

**Animal welfare in terms of lung health in cattle, pigs, sheep and goats assessed at slaughter**Lenka Válková<sup>1</sup>, Eva Voslářová<sup>1</sup>, Francesca Conte<sup>2</sup>, Vladimír Večerek<sup>1</sup><sup>1</sup>University of Veterinary Sciences Brno, Faculty of Veterinary Hygiene and Ecology, Department of Animal Protection and Welfare and Veterinary Public Health, Brno, Czech Republic<sup>2</sup>University of Messina, Department of Veterinary Sciences, Messina, Italy

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**Abstract**

Lung health has a significant impact on the well-being of farm animals. In this study, the incidence of lung damage in cattle, pigs, sheep and goats was monitored in animals slaughtered in slaughterhouses in the Czech Republic between 2010 and 2021. In fattened animals (bulls, finisher pigs, lambs and kids), the incidence of lung damage was statistically significantly the highest in finisher pigs (39.08%) followed by lambs (25.2%), bulls (13.1%) and kids (6.4%). In adult animals (cows, sows, ewes and does), the incidence of lung damage was significantly the highest in ewes (39.5%), followed by cows (36.4%), sows (23.7%) and does (21.5%). For chronic lung damage, the results showed significantly the highest incidence in finisher pigs (37.2%) and young culled from farms (calves 34.0%, piglets 31.3%). For acute lung damage, the results showed significantly higher incidence in piglets (27.4%) and calves (9.7%) compared to other categories of slaughtered animals. In cows and sows, the findings ranged approximately between 6–8%, and did not exceed 2% in the other categories. For parasitic lung damage, significantly the highest findings were found in ewes (25.8%) followed by lambs (17.1%), does (5.8%) and kids (1.0%). The incidence of parasitic lung damage in cattle and pigs did not exceed 0.05%. The differences between chronic, acute and parasitic findings in each category of animals were significant. The findings of lung damage illustrate the fact that the welfare of slaughter animals is inadequate and should be increased.

*Livestock, slaughter, postmortem examination, pathoanatomical findings*

The lungs are the primary organs of the respiratory system in animals, any alterations in their health have a very high impact on animal health and welfare (Archer et al. 2021). Lung disease is accompanied by clinically manifested respiratory problems and cough affecting the overall condition, growth, production and reproduction of the animals. Lung disease at a subclinical level affects the locomotor and possibly also other systems' condition of the animals. In acute lung diseases, elevated temperature, lethargy, reluctance to move and other signs limiting the natural behaviour of healthy animals are also present (e.g. Schneider et al. 2009; Leruste et al. 2012).

The level of lung health can be determined by examining the lungs of animals slaughtered in slaughterhouses. When large numbers of slaughtered animals are monitored, lung health assessment can provide an indication of the overall lung health and associated welfare level of slaughter animals in a particular region. By analysis of big data, findings at the level of general validity can be obtained. The veterinary examination is thus of great importance in terms of controlling the health of livestock (Stark et al. 2014; Stark 2017; Večerek et al. 2020a,b; Kaluža et al. 2021; Ninčáková et al. 2022). Pathoanatomical changes can be best monitored during postmortem examination at the slaughterhouse (Huneau-Salaun et al. 2015). A thorough analysis of trends in the incidence of pathoanatomical findings can provide feedback to farmers and veterinarians so that they can apply appropriate preventive measures to eliminate the risk of animal health risks and economic losses on their farms (Januskeviciene et al. 2010; Ceccarelli et al. 2018). The recording of lung lesions

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at slaughter provides more accurate information on the prevalence of respiratory problems in the herd than on-farm observation of clinical signs (Leruste et al. 2012).

Pathoanatomical findings on the lungs of slaughtered animals were mainly reported in studies dealing with the causes of condemnation of organs and carcasses of livestock during postmortem veterinary inspection. Lung findings were among the most frequent causes of seizure in cattle, sheep and horses examined in slaughterhouses in Italy between 2010 and 2016 (Ceccarelli et al. 2018). The most common causes for partial seizure of the lung were the inflammatory diseases of the pleura and parenchyma, thus pleurisy, pneumonia and bronchopneumonia. Pneumonic lungs were also among the most frequently reported portion condemnations by provincial inspectors in Ontario, Canada, in the period 2001–2007 (Alton et al. 2012). In Nigerian slaughterhouses, tuberculosis and pneumonia accounted for over 79% of bovine lung condemnations in the period from 1999 to 2002 (Opara 2005). Jaja et al. (2016) identified pleuritis, pneumonia, abscesses, haemorrhages and lung worms as major causes of lung condemnation in the Eastern Cape Province, South Africa in the period from 2010 to 2012.

Januskeviciene et al. (2010) analysed the occurrence of pathological findings in all slaughtered animals in selected slaughterhouses in Lithuania between 2000 and 2009 and found that lung findings occurred at a level of 7.4% to 78.98% in the slaughtered livestock and poultry species studied. Leruste et al. (2012) reported lung lesions in half of the calves originating from farms located in the Netherlands, France, and Italy that were examined post mortem at the slaughterhouse.

The aim of the study was to compare the level of lung damage manifested by pathological findings on the lungs at postmortem inspection for different species and categories of livestock. In terms of targeting potential measures to improve lung health in slaughter animals, the aim was to determine which categories had the highest and the lowest incidence of acute lung damage, chronic lung damage and parasitic lung damage. By comparing the overall occurrence of lung damage between the different categories of slaughtered animals, the aim was to identify which categories are most and least affected in terms of lung health, i.e. which categories of slaughter animals have the highest and lowest levels of reduced welfare due to lung damage. Based on the results, the need for changes in animal husbandry leading to improved lung health and thus also to improved welfare of cattle, pigs, sheep and goats slaughtered in slaughterhouses was inferred.

### Materials and Methods

The occurrence of lung damage detected by postmortem inspection in slaughterhouses was compared between different species and categories of slaughtered animals, namely cattle (cows, heifers, fattening bulls and calves culled from the farms), pigs (sows, finisher pigs and piglets culled from the farms), sheep (ewes and lambs) and goats (does and kids).

The monitoring included a large number of animals, the subjects of the analysis were all animals reared on the Czech farms and inspected after slaughter in the slaughterhouses in the Czech Republic from 2010 to 2021. The dataset comprised 1 348 393 slaughtered cows, 315 406 slaughtered heifers, 1 214 298 slaughtered bulls, 120 238 calves culled from the farms for fitness or health reasons, 683 912 slaughtered sows, 29 628 524 finisher pigs, 152 088 piglets culled from the farms for fitness or health reasons, 26 026 slaughtered ewes, 132 553 slaughtered lambs, 1 680 slaughtered does and 7 690 slaughtered kids. Postmortem examinations of the lungs were carried out by official veterinarians, recording the number of healthy lungs and the number of damaged lungs, broken down into chronic, acute and parasitic disorders.

From the number of animals slaughtered and the number of lung lesions detected, relative numbers expressed as percentages were calculated for each category of animals for the entire period under study.

For chronic, acute, and parasitic lung damage, it was investigated in which categories of slaughter animals lung damage occurred most frequently, in which less frequently, and in which least frequently. From the total numbers of lung damage, it was determined by comparing each category of animals with each other which categories of animals had the highest overall lung damage rates and thus the worst lung health and associated worst animal welfare in terms of lung health and fitness in slaughter animals.

Chi-square test was used to statistically compare the numbers of findings. *P* values lower than 0.05 were considered significant.

## Results

The occurrence of chronic lung damage in cattle, pigs, sheep and goats slaughtered in slaughterhouses is shown in Fig. 1. The results show that very high numbers of findings of chronic lung damage were detected in young animals culled from the farms for poor condition or health, namely in calves (34.0%) and piglets (31.3%). These numbers were significantly ( $P < 0.05$ ) different from other categories of slaughtered animals. Among fattened animals (bulls, finisher pigs, lambs and kids), the occurrence of chronic lung damage was significantly the highest in finisher pigs (37.2%), followed by bulls (12.0%), lambs (7.1%) and kids (5.3%). In adult animals (cows, sows, ewes and does), the occurrence of chronic lung damage was significantly the highest in cows (29.7%) followed by sows and does (15.8% and 15.3%, respectively) with no significant difference between them while it was the lowest in ewes (13.4%).

The occurrence of acute lung damage in slaughtered cattle, pigs, sheep and goats is shown in Fig. 2. The results show that the highest numbers of findings of acute lung damage were found in piglets (27.4%) and calves (9.7%), where the occurrence of findings was significantly ( $P < 0.05$ ) higher compared to all other categories of slaughtered animals.

The occurrence of parasitic lung damage in slaughtered cattle, pigs, sheep and goats is shown in Fig. 3. The results show that the highest numbers of findings of parasitic lung damage were found in ewes (25.8%) followed by lambs (17.1%), which had significantly higher ( $P < 0.05$ ) numbers of findings compared to all other categories of slaughtered animals. Relatively high numbers of parasitic lung damage were also found in does (5.8%) and kids (1.0%), in which the numbers of findings were significantly higher ( $P < 0.05$ )

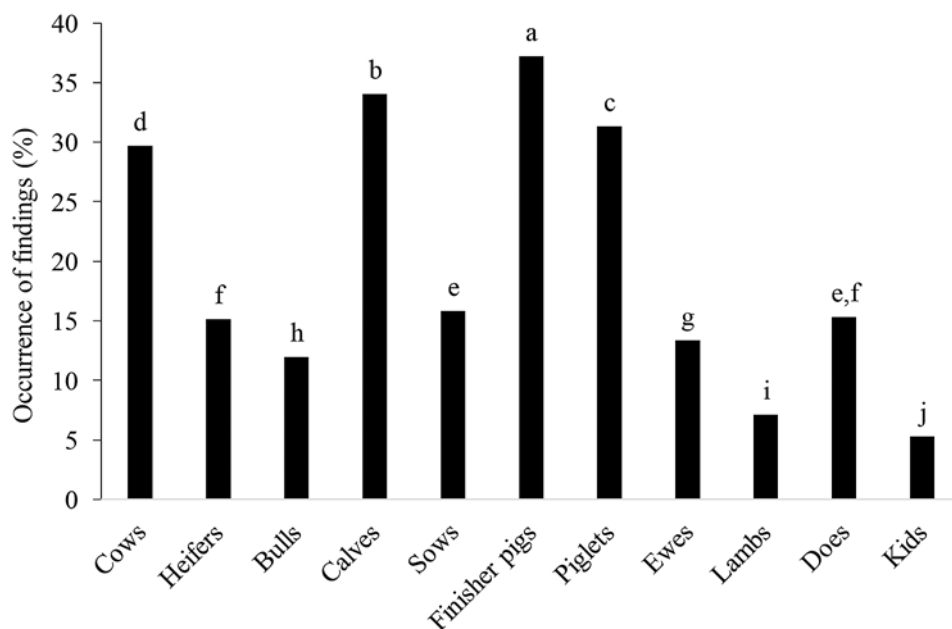


Fig. 1. Occurrence of findings of chronic lung damage in different categories of cattle, pigs, sheep and goats slaughtered in slaughterhouses in the Czech Republic.

<sup>a-j</sup> Different superscripts express a significant difference ( $P < 0.05$ ) between the individual species and categories of animals

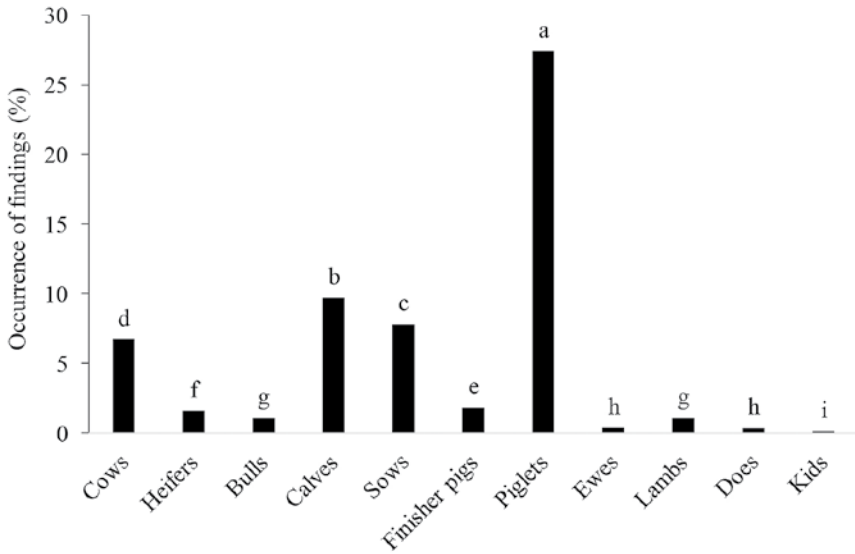


Fig. 2. Occurrence of findings of acute lung damage in different categories of cattle, pigs, sheep and goats slaughtered in slaughterhouses in the Czech Republic.

<sup>a-i</sup> Different superscripts express a significant difference ( $P < 0.05$ ) between the individual species and categories of animals

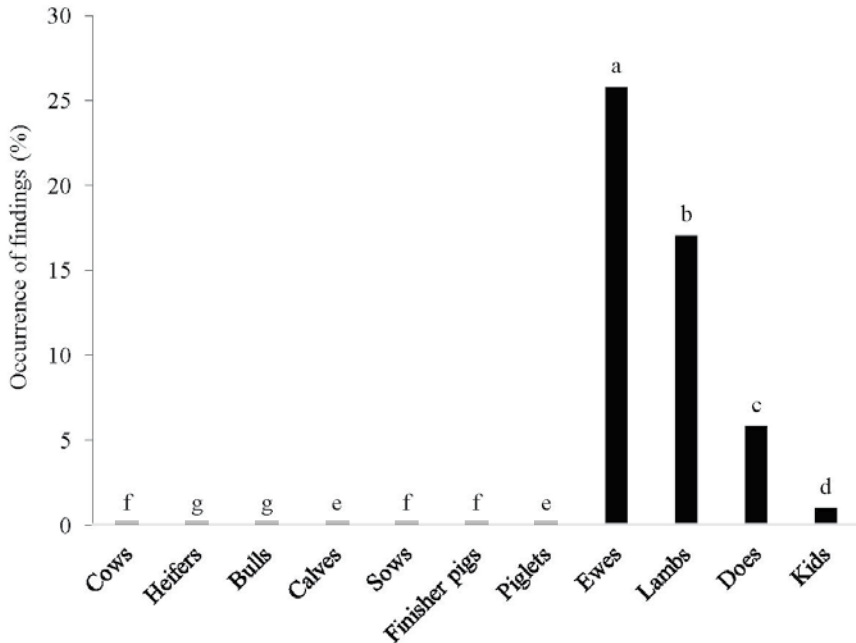


Fig. 3. Occurrence of findings of parasitic lung damage in different categories of cattle, pigs, sheep and goats slaughtered in slaughterhouses in the Czech Republic.

<sup>a-g</sup> Different superscripts express a significant difference ( $P < 0.05$ ) between the individual species and categories of animals

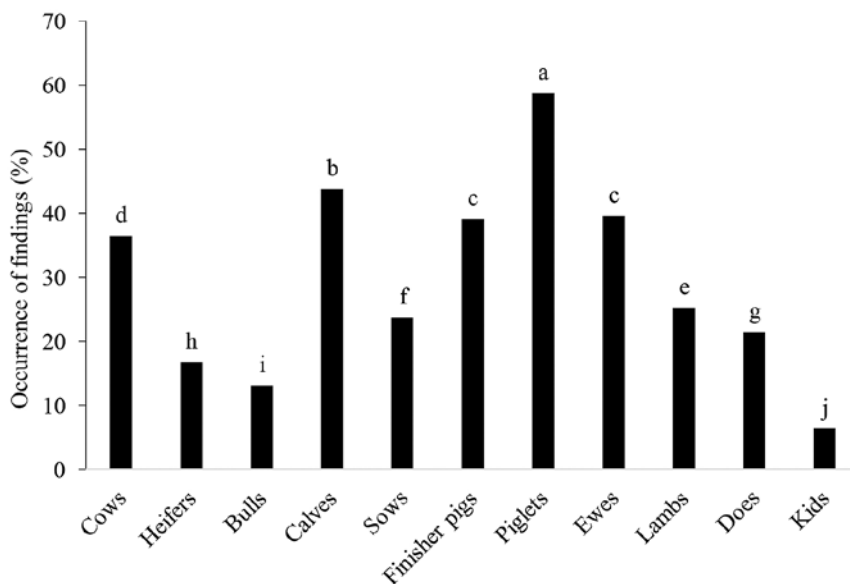


Fig. 4. Occurrence of findings of overall lung damage in different categories of cattle, pigs, sheep and goats slaughtered in slaughterhouses in the Czech Republic.

<sup>a-j</sup> Different superscripts express a significant difference ( $P < 0.05$ ) between the individual species and categories of animals

compared to cattle and pigs. The occurrence of parasitic lung damage in cattle and pigs was significantly ( $P < 0.05$ ) lower (not exceeding 0.05%) compared to the findings of parasitic damage in ewes, lambs, does and kids.

The differences between chronic, acute, and parasitic findings in each category of animals were significant ( $P < 0.01$ ). In all categories of slaughtered pigs and cattle, chronic lung damage was the most frequent, followed by acute damage while damage of parasitic origin was the least frequent. In ewes and lambs, the occurrence of parasitic lung damage was the highest, followed by chronic and then acute damage. Does and kids had the highest occurrence of chronic lung damage, followed by damage of parasitic and then acute origin.

The occurrence of overall lung damage in cattle, pigs, sheep and goats slaughtered in slaughterhouses is shown in Fig. 4. The results show that overall lung findings in slaughtered categories of cattle, pigs, sheep and goats are very high, ranging from 6.4% (does) to 58.7% (piglets).

## Discussion

Analysis of the number of lung lesions showed that very high numbers of chronic lung lesions were found in young animals culled from the farms (calves, piglets). These numbers were significantly different from all other categories of slaughtered animals. This finding means that young animals culled for poor condition or health suffered from varying degrees of chronic lung damage. The rearing systems used for calves and piglets often have deficiencies in terms of poor flooring and/or bedding, draughts, inability to keep them warm or prevent the impact of low ambient temperatures on animals with reduced

thermoregulation, thus leading to hypothermia and subsequent pneumonia, which, given the long-term effects of the rearing deficiencies, develop into chronic lung damage in the animals. Reinhold and Elmer (2002) found the relationship between short-term changes in ambient temperature and the occurrence of variable pneumonic lung lesions in calves 21 days post exposure. Chronic pneumonia affects overall health, animals show lower growth rates which result in them being culled from the farms. Respiratory dysfunction and coughing accompanying chronic pneumonia significantly affect the welfare of calves and piglets on farms. Respiratory diseases have a major impact on the welfare of growing pigs (Algers et al. 2007) as well as young calves (McGuirk and Peek 2014).

The very high occurrence of chronic lung damage in finisher pigs compared to other fattening categories of animals is probably due to the confined housing technology with a high concentration of animals allowing easy transmission of disease between animals and the species' high susceptibility to respiratory diseases, usually of infectious origin. Increased dustiness on farms due to the feeding of bulk mixtures may also be a negative factor, thus negatively affecting the respiratory system and increasing its susceptibility to infectious diseases. These factors promote the spread of respiratory diseases on fattening pig farms and the development of long-term pneumonia in a large number of animals, manifested in slaughterhouses by a high proportion of animals with findings of chronic lung damage.

Januskeviciene et al. (2010), who analysed the occurrence of pathological findings in animals slaughtered in Lithuanian slaughterhouses between 2000 and 2009, found that lung findings occurred in 70.4% of clinically healthy slaughtered pigs. The high occurrence of lung lesions in pigs is consistent with the findings of other studies, according to which lung lesions are the most frequently diagnosed pathology in pigs at postmortem examination (Osborne et al. 1981; Wilson et al. 1986; Hansson et al. 2000). The occurrence of pathological findings in the lungs of pigs was also highlighted by Köfer et al. (1993) and Schuh et al. (2000) in Austria.

In the Czech Republic, fattening bulls are not reared in confinement and the species' susceptibility to respiratory diseases is not as high as in pigs. The occurrence of chronic diseases is therefore significantly lower in bulls than in finisher pigs, given the way they are reared and fed. However, the prevalence of lung lesions may be different in large beef feedlots. Schneider et al. (2009) found lung lesions in 61.9% of feedlot cattle slaughtered and examined at a commercial packing plant in Iowa.

Lambs are reared on pasture, where factors affecting the spread of respiratory disease are reduced, and the occurrence of chronic lung damage in lambs is thus significantly lower than in finisher pigs or bulls. The same is true for kids that are reared with a high proportion of natural grazing. According to Yaeger and van Alstine (2019), open systems offer many protective factors against respiratory diseases, particularly in terms of air quality, compared with confined conditions and thus also pigs kept in such farming systems seem to be less affected by respiratory diseases.

In adult animals (cows, sows, ewes and does), the highest occurrence of lung damage was found in cows (20.7%) followed by sows and does (15.8% and 15.3%, respectively), and the lowest was found in ewes (13.4%). These results are quite surprising. The common free-stall indoor housing system for rearing cows should not lead to a significantly higher occurrence of lung damage in cows compared to sows, where, on the other hand, rearing in barns with a high concentration of animals and the susceptibility of pigs to respiratory disease could be expected to lead to higher numbers of findings of chronic lung lesions. An explanation for the high occurrence of chronic lung damage in cows compared to sows may be the higher lifespan of cows compared to sows increasing the likelihood of chronic lung disease in cows, and the higher level of care provided to sows on the farm, as the reproductive potential of sows is significantly higher than that of cows and the illness

or loss of each sow significantly reduces the economics of the farm. Similarly, Rezac et al. (2014) observed mild lung lesions in 23.5% and severe lung lesions in 10.3% of culled cows evaluated at a commercial slaughterhouse in the United States. Considering the lung lesion prevalence rates, more attention to diagnosis and treatment should be given to cows on farms. Rezac et al. (2014) also evaluated odds ratios and found that 33.4% of cattle with a liver abscess also had a lung lesion, whereas 68.5% of cattle that did not have a lung lesion did not have a liver abscess. Data analysed in our study do not enable such comparisons but Válková et al. (2023a) who compared the incidence of liver damage in livestock slaughtered in the Czech Republic found it to be the highest in cows (46.38%). Moreover, also the incidence of kidney damage was reported to be the highest in cows (40.46%) compared to other species and categories of farm animals slaughtered in the Czech Republic (Válková et al. 2023b).

The occurrence of chronic lung damage is lower in does and ewes than in cows likely due to the pasture management of sheep and goat outdoor farming that allows the animals to regulate the environment to their comfort and thus reduce the possibility of hypothermia resulting in pneumonia; moreover, some chronic lung findings may be of parasitic origin (e.g. *Dictyocaulus filaria*, *Protostrongylus rufescens*, *Muellerius capillaris*) (Vasileiou et al. 2015) with the animal overcoming the invasion, and thus the number of chronic lung findings in ewes and does may actually be even lower.

The occurrence of the highest number of acute lung damage findings in piglets (27.4%) and calves (9.7%) compared to other slaughtered animal categories corresponds to young animals culled for poor condition or health being affected by varying degrees of acute lung inflammation, which affect overall health and result in lower growth rates that eventually lead to culling. Acute lung damage with clinical manifestations, most commonly elevated temperature, varying degrees of lethargy, difficulty breathing, coughing or even subclinical manifestations, significantly affects animal welfare (e.g. Schneider et al. 2009; Leruste et al. 2012).

The findings of parasitic lung damage were low and did not exceed 0.05% in pigs and cattle. In contrast, a high occurrence of parasitic lung damage was found in ewes (25.8%) and lambs (17.1%). Parasitic findings were the most common type of lung damage found in sheep, in contrast to pigs, cattle and goats, which had more frequent findings of chronic lung damage. Systems of small ruminant production involve a component of grazing as part of routine husbandry, which favours the spread of parasitic forms which include internal parasites of the respiratory system (Vasileiou et al. 2015). Thus, the findings are consistent with the fact that ewes and lambs are reared on pastures where lungworm invasion and subsequent lung damage occurs, with a higher frequency of lung damage by parasitic lungworm in ewes compared to lambs due to age. Goat farming is usually a combination of outdoor grazing and indoor housing, thus lungworm infestation of goats is significantly lower than in sheep, and again the problem is more pronounced in does compared to kids, given their age. This corresponds to the lower numbers of parasitic lung damage found in does (5.8%) and kids (1.0%). Parasitic lung damage is associated with clinical signs of laboured breathing and coughing (Engdaw 2015), and these health impairments considerably affect the fitness and natural behaviour of the animals, thus notably reducing the welfare of ewes and lambs, but also of does and kids.

In conclusion, the numbers of findings of lung damage in slaughtered categories of cattle, pigs, sheep and goats were very high and illustrate the fact that the welfare of slaughter animals is inadequate and should be improved by targeted health measures aimed at reducing the occurrence of lung disease. By improving the lung health of animals on farms, it would be possible to achieve a major improvement of welfare in all categories of animals reared for slaughter.

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