Emergency slaughter and regular slaughter: prevalence of *post mortem* lesions and effect of risk factors

SIMONE FINAZZI[1], CARLO SGOIFO ROSSI[2], STEFANO PELIZZARI[3], SILVIA GROSSI[2], ERICA TIRLONI[2], CRISTIAN BERNARDI[2], SIMONE STELLA [2*]

[1] Freelance Veterinarian
[2] Department of Veterinary Medicine and Animal Sciences, University of Milan, Via dell'Università 6, Lodi, Italy
[3] Dipartimento Veterinario e Sicurezza degli Alimenti di Origine Animale, ATS Milano Città Metropolitana, Distretto Veterinario Basso Lodigiano, Viale Trieste 76, Codogno, Italy

SUMMARY

This retrospective study collected and compared information about the occurrence and typology of pathological lesions observed throughout the *post mortem* inspection of cattle (focusing on dairy cows) that have undergone emergency slaughter compared to those obtained from animals subjected to regular slaughter. Data from 16,899 dairy cows (6761 of them being submitted to emergency slaughter – ES, and the others to regular slaughter - RS), were recovered at an industrial plant located in Lombardy (Northern Italy) through a two-year period. Lesions were classified based on the organ affected (lung, heart, liver, kidney and other locations) and on the typology. General and specific prevalence was calculated, and the effect of animal age and slaughtering season was analyzed.

The general prevalence of lesions determining the condemnation of the viscera and/or of the whole carcasses was 9.2% for both RS and ES animal populations. Significant differences were detected considering single organs, with higher prevalence in RS animals for lung (2.0% vs 1.6%), heart (1.0% vs 0.6%), liver (5.8% vs 2.6%) and kidney (1.5% vs 0.7%) lesions, whereas a significantly higher rate was observed in ES animals (5.3% vs 1.0%) for lesions in other locations (including muscles). The most frequently detected lesions in the organs were pneumonia (lung), pericarditis (heart), steatosis (liver), and interstitial nephritis (kidney); despite of their prevalence, these lesions were hardly associated to whole carcass condemnation, that occurred mainly in the presence of purulent/gangrenous lesions. Lesions in "other" locations were mainly represented by alteration of meat characters (infiltration of serum/blood, altered flesh characteristics), that were frequently associated to the condemnation of the whole carcass.

Considering the slaughtering season, a significantly higher prevalence of lesions was observed in autumn for all the organs inspected in both RS and ES animal populations. Finally, animals' age influenced significantly the prevalence of lesions, with an increasing rate in older animals for liver and kidney lesions, while for lung and heart lesions an increase was observed until 5-7 years-old category, and a slight decrease was evidenced in older animals. The lesions in other locations followed an opposite trend, with significantly higher prevalence in younger animals (< 3 years of age) and a gradual decreasing trend.

The data obtained showed the utility of feedback of data collected at slaughter to direct the inspection procedures, especially in higher risk situations (such as emergency slaughtered animals) and to improve farming practices to reduce the impact of health/welfare problems occurring in the population of dairy cows.

KEY WORDS

Post mortem inspection; dairy cows; gross lesions; emergency slaughter.

INTRODUCTION

Slaughterhouses run a fundamental role as epidemiological observatories of animal health status providing relevant indicators about both pathologies and animal welfare. The frequency of parasitosis, the body condition score evaluation, the detection of organ injury, the animal cleanliness and the presence of feet lesions are all factors that, together with data obtained from the National livestock register and with information included in the documents accompanying animals to slaughter, can reveal the presence of management problems or endemic diseases in farms or in a given region. The formulation of hypothesis starting from the data collected in the slaughterhouse is not only interesting for the veterinary inspector, but also for the company involved in the supply chain; in fact, it is clear that operators can act retroactively to contrast infective diseases occurring at farm or issues related to the transport and slaughter of animals [1, 2]. The collection of the inspective evaluations is subjected to various regulations; the EU Reg. n. 627/2019 establishes that the lesion detection must be registered by the veterinarian in charge and must be reported in an

Corresponding Author:
Simone Stella (simone.stella@unimi.it)

objective way [3]. Consequently, methodological uniformity and a fast recognition and registration of the lesions are required in order to favor the ordinary course of the slaughter line. The first goal can be achieved by using standardized software among companies, whereas the second one can be achieved by the use of touchscreens placed near the inspection workplace.
This useful approach can be applied to various animal categories, giving precise feedback to farmers who can focus their interventions for the prevention of specific problems, such as pulmonary diseases (Bovine Respiratory Syndrome) in calves, or liver abscesses in feedlot cattle.
A particular category of slaughtered animals is represented by cattle (and especially cows) that are submitted to emergency slaughter. According to the EC Reg. n. 853/2004, emergency slaughter is demanded by the official veterinarian when an animal suffered an accident that prevented its transport to the slaughterhouse for welfare reasons [4]. Transportability is the main factor for which the official veterinarian demands emergency slaughter in a breeding farm. The transport of unsuitable animals is not convenient for the animal welfare; it also reflects a non-compliant behavior of the veterinarian who eventually allowed the journey. The condition of "downer cow" is the primary cause that leads the veterinary inspector, through a decision-making process, to bovine emergency slaughter [5]. When veterinarians decide for an emergency slaughtering, they must evaluate deeply the general status of the animal: recent notes supplied by the Italian Ministry of Health have stated the possibility to apply this intervention only in case of traumatic lesions, thus leading to killing and destruction of animals affected by systemic/metabolic syndromes [6].
The aim of this retrospective study is to collect information about the occurrence and typology of pathological lesions observed throughout the *post mortem* inspection of bovines, especially cows, that have undergone emergency slaughter. The collected data were compared to those obtained from animals belonging to the same population and subjected to ordinary slaughter in the same slaughterhouse. Data were analyzed according to the available information (age, category, month of slaughtering), in order to detect the possible effect on the frequency of lesions detection.

MATERIALS AND METHODS

Animals and data

The analyzed data were provided by a bovine slaughterhouse located in Lombardy (Northern Italy) with an industrial capacity of around 8,000 animals slaughtered annually; data from 19,366 slaughtered animals were recovered through a two-years period; data from dairy cows, representing the main part of the animal population (87.3%) were selected for the analysis: finally, a total of 16,881 slaughtered animals were considered, 6,761 of which (40%) being submitted to emergency slaughter (ES), while 10,120 were regularly slaughtered (RS). All the animals were submitted to gross *post mortem* examination by the official veterinarian, that collected data on slaughtered animals and detected lesions, which were recorded in the company's computer system and shared electronically for analysis. The animals that were killed but not inspected (previously condemned based on the outcomes of *ante mortem* inspection or on Food Chain Information accompanying the animals) were excluded from the study.

All the lesions determining the condemnation of single organs/portions or of the whole carcasses were registered and classified as reported below, considering the organs affected and the main lesion typology:
- Lung lesions: pneumonia; pulmonary edema; emphysema; purulent/gangrenous lesions; pleuritis; other lesions;
- Heart lesions: endocarditis; pericarditis; purulent lesions; other lesions;
- Liver lesions: abscesses; steatosis; telangiectasias; fatty infarctions; necrotic lesions; parasitic lesions (cholangitis); perihepatitis/adherences; other lesions;
- Kidney lesions: glomerulonephritis; interstitial nephritis; purulent lesions (abscesses/pyelonephritis); degenerative lesions (nephrosis/steatosis); other lesions;
- Lesions on the carcass: serositis (adherences/foreign body syndrome); purulent/gangrenous lesions; necrotic lesions; traumatic lesions (including bruising); altered flesh characteristics (emaciation, fevered flesh, etc.); edema (with serum and/or blood); other lesions.

The prevalence data regarding the presence of specific lesions were clustered and analyzed to reveal eventual differences between RS and ES animal populations. The impacts of animal age and of the slaughtering season on the prevalence of the lesions were also evaluated.

Statistical analysis

Prevalence data were analyzed by non-parametric χ^2 test; the differences between the two animal populations (RS and ES) and among slaughtering seasons and animal age categories were investigated. Significance threshold was set at $P<0.05$.

RESULTS AND DISCUSSION

Number of ES animals

As mentioned previously, about a 35% of slaughtered cows were submitted to emergency slaughter: this high value is justified by the functionality of the plant, that is specifically dedicated to emergency slaughter of cattle, and applies specific procedures. Considering the eventual influence of climatic conditions on the prevalence of emergency slaughter, the data were clustered by month and season (Table 1). A significant difference among the seasons was evidenced, with higher prevalence in summer (the highest value, 53.7%, was observed in July), and lower values in spring (about 27-28% in March and April). Considering the age of the animals, the highest frequency of ES was observed in younger animals (53.7%), while lower rates were detected in the other age categories (36-39%). The age distribution of the two animal populations was not significantly different, even if higher rate of young (< 3 years) animals was de-

Table 1 - Seasonal differences in the rate of emergency slaughtering.

	RS	ES	Rate ES (%)
Spring	1384	2612	34.6^{D}
Summer	1823	2071	46.8^{A}
Autumn	1852	2982	38.3^{C}
Winter	1713	2462	41.0^{B}

Superscript letters (^{A,B,C,D}) indicate a significant difference ($^{A>B>C>D}$, $P<0.01$) among the seasons.

Table 2 - Prevalence of lesions in the slaughtered dairy cow population inspected.

	N. of slaughtered animals (total)	N. of animals presenting lesions in organs/carcasses (%)					
		Total (any part)	Lung	Liver	Heart	Kidney	Other (including carcass)
ES	6761	623 (9.2)	108 (1.6)^{b}	173 (2.6)^{B}	42 (0.6)^{B}	45 (0.7)^{B}	355 (5.3)^{A}
RS	10.120	927 (9.2)	204 (2.0)^{a}	590 (5.8)^{A}	103 (1.0)^{A}	156 (1.5)^{A}	97 (1.0)^{B}
Total	16.881	1550 (9.2)	312 (1.8)	763 (4.5)	145 (0.9)	201 (1.2)	452 (2.7)

^{A,B}: significant difference ($^{A>B}$, P<0.01) between RS and ES animal populations.
^{a,b}: significant difference ($^{a>b}$, P<0.05) between RS and ES animal populations.

tected in ES animals (21% vs 13% in RS), and the mean age of slaughtered cows was slightly lower for ES population (1723 days vs 1833 in RS).

Prevalence of lesions among slaughtered cows

The general prevalence of lesions detected during the *post mortem* inspection and determining the condemnation of the viscera and/or of the carcasses of slaughtered cows is reported in Table 2. The rate of condemned organs/portions (9.2%) was lower than that observed in a previous study [7]. A high prevalence of organs condemnation is considered a frequent event for dairy cows: this could be expected, as the decision to send a dairy cow to slaughter is often taken when a fall in milk production, or insufficient health/production status occur. In these cases, depending on the typology and severity of health problems, the animals are destined for regular slaughter or, in more severe cases (e.g. downer cows), emergency slaughter. No differences were detected between RS and ES carcasses regarding the total prevalence of lesions; thus, it appears that the conditions leading to emergency slaughter do not cause obvious pathological issues in the organs that are typically examined. However, the similarity of general prevalence was apparent, and a marked difference was observed when considering the single inspected organs (Table 2). A higher lesion prevalence was detected in RS animals in lung, liver, heart and kidney; the differences were statistically significant (P<0.01 for heart, liver and kidney; P<0.05 for the lung); considering liver and kidney lesions, the rate observed in ES animals was more than doubled in RS animals. An opposite picture was observed for the lesions detected in "other" localizations, with a prevalence five times higher in animals submitted to ES.

Figure 1 shows the relative rate of the lesions (ratio between specific organs and total number of lesions): liver lesions represented about half of the lesions in cows submitted to RS, doubling the relative frequency detected in ES animals; an opposite situation was observed for lesions in other locations, that constituted quite half of the lesions detected in ES animals, and less than 10% of those detected in RS animals.

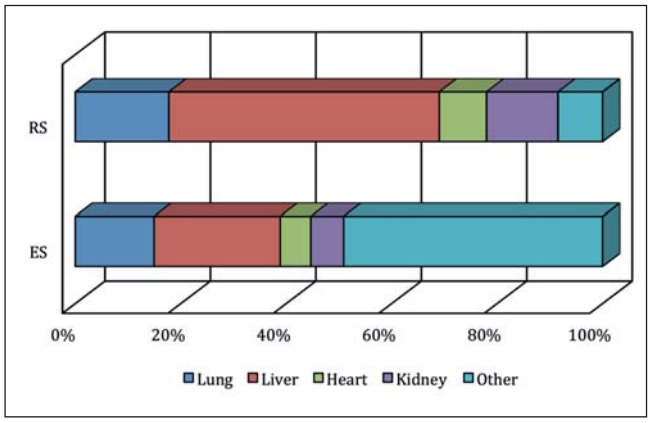

Figure 1 - Relative prevalence of the lesions detected in different organs/sites.

During *post mortem* examination, it was possible to detect lesions in more than one organ in the same animal: single lesions were detected in more than 4/5 of the animals (N=1286, 83.0%), with markedly lower number of carcasses showing lesions in two (13.8%), three (2.8%), four (0.3%) or all the inspected parts/viscera of the animals (0.1%). This distribution was very similar between RS and ES animals, without evident differences.

The severity of the lesions detected in RS and ES animals can be evaluated by the association between lesion detection and whole carcass condemnation. The global carcass condemnation rate was 2.8%; the value obtained in RS animals (0.5 %) was similar to that reported by previous studies [8, 9]. A significantly higher value (6.3%, P<0.01) was detected in ES animals: this result was expected, as the condition of the animals determining the impossibility to transport them to the slaughterhouse are thought to be more severe than those determining the need for slaughtering but allowing their transport. Moreover, some carcasses were condemned based on the positive result of the bacteriological analysis of muscle tissue, a test that is mandatory in case of ES, but it is applied only in cases of suspect of bacteremia, when animals are regularly slaughtered. In our study, 70.6% of ES carcass condemnation was justified by the official veterinarian by the presence of muscle bacterial contamination (mainly Clostridia, *Escherichia coli* or *Salmonella* spp.), whereas only 7.6% of RS carcasses was condemned with this indication.

The condemnation of the whole carcass was strongly associated with lesions in "other sites", including muscles, as expected: when considering the cause of carcass condemnation excluding microbiological outcomes (thus based only on gross *post mortem* examination), 73% and 98% of cases were due to pathological findings in "other" sites, mainly described as altered flesh characteristics (20% and 48% in RS and ES carcasses, respectively) and peritonitis (33% in RS and 13% ES carcasses); in RS carcasses, also lung lesions were cited as important cause for condemnation (15%), with purulent lesions playing the major role.

Prevalence of specific lesions

The prevalence of specific lesions among RS and ES animals is shown in Table 3.

Pneumonia was by far the most frequent lung lesion (around

Table 3 - Absolute and relative prevalence of the single lesions in animals submitted to regular slaughtering and emergency slaughtering.

Organ	Lesion	Absolute rate		Relative rate	
		RS	ES	RS	ES
Lung	Pneumonia	1.3	1.0	59.9	59.3
	Emphysema	0.6	0.5	26.3	28.3
	Pulmonary edema	0.0	0.0	1.4	0.0
	Purulent/gangrenous lesions	0.2	0.1	7.8	6.2
	Pleuritis	0.0	0.1	4.1	5.3
	Other lesions	0.0	0.0	0.5	0.9
Heart	Pericarditis	0.9^{A}	0.5^{B}	84.0	79.1
	Endocarditis	0.1	0.0	7.5	7.0
	Purulent lesions	0.0	0.1	3.8	9.3
	Other lesions	0.0	0.0	4.7	4.7
Liver	Steatosis	2.9^{A}	1.6^{B}	48.5	60.5
	Abscesses	1.4^{A}	0.4^{B}	23.2	14.7
	Perihepatitis/adherences	0.8^{A}	0.2^{B}	13.9	7.3
	Telangiectasias	0.5^{A}	0.2^{B}	7.7	7.9
	Fatty infarctions	0.2	0.1	3.4	5.1
	Parasitic lesions	0.1	0.1	1.8	2.8
	Necrotic lesions	0.0	0.0	0.8	0.0
	Other lesions	0.0	0.0	0.8	1.7
Kidney	Interstitial nephritis	0.6^{a}	0.3^{b}	35.7	44.4
	Degenerative lesions	0.5^{A}	0.1^{B}	33.8	11.1
	Glomerulonephritis	0.3	0.1	17.8	22.2
	Purulent lesions	0.2	0.1	11.5	20.0
	Other lesions	0.0	0.0	1.3	2.2
Other (carcass)	Serositis	0.3	0.4	31.7	7.0
	Purulent/gangrenous lesions	0.2^{B}	0.9^{A}	20.2	15.7
	Altered flesh characteristics	0.2^{B}	1.3^{A}	16.3	23.2
	Edema	0.1^{B}	1.6^{A}	11.5	28.9
	Necrotic lesions	0.0^{B}	0.3^{A}	3.8	6.2
	Traumatic lesions	0.0^{B}	0.5^{A}	2.9	10.0
	Other lesions	0.1^{B}	0.5^{A}	13.5	8.9

^{A,B} Significant difference ($^{A>B}$, $P<0.01$) between RS and ES animal populations.
^{a,b} Significant difference ($^{a>b}$, $P<0.05$) between RS and ES animal populations.

60% of the total); inflammatory diseases are often observed in dairy cows and other cattle categories, and have a severe impact on animal health [10]. The major number of lesions was represented by chronic *sequelae* (personal communication by the official veterinarians), that could hardly be a cause of anticipated regular slaughtering or of emergency slaughtering. This hypothesis was confirmed by combining data concerning the lesions and carcass condemnation rates: the whole carcass was condemned in 7.6% of the cases of pneumonia; the more severe cases, when also pleuritis was signaled, were more clearly associated to carcass condemnation (4/8 cases). High elimination rate was observed for purulent/gangrenous lesions (33.3%), whereas emphysema was not associated to carcass elimination (2% of cases, but with the presence of other lesions). Pericarditis largely dominated heart lesions in both animal populations (about 80% of the total); a significantly higher prevalence was observed in RS animals. The most evident difference between the two animal populations was the higher rate of purulent lesions in ES animals. In our study, the term "pericarditis" was used to indicate the presence of a fibrinous process, whereas, when also purulent/gangrenous process was evidenced, it was classified as purulent lesion. The impact of these two lesions on the possibility of carcass suitability for consumption was evidenced by the condemnation rate, that was 7.3% (9/123) for carcasses where pericarditis was detected, and 50% (4/8) for those affected by purulent lesions.

Among liver lesions, the main role was played by steatosis (48.5 and 60.5% in RS and ES animals, respectively), followed by abscesses (23.2 and 14.7% in RS and ES). These two lesions are known for their high diffusion among dairy cows; steatosis is a metabolic disorder that often occurs in early lactation period, when the energy requirements are not sufficiently met by feed intake, and lipid oxidation is not sufficient to metabolize lipids within the liver, resulting in their accumulation [11]. Also

liver abscesses are favored by the condition of lactating animals; rumen acidosis, that can occur when a change in diet is made (e.g. from pregnancy to lactation), is a favoring factor for the release of bacteria through the portal vein to the liver [10, 12]. None of the liver lesions was associated to a high rate of carcass condemnation (3.5% for steatosis, 3.3% for telangiectasias, and lower values for the other lesions). The comparison between RS and ES animals showed a significantly higher prevalence ($P<0.01$) in the RS ones for all the most diffused lesions (steatosis, abscesses, perihepatitis, telangiectasias). In most cases, cows with conditions involving liver dysfunctions (mainly steatosis) are evaluated as «transportable» by the official veterinarian and then slaughtered under the regular regime.

Considering kidney lesions, a high relative rate was observed in ES animal population for inflammatory diseases (presumably of bacterial origin), such as interstitial nephritis, glomerulonephritis and purulent lesions (86.6% of the total), whereas degenerative forms were relatively more diffused in RS animals (33.8%). The absolute prevalence was significantly higher in RS for interstitial nephritis ($P<0.05$) and degenerations ($P<0.01$). Considering the role of kidney lesions in determining carcass condemnation, purulent lesions showed to be very important, with the elimination of the whole carcass in 25.9% of the cases, whereas this occurred in less than 3% of the cases for the other lesions.

Finally, considering the lesions in other sites (mainly in muscles), a different relative distribution of the lesions was observed in RS and ES animals: serositis (including traumatic reticuloperitonitis) and purulent/gangrenous lesions were the most prevalent in RS animals, whereas the alteration of meat characters (infiltration of serum/blood, altered flesh characteristics) had a major role in ES animals. A marked difference was also observed for traumatic lesions, that were evidently more frequent in ES animals: this result was expected, as traumatic events are considered as the main cause of emergency slaughtering («downer cow» condition), owing to the impossibility of transporting the animals. However, considering the absolute prevalence, all these lesions except serositis were significantly more frequent in ES animals. The association between the presence of the specific lesions and carcass condemnation was very evident especially for altered flesh characteristics (70.9% resulting in total elimination), serositis (39.8%) and "other" lesions (53.2 %), while relatively lower values were observed for necrotic (22.2%) and purulent/gangrenous lesions (15.2%), and especially for edema and traumatic lesions (6.7 and 5.0%, respectively).

Influence of slaughtering season and animal age on the prevalence of post mortem lesions

The evaluation of the influence of slaughtering season on the prevalence of lesions showed a significantly higher rate in autumn: this finding was evidenced for all organs inspected (Table 4), but it was more evident for lung, liver and kidney lesions. The same trend was observed for RS and ES animals for total lesions and for all the parts/viscera considered.

Considering the rate of whole carcass condemnation, a higher value (6.8%) was observed in ES animals in Autumn, while no evident differences were detected in RS ones. Our data disagree with other studies performed in France, Switzerland and Canada [8, 9, 13]; the reason for this finding is not clear and should be deepened, as different climate characterizes the areas of study, and different animal management practices are generally applied (e.g. seasonality of calving, pasture grazing).

Table 4 - Seasonal trend in the rate of lesions detection.

	Spring	Summer	Autumn	Winter
Lung	1.7^{B}	1.4^{B}	2.7^{A}	1.4^{B}
Liver	3.9^{B}	4.3^{B}	5.6^{A}	4.1^{B}
Heart	0.9	0.6^{b}	1.2^{a}	0.7^{b}
Kidney	1.3^{b}	$0.7^{B.c}$	$2.0^{A.a}$	$0.7^{B.c}$
Other	2.3^{b}	2.4	3.0^{a}	2.9
Total	8.2^{B}	7.8^{B}	11.6^{A}	8.6^{B}

$^{A.B}$ Significant difference ($^{A>B}$, $P<0.01$) among the seasons.
$^{a.b.c}$ Significant difference ($^{a>b>c}$, $P<0.05$) among the seasons.

The age of slaughtered cows had an evident influence on the prevalence of lesions; the results are reported in Table 5, where animals' ages are clustered in four categories.

Table 5 - Influence of the age of slaughtered cows on lesions prevalence.

	< 3	3-5	5-7	> 7
Lung	1.6	1.9	2.0	1.6
Liver	2.6^{C}	4.4^{B}	5.0^{B}	6.4^{A}
Heart	0.8	0.7^{b}	1.1^{a}	1.0
Kidney	0.7^{B}	1.0^{b}	$1.4^{A.a}$	$1.6^{A.a}$
Other	4.2^{A}	2.6^{B}	2.2^{B}	2.1^{B}
Total	8.4^{B}	8.8^{B}	9.5^{B}	10.7^{A}

$^{A.B}$ Significant difference ($^{A>B}$, $P<0.01$) among the age categories.
$^{a.b}$ Significant difference ($^{a>b}$, $P<0.05$) among the age categories.

The global lesion prevalence showed a significant increase with animal age; this trend was in agreement with the results of previous studies [9, 13] and can be justified by the increased possibility for the animals to be affected by diseases or events having a negative impact on animal health.

An evident increasing trend was observed for liver and kidney lesions, observing a gradual increase following the age of the cows; for lung and heart lesions, the increasing trend was observed only until 7 years whereas a slight decrease was detected in older animals. The lesions in other sites showed an opposite trend with a marked decrease after 3 years of age and a further slight decrease as animals age increased. Such results were expected as the gradual occurrence of lesions through the animal life could be hypothesized for degenerative lesions (e.g. steatosis) that are favored by stress or intense production rate or for infections whereas the causes of destination of emergency slaughter could be due to traumatic events or can result from problems occurring during the first pregnancy/partum/lactation period. Even if some differences were observed between ES and RS animal populations (data not shown), the age trends of lesions detection rate were similar between the two categories.

CONCLUSIONS

Emergency slaughter is a crucial process in both the beef production chain and the life of an animal, and it is essential to

monitor this phase to ensure the well-being of animals and consumers. In this study the registration of gross *post mortem* lesions determining the condemnation of organs or the whole carcasses allowed to obtain a picture of the distribution of the main health/welfare problems occurring in the population of dairy cows in a representative area of Northern Italy. This function of slaughtering phase as "epidemiological observatory" is particularly important in higher risk situations such as anticipated slaughtering or emergency slaughtering that occur frequently for dairy cows. The combination of the elements supplied by *post mortem* examination can be easily combined with the information held in the documents accompanying the animals; in this study animal age and slaughtering season were analyzed showing an evident influence on lesions frequency. This study highlights the importance of utilizing the data collected by veterinary inspectors to obtain useful feedback for the continuous improvement of the production process: the outcomes allow the competent authority to identify the main risk factors and direct its procedures during inspection activity, but are also useful for food business operators, including farmers, allowing improvements of farming practices for a proper management of animals' health and welfare at farm.

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