as usual, regardless of this project. Later follow-ups of sanctions, court decisions, and consequences aside from injunctions were not included in this study.

The data were gathered on a regional level, and information about slaughterhouse location, species slaughtered, and inspection events were collected as described above. Based on the 67 control points in the checklist, the non-compliances were then grouped into five control categories (SOPs, CoCs, handling, stunning, and bleeding). For several analyses, the two first categories, i.e., SOPs and CoCs, were merged into the general category 'administrative', whilst the remaining three, i.e., the animal-related ones, were merged into the general category 'operational'.

Data analysis

The data were processed and analysed using MS Excel for Windows (2016). This study covers approximately two-thirds of the slaughterhouses in the country.

Before further analyses, two additional variables were created by clustering the non-compliance categories into two main clusters: administrative requirements (e.g., SOPs and CoCs) and operational requirements (e.g., handling, stunning, and bleeding). Statistical analyses were performed using SAS version 9.4 (SAS Institute, Inc., Cary, NC, USA). The statistical unit was one inspection. Differences in non-compliance between slaughterhouse capacity (small, medium, or large) (model 1) and between stunning methods (electrical, mechanical, or gas) within species (model 2) and the associations between administrative and operational non-compliances (model 3) were analysed with logistic regression using the GLIMMIX procedure using a logit link and a binomial distribution.

Model 1 included the fixed effect of slaughterhouse capacity, the random effect of species, and a random error effect, whilst model 2 included the fixed effect of stunning method and a random error effect. Model 3 included the fixed effect of administrative non-compliance, the fixed effect of slaughterhouse capacity, the random effect of species, and the random error effect. Outcomes from these models are presented in Supplementary Tables S1A-S3C.

P-values <0.05 were considered significant. *P*-values >0.05 but <0.1 were considered a statistical tendency.

The results are presented as proportions of inspections resulting in at least one non-compliance per control category and species. 'An inspection' was defined as one visit on a given date at one slaughterhouse covering one species. Hence, a slaughterhouse that processes two different animal species may have been recorded as having two inspections on the same day, if it was possible to inspect the slaughter of both species within the time frame of one working day.

Ethics statement

As the animals involved would have been inspected and slaughtered in the same manner regardless of this project, no extra interventions with the animals were made. Both the work carried out by the employees at the slaughterhouses and the inspection visits made by the animal welfare inspectors were part of their routine work and followed the standard protocols for the respective workplaces. This study did not fall within the criteria for requiring formal human or animal ethical permits. No personal data on natural persons were handled within this project, and it was established that no permit from the Swedish Ethical Review Authority was needed. Data have been stored and handled in line with the data management guidelines of the Swedish University of Agricultural Sciences.

Results

Number of inspections and general outcome

In total, 102 inspection visits were recorded. Of these, 90 were planned routine on-site inspections and 12 were follow-ups. If presented by species, a total of 132 species-specific inspections were performed (Table 2), as certain slaughterhouses processed more than one species. Slaughterhouses that met the inclusion criteria were located in 19 out of the 21 regions of the country, and all but one of the relevant CABs, i.e., 18 regional authorities, participated in the project. Out of the 129 slaughterhouses nationally registered, 86 (21 large, 21 medium, and 44 small) (see Table 1; Figure 1) received at least one inspection during the study period. In four cases, the same slaughterhouse received more than

TABLE 2 Number of inspections per species in this study, including follow-ups.

Cattle	Sheep	Pigs	Horses	Poultry	Reindeer	Other	Total
40	34	28	5	14	8	3	132

In some cases, the same slaughterhouse has processed several different species, resulting in more than one 'inspection' per slaughterhouse.

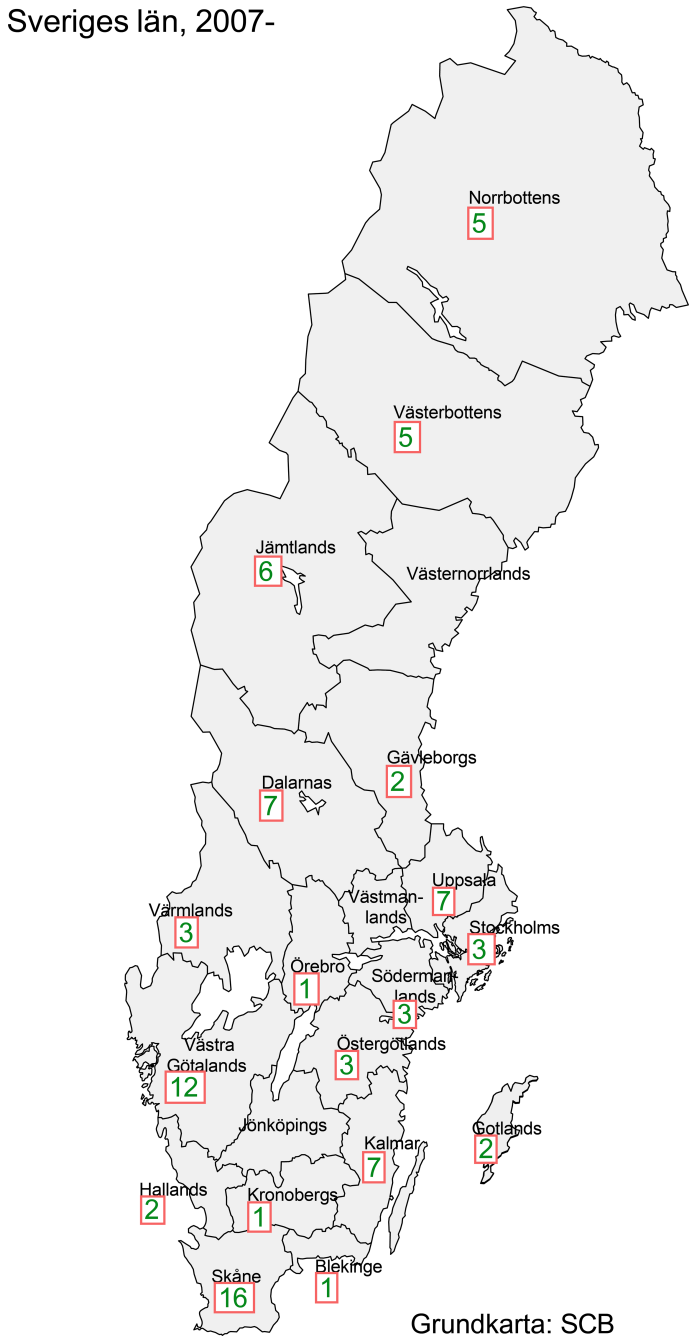

FIGURE 1
Map showing the geographical distribution of the 86 slaughterhouse establishments included in this study by county. Map source: SCB.

one planned routine visit due to the establishment slaughtering different species on different weekdays.

Of the 90 planned on-site routine inspections, non-compliances were identified at 84 for one or more species. There were 12 on-site follow-up inspections to ensure rectifications were carried out within the study period, and in 71 cases (including those 12 inspections), the slaughterhouses were followed up after the study period. In 13 cases, the non-compliances were considered minor by the inspector and did not require any formal follow-up. In four cases, the non-compliances led to the FBO receiving a formal injunction notice. Basic information concerning the covered species can be found in Table 2, where the category 'other' includes goats, American bison, and ostriches.

The majority of non-compliances detected at the routine inspection visits (n = 90) were related to administrative requirements, such as incomplete SOPs (88% of the inspections) or missing CoCs for employees working with live animals (14%). Non-compliances were also found in relation to animal-related operational aspects, such as handling (8% of the inspections), stunning (27%), and bleeding (13%).

For the SOPs, non-compliances—i.e., missing written descriptions and instructions—were often related to aspects of slaughter that are relatively rare, such as the SOPs for operational malfunction and disruptions, including the need to immediately euthanise animals in lairage or to service plans for heating and ventilation systems. However, at 57% of the inspections, the SOPs regarding how to stun the animals were found to be insufficient.

In certain cases of non-compliant CoCs, individuals without a CoC had been involved in handling live animals to only a minor extent (e.g., receiving animals from transport vehicles or shackling), whilst in other cases employees did not possess a CoC for the species or stunning method in question or completely lacked a CoC altogether.

When comparing the proportions of inspections that resulted in at least one operational non-compliance between inspections with or without simultaneous administrative non-compliances, the proportion of such operational non-compliance inspections was higher if administrative non-compliances were also identified (42% *vs.* 13%, p = 0.024).

Size and capacity of the slaughterhouses in relation to non-compliances

Overall, small slaughterhouses presented a higher proportion of non-compliances than both medium-sized and large slaughterhouses (Table 1; Figure 2). This was particularly notable for the administrative requirements, where large slaughterhouses exhibited a statistically significant lower proportion of non-compliances, mainly in relation to the SOP category.

Regarding the operational non-compliances, there were no significant differences between the different slaughterhouse capacities.

For stunning, however, there was a statistical tendency for medium-capacity slaughterhouses to demonstrate a lower proportion of non-compliances compared with the large and the small slaughterhouses (Figure 2).

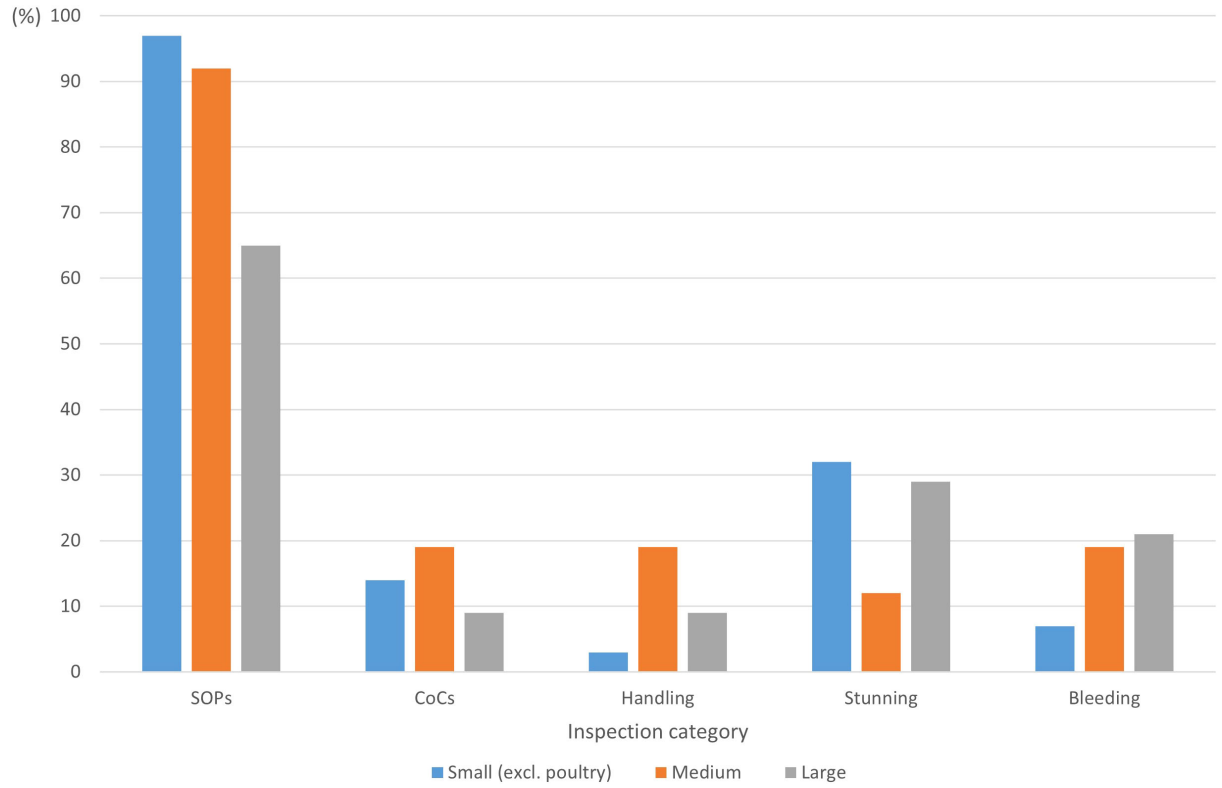

FIGURE 2
Proportion (percentage) of inspections identifying at least one non-compliance by category and capacity of slaughterhouse. Small (n = 44), medium (n = 21), and large (n = 21).

Stunning methods used

At poultry slaughterhouses, electrical water bath stunning was used during 10 out of 14 inspections (large slaughterhouses), whilst dry electrical stunning was used at three (medium-sized) slaughterhouses and carbon dioxide stunning at one (large) plant.

For sheep, 24 out of 34 inspections were made at slaughterhouses that process sheep using mechanical stunning (captive bolt gun), whilst the other 10 used electrical stunning as their primary stunning method. Mechanical stunning was more commonly used at small- and medium-sized slaughterhouses, whereas the majority of large slaughterhouses used electrical stunning.

For cattle, all 40 inspections were carried out at slaughterhouses that used mechanical stunning, which is the only legal method for stunning cattle in Sweden. A cartridge-powered penetrating captive bolt gun, a pneumatic-driven penetrating captive bolt gun, a safety rifle, or a hunting rifle can be used. To this end, a hunting rifle with a free bullet was used at 40% of the inspections, a safety rifle with a free bullet at 5%, a cartridge-powered captive bolt gun at 42%, and a pneumatic captive bolt gun at 13%. However, the use of pneumatic bolt guns was the most common method at large cattle slaughterhouses (56%), followed by cartridge-driven captive bolt guns (22%) and safety rifles (22%). For small slaughterhouses, hunting rifles were the most frequently used type of device (59%). Thus, the vast majority of the cattle were stunned using a captive bolt gun.

Regarding pigs, 9 out of 28 inspections were made at slaughterhouses that used mechanical stunning as their primary method (cartridge-driven captive bolt, except for two small establishments that used hunting rifles), nine used electrical stunning, and 10 used carbon dioxide stunning. For pigs, gas stunning was the predominant method at large slaughterhouses (used at 90% of these slaughterhouses), whilst gas and electrical stunning were used in equal proportions at medium-sized slaughterhouses, with electrical and mechanical stunning in equal proportions at small slaughterhouses. This means that, overall, the majority of the slaughtered pigs were stunned through carbon dioxide stunning.

For reindeer, mechanical stunning (pneumatic, 38% of the inspections) or cartridge-powered stunning (penetrating captive bolt gun, 62%) was used at all eight inspected premises.

At the five horse slaughterhouse inspections, hunting rifles were used at 60% (predominantly the smaller ones) and cartridge-powered penetrating captive bolt guns at 40%.

Categories of non-compliance by species

In this section, the term 'low' is used for percentages up to 33%, 'intermediate' for percentages ranging from 34% to 66%, and 'high' for percentages from 67% and above. The proportion of inspections with non-compliances related to SOPs was intermediate among poultry (57%) and the category 'other' (66%); high for cattle (88%), pigs (93%), and sheep (94%); and reached 100% for horse and reindeer slaughterhouses (Figure 3).

Similarly, the proportion of inspections with non-compliances related to CoCs was low for poultry (0%), 'other' (0%), sheep (13%), reindeer (13%), pigs (14%), and cattle (20%) and intermediate for horses (40%). Regarding driving/handling, e.g., rough handling or improper use of electric goads or other tools, the proportion of inspections with at least one reported non-compliance was 0% for poultry, horses, and 'other' and ranged from 7% for pigs, 8% for cattle, and 9% for sheep to 13% for reindeer.

The proportion of inspections that found at least one non-compliance related to the stunning process was low at the slaughter of cattle (18%), horses (20%), sheep (26%), pigs (32%), and 'other' (33%) and intermediate at the slaughter of reindeer (38%) and poultry (43%).

When bleeding was inspected, which involves the period from sticking/cutting until the animals are dead, no non-compliances were identified for horses (0%), whilst the proportion for pigs was 7%, for sheep was 12%, and for cattle and reindeer was 13%. Numerically higher proportions were reported for both poultry (29%) and the category 'other' (33%); both were still classified as 'low'.

Stunning methods and stunning-related non-compliances

The data were analysed with the proportion of inspections with non-compliances in relation to species and stunning method. Certain differences related to non-compliances at stunning were found between the different stunning methods (mechanical/electrical/gas) for the species where more than one method has been used at the slaughterhouses included in this study. There were also species-specific differences, which are presented below (Table 3). Given the limited number of slaughterhouses and the correlation between slaughterhouse size and the choice of stunning method, these figures should be interpreted with caution.

For cattle, horses, and reindeer, where mechanical stunning was the only method used, the corresponding figures for the proportions of inspections where stunning-related non-compliances were detected were 18% (n = 40), 20% (n = 5), and 38% (n = 8), respectively. Neither pneumatic captive bolt guns nor safety rifles were used at any cattle slaughterhouse inspections where non-compliances were identified in relation to stunning. In contrast, 24% of the inspections at slaughterhouses using cartridge-powered captive bolt guns and 19% of those using hunting rifles for the stunning of cattle detected non-compliances. For reindeer, no major differences related to the type of captive bolt gun were found. Despite the numerical differences, there were no statistically significant differences between the different stunning methods for cattle, likely due to the limited sample size for some of these methods.

The proportion of non-compliances at electrical stunning of sheep (50%, n = 10) showed a statistical tendency to be higher than those with mechanical stunning (17%, n = 24).

The proportions of inspections at pig slaughter that resulted in at least one reported non-compliance at stunning were 67% (n = 9) at electrical stunning, 22% (n = 9) at mechanical stunning, and 10%

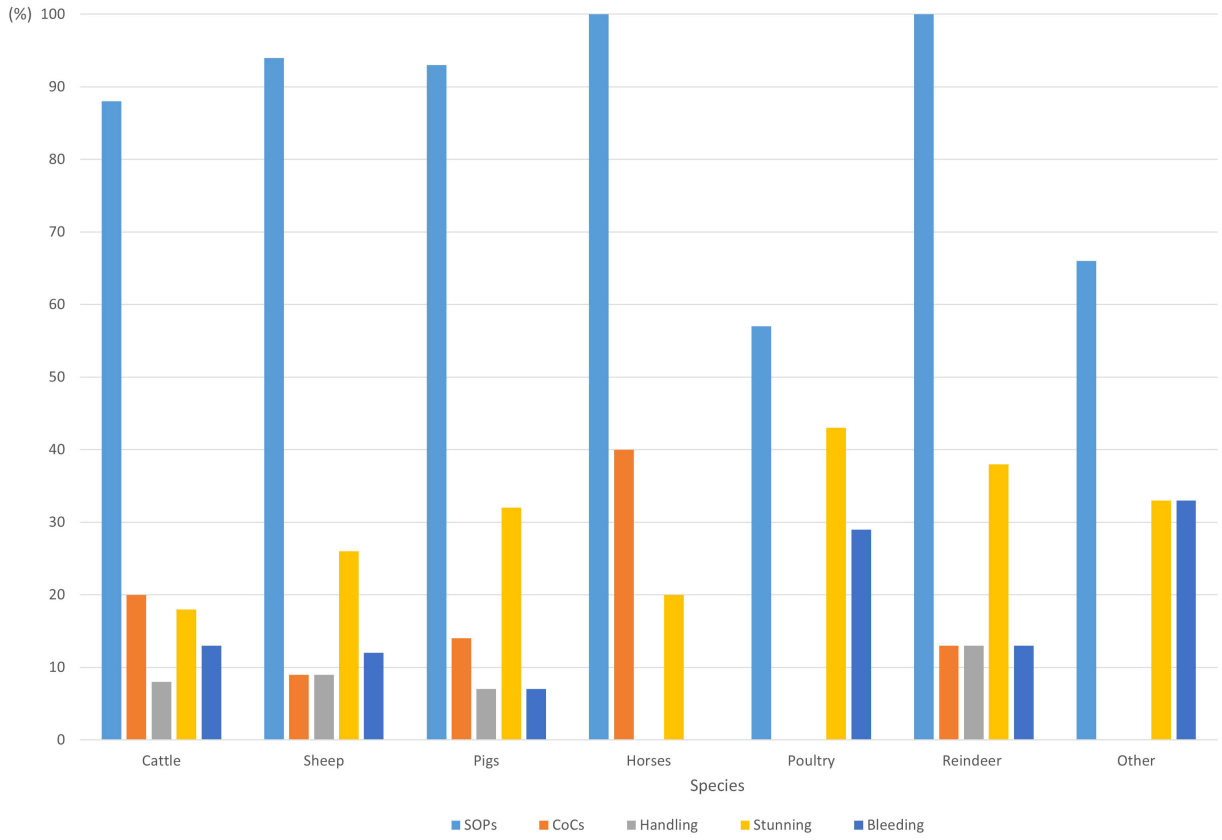

FIGURE 3
Proportion (percentage) of inspections that identified at least one non-compliance by category and species. Cattle (n = 40), sheep (n = 34), pigs (n = 28), horses (n = 5), poultry (n = 14), reindeer (n = 8), and other (n = 3).

(n = 10) at gas stunning. Here, there was a tendency for a statistical difference between electrical stunning and the two other methods.

For poultry, the proportions of inspections with at least one non-compliance at stunning were 40% (n = 10) for electric water baths and 33% (n = 3) for dry electrical stunning, with no statistically significant difference. The one poultry slaughterhouse that used gas stunning was also reported to have non-compliances in relation to stunning.

Non-compliances related to the actual stunning intervention were most common at electrical stunning and involved incorrect placement of the electrical tongs, poor stun quality (without immediate detection and re-stunning), too short of an exposure time, insufficient electrical current (Amp), or too long of a duration until the required current was reached after application of the tongs. For poultry, pre-stun electrical shocks and insufficient immersion depth in the water bath were reported. In terms of mechanical stunning, the main non-compliances were improper ammunition and poor stun quality.

For the non-compliances recorded in relation to stunning, regardless of species, the absence of a device that displays and records the details of the key parameters for each stunned animal, as requested by the Council Regulation (EC) No. 1099/2009 (Annex II, point 4.1, applicable to electrical stunning), was the most common non-compliance identified in this study, reported at 25% of the inspected slaughterhouses. This aspect is related to documentation, but not to the SOPs or CoCs. The severity of this type of compliance varied from, e.g., one or several of the requested parameters missing in the records to the complete absence of any possibility to record any electrical parameters. In addition, problems associated with improper restraint, absence of breast comfort plates (poultry), poor stun box design, improper stun settings and equipment (electric current, exposure time, and ammunition type, among others),

TABLE 3 **Proportions of inspections (in percent, presented next to the number of inspections per species and method, i.e., *n*, in brackets) identifying at least one stunning-related non-compliance by stunning method and species.**

Method/species	Cattle	Sheep	Pigs	Horses	Poultry	Reindeer
Mechanical	18 (40)	17 (24)	22 (9)	20 (5)		38 (8)
Gas			10 (10)			
Electric, water bath					40 (10)	
Electric, dry		50 (10)	67 (9)		33 (3)	

Due to limited data, the results related to 'other species' and 'gas stunning of poultry' (dark grey) have not been included in this table. Light grey shading denotes 'not applicable'.

insufficient stun quality, and insufficient checks of stun quality were the other commonly identified non-compliances.

Non-compliances related to restraint were noted most often at cattle slaughterhouses that used mechanical stunning methods. Examples of this are that the animals had too much room to move at stunning (making it difficult to position the gun correctly, resulting in misplacement or long stressful delays), that the design of the stun box was severely suboptimal, there was no restraint, or the stun box design makes it impossible to re-stun animals when necessary. For pigs, the most common non-compliances related to restraint was stun box design, absence of restraint, and use of the stunning equipment (electrical tongs) to 'catch or restrain' the animal. For poultry, absence of breast comfort plates at shackling was the most common non-compliance not related to the stunning intervention per se.

Non-compliances related to bleeding

The last category evaluated was sticking or cutting, also referred to as bleeding or exsanguination. One example of a non-compliance detected in this category is excessively long stun–stick intervals. The accepted stun–stick interval for each stunning method at each slaughterhouse must be stated in the FBO's own SOPs and should be based on the national guidelines for good practice or on the results from independent stun quality studies performed at the individual slaughterhouse.

Another example of non-compliance in this category is further processing of the carcass before the animal was inspected and identified as dead. Furthermore, there were cases where no systematic assessment for consciousness/unconsciousness was made after sticking, even though recurring consciousness cannot be ruled out at this stage.

Discussion

The aims of this study were to describe the current level of compliance with national and EU animal welfare legislations at slaughter in Sweden and to identify areas that may require increased focus from slaughterhouse managers and official control bodies.

The main findings were that the majority of inspected slaughterhouses had at least one non-compliance relating to animal welfare and that administrative non-compliances were particularly prevalent at small- and medium-sized establishments. However, the proportion of operational non-compliances was higher if administrative non-compliances were also identified at a given slaughterhouse. A higher proportion of small- and medium-sized slaughterhouses had at least one animal welfare-related non-compliance, with the main types of non-compliance varying between small, medium, and large establishments. Considering the small number of premises involved in slaughtering certain species, it is difficult to draw general conclusions about species-related aspects. Regarding the stunning methods, a relatively high proportion of non-compliance with legislative requirements was found when electrical stunning was used.

This is a large-scale study covering two-thirds of the country's registered slaughterhouses, except for very small poultry slaughterhouses. Whilst this material is unique in several ways, the study also has certain limitations. For instance, conditions at lairage were not considered, despite this aspect of animal welfare at slaughter potentially being highly relevant. Furthermore, the study was based on standard routine inspections performed by regional authorities that involved a number of different inspectors and consequently carried a risk of variation in what was considered non-compliance. We cannot be sure that the training provided to mitigate this risk achieved a high level of inter-rater agreement. As the outcome of the inspection in terms of compliance *versus* non-compliance was dichotomous and free-text comments were voluntary, the amount of detail regarding various non-compliances and their severity unfortunately does not allow for in-depth analysis. Lastly, as this study occurred across only 1 year, we were unable to follow up on any long-term changes or improvements.

In general, the types of animal welfare-related non-compliances detected in this study are rather similar to those identified in previous European studies focusing on risk assessment or on the work of official veterinarians and court cases as indicators of animal welfare issues at slaughter (Schneidewind et al., 2023, 2024; Sundermann et al., 2023) with, e.g., ineffectively stunned animals, incorrect use of stunning device, failure to detect insufficient stunning and failure to re-stun, and inadequate formal training or certification of employees, i.e., missing CoCs. It should be emphasised that the inspection methodology and the indicators used for assessing legislative compliance related to animal welfare at slaughter may be quite different from those used to assess animal welfare at slaughter per se, which tend to primarily focus on animal-based indicators (e.g., Wigham et al., 2018).

Administrative non-compliances with animal welfare relevance

The results showed that animal welfare infringements were identified at majority of the planned routine inspections carried out by the CAB animal welfare inspectors, which appears worrying. However, the vast majority of these non-compliances were related to administrative requirements, such as incomplete SOPs or missing CoCs for employees working with live animals. Having said this, the administrative requirements are still certainly relevant to animal welfare. The animal welfare legislation is intended to be preventive (Hultgren, 2009; Lundmark Hedman et al., 2021a), and the requirements associated with the FBOs' handling of animals, including set and clear procedures for stunning and bleeding, and the competence and attitude of the personnel working with live animals, can undoubtedly contribute to animal welfare (Hultgren et al., 2014). Hence, administrative non-compliances should be viewed as an increased risk for animal welfare-related problems, but does not mean that suffering in individual animals has been detected at the specific inspection. In any case, such non-compliances related to the SOPs must be corrected within a given time frame, and personnel not holding a CoC must be immediately removed from the live animal side of the slaughterhouse, possibly to

the processes where animal welfare is not an issue. Non-compliances during the handling, stunning, or bleeding of the animals may constitute direct and ongoing negative animal welfare issues, which would warrant immediate correction.

The requirements in the EU Regulation 1099/2009 (European Commission, 2009) on animal welfare at killing (including slaughter) have now been in force for over 10 years, and there has been a plethora of communication with the slaughterhouses about the need for site-specific SOPs. The Central Competent Authority has, with the assistance of the Swedish Centre for Animal Welfare (SCAW) at the Swedish University of Agricultural Sciences, developed and distributed national guidelines for good practice in accordance with Regulation 1099/2009. The National Contact Point has also held meetings for the FBOs' AWOs where this topic has been repeatedly discussed. Therefore, the FBOs are likely aware of the requirement and have generally produced such documents. This project has demonstrated that this work is not yet complete, as 'incomplete SOPs' was the most commonly found infringement. It can be hypothesised that many FBOs may need to receive professional advice on the design and content of their SOPs, just as many of them already do for HACCP procedures and similar processes, although the responsibility will still lie with the FBOs' AWO (European Commission, 2012).

Allowing formally non-trained and potentially non-qualified personnel, without a CoC or without similar proper training (outside of the EU), to handle, stun, or bleed animals during the slaughter process is an infringement that can be easily prevented and should not occur in the first place. However, similar problems have also been detected in other countries (Abyaneh et al., 2020; Schneidewind et al., 2023). For example, Schneidewind et al. (2024), in their study based on an online survey of German official veterinary inspectors, reported that 36.4% of the participants had reported missing or inadequate CoCs as a violation during 2019–2021 at their workplace. The EU requirement for a formal CoC does not apply outside of the European Union, unless the slaughterhouse in question aims to export products to the EU. However, in other regions, the importance of training has also been highlighted. For instance, Abyaneh et al. (2020), in their study of slaughterhouses in Iran, found that only 30% of the employees in modern slaughterhouses and 0% of the employees in traditional slaughterhouses had taken relevant training courses in animal behaviour and handling. In a study from Chile, Gallo et al. (2003) showed that staff training resulted in a significant improvement in stun quality, which is highly relevant for animal welfare. Furthermore, Wigham et al. (2020) described that participating in animal welfare training courses was associated with more positive attitudes towards animals at slaughter. It is somewhat surprising that, in this study, the proportion of inspections where at least one of the employees did not possess a relevant CoC was the highest at slaughterhouses that slaughtered cattle or horses. Considering how large and potentially dangerous these animals are, training in species-specific biology and behaviour—which is covered in the courses that must be taken to qualify for a CoC—may be beneficial not only for animal welfare but also for workers' safety. Given the design of this study, we can, however, not rule out the possibility that employees may have actually received proper formal training, but did not proceed to request a CoC from the competent authorities.

Stunning methods, size, and capacity of the slaughterhouses

In a study of French slaughterhouses, Sundermann et al. (2023) found that the total annual slaughter volume was statistically associated with a higher risk of non-compliance with animal welfare regulations, with intermediate tonnage slaughterhouses being at a greater risk. In our study, the proportion of inspections identifying at least one non-compliance overall was not clearly linked to slaughterhouse capacity. For the non-compliances related to the SOPs, however, the proportion of non-compliance was lower for the large slaughterhouses than for the medium-sized or small establishments.

In this study, the smaller slaughterhouses appeared to find it more challenging to fulfil the administrative requirements, e.g., to write SOPs that cover all necessary aspects, possibly because the low number of people involved means that they typically rely more on verbal communication than written documents. On the other hand, the smaller slaughterhouses displayed fewer non-compliances related to the actual handling of the animals, which may be related to the considerably lower line speed, which can allow the animals more time to move forward voluntarily. For stunning, the medium-sized slaughterhouses showed the best compliance. One could hypothesise that, for the smallest slaughterhouses with limited investment budgets, the equipment may be more old-fashioned, and there may be a trend to work in the same way as one has always done, i.e., not developing the activities in line with updated scientific knowledge and updated legislation requirements. For large slaughterhouses, it is possible that the problems are at least partly related to a rather high line speed or a high staff turnover, but these aspects were not investigated in this study. It is worth noting that horse slaughter is a very limited activity in Sweden and only occurs at small slaughterhouses with a low line speed, which is reflected in the remarkably low level of non-compliances related to handling and bleeding. However, stunning can also be difficult at a low line speed, which is illustrated by the reported level of inspections detecting non-compliances related to the stunning of horses.

As indicated by Terlouw et al. (2008), practices and preferences regarding the choice of stunning methods may vary between countries and regions, although the animal welfare concerns are often similar. This project involved inspections at two-thirds of all Swedish slaughterhouses under governmental control; however, the total number of slaughter plants in the country remains limited. Moreover, each slaughterhouse typically only applies one main stunning method per species. Hence, when dividing the data by stunning method and species, the number of 'cases' per group will be quite low, and we are consequently reluctant to draw any major conclusions on the effectiveness of various stunning methods based on this study as this factor is far from independent. Nevertheless, attention should be drawn to the fact that, for the mammal species where electrical stunning is applied individually to the animals (i.e., sheep and pigs), the proportion of inspections with non-

compliances noted was remarkably higher for electrical stunning than for mechanical stunning, irrespective of the size of the slaughterhouse. This is a cause for concern, which is further supported by Sundermann et al. (2023), who found head-only electrical stunning to be one of the variables statistically associated with a higher risk of non-compliance with animal welfare regulations at slaughter in France. Although the electrical head-only stunning method has been used for a long time and is well described scientifically (EFSA, 2004) it may be that the practical application of the method involves too many difficult or complicated aspects. This can lead to problems such as inappropriate tong placement, electrical contact problems, insufficient exposure time, and inadequate electrical settings in practice, resulting in poor stun quality (Berg et al., 2012). Indeed, countries outside the EU have also reported this (Sentamu et al., 2022), where the design and the use of such equipment may be less regulated. It should be borne in mind that, alongside these electrical stunning-related non-compliances, administrative infringements associated with the absence of correct devices to display and record the key electrical parameters (European Commission, 2009) were very common, making the evaluation of compliance additionally difficult for the inspectors.

For mechanical stunning, there was a difference in the proportion of inspections with non-compliances depending on the type of device used, with no non-compliances at inspections of safety rifles (where a sensor must be pushed against the animal's forehead to make it possible to fire the gun) or pneumatically operated captive bolt guns. In contrast, a considerable proportion of non-compliances were reported for inspections related to stunning using cartridge-powered captive bolt guns or a hunting rifle with a free bullet. This is in line with Atkinson et al. (2013) and Kaluza et al. (2022), who emphasised the importance of using more powerful stunners—such as pneumatically operated guns—to achieve a sufficient stun result, especially for bulls.

Implications of this study

This project, which includes details on the applied stunning methods and the occurrence of various categories of non-compliance with animal welfare legislation at slaughter, will be a useful tool for the development of a risk-based control of Swedish slaughterhouses in the future. One can assume that non-compliance at similar critical points may also be present in other countries, as has been suggested for, e.g., Germany (Schneidewind et al., 2023, 2024), France (Sundermann et al., 2023), Iran (Abyaneh et al., 2020), and Mexico (Miranda-de la Lama et al., 2012). Thus, the results from this study may also be helpful to competent authorities in other EU member states and outside the EU, wherever compliance with animal welfare legislation at slaughter is routinely inspected.

Although the legislation in this field, and in many others, may be perceived as reasonably detailed, each inspection is, to some extent, unique and decisions are to be made by the individual inspector, i.e., the 'street-level bureaucrat' (Lipsky, 2010; Lundmark Hedman, 2016). In line with this, previous research indicates that significant variability may be seen when regulatory frameworks are operationalised (May and Winter, 2002; Borraz et al., 2022). To achieve a fair result of the official (or private, when relevant) control, a uniform assessment standard and a certain level of predictability are desirable. Many competent authorities strive for consistency and uniformity in regulatory inspections using a relatively wide variety of approaches and strategies to enhance consistency. This study can be described as a 1-year strategic inspection campaign, where a combination of approaches, including advisory support (by an expert group), professionalisation (guidelines and continuous education), and standardisation (checklists) was used. These interventions were directed to all CAB inspectors carrying out slaughterhouse inspections. However, given the limitations of this study, it was not possible to evaluate the direct effect of the interventions, and the authors would like to emphasise that such a project is just one of many efforts necessary to improve consistency. Based on the input received during this project and the interest in the popular science presentations provided at the annual meetings for the animal welfare inspectors and the AWOs at Swedish slaughterhouses, we believe that the project has, in itself, contributed to an increased awareness of both animal welfare at slaughter and the legislation and guidelines for good practice related to such activities, both at the regional competent authorities and at the FBOs. This potential effect has, however, not been scientifically investigated. Knowledge about the minimum requirements and expectations, as well as suitable operating procedures, may improve the likelihood of achieving good animal welfare, but this must be followed up with further inspections to ensure enforcement and implementation (Lundmark Hedman et al., 2021b). Projects such as this, where guidelines and checklists are used, may enhance the level of uniformity and predictability within the animal welfare control system, but it should be highlighted that there may also be a need for the development of the inspector role in terms of in-depth understanding of the professional tasks to achieve good inter-rater reliability (van Kleef et al., 2015). This has, however, not been evaluated within the present study.

Recommendations

Based on the results of this study, we recommend that the authorities consider more frequent systematic official routine inspections of animal welfare at commercial slaughterhouses to improve compliance with animal welfare legislations and, consequently, improve the welfare conditions for animals at slaughter.

Whilst this study did not investigate the reasons behind non-compliance with animal welfare legislations at slaughter, we might hypothesise that limited knowledge of legislative requirements and limited insights into animal welfare may be contributing factors. Therefore, improved basic training and continued education aimed at slaughterhouse workers, managers, and inspectors may be relevant. Based on our results, we would also recommend, especially for smaller slaughterhouses, the use of external professional help for the development of their SOPs.

As failures related to stunning often have immediate and very negative consequences for animal welfare, and as the proportion of non-compliance relating to electrical stunning was in particular found to be relatively high, we suggest that specific attention is paid to the application of these methods at commercial slaughterhouses.

Conclusions

Although the current EU regulation on animal welfare during slaughter has been in force for over a decade, we can conclude that much remains to be done to improve compliance with the EU regulation and national legislation. This study, which is based on routine animal welfare inspections carried out by regional authorities, found that most of the inspected premises complied with the majority of control points. However, as very few inspections were completely compliant, and some slaughterhouses had several non-compliances in various categories, there is clearly room for improvement. These non-compliances relate to both the administrative and operational aspects of animal welfare at slaughter, although non-compliances related to the former group were more prevalent. Furthermore, non-compliances were found related to all five of the categories investigated: SOPs, CoCs, handling, stunning, and bleeding.

A larger proportion of the small- and medium-sized slaughterhouses had at least one animal welfare-related non-compliance, and the main types of non-compliance also varied between small, medium, and large establishments. Due to the small number of premises involved in slaughtering certain species, it is difficult to draw general conclusions about species-related aspects. Nevertheless, the proportion of non-compliance with the legislation related to electrical stunning, regardless of species, was unexpectedly high and thus raises concerns.

Data availability statement

The datasets presented in this article are not readily available because they contain information that may identify commercial FBOs. Requests to access the datasets should be directed to the first author, Charlotte Berg, Lotta.Berg@slu.se.

Author contributions

CB: Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing. HL: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Supervision, Visualization, Writing – original draft, Writing – review & editing. KE: Conceptualization, Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing. MG: Conceptualization, Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing.

Funding

The author(s) declared that financial support was not received for this work and/or its publication.

Acknowledgments

The authors would like to thank the entire project group, the county animal welfare inspectors, the county administrative veterinarians, the official veterinarians at the slaughterhouses and the food business operators for their contributions to this project. We would also like to thank Anna Wallenbeck for valuable statistical assistance.

Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declared that generative AI was not used in the creation of this manuscript.

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The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fanim.2026.1688590/full#supplementary-material

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