

Health and economic burden of pathological lesions in livers and lungs of slaughtered sheep at Mosul Abattoir, Iraq

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Abstract

Background: Slaughterhouses can provide valuable information about animal diseases and their epidemiology.

Objectives: The current study was designed to examine the health and economic burden of pathological lesions in livers and lungs of slaughtered sheep at Mosul abattoir, Iraq.

Methods: Mosul abattoir records for sheep slaughtered between 2011 and 2013 were considered for inclusion in this study. The direct financial loss due to liver and lung lesions was estimated considering the average number of slaughtered sheep per year, the average percentage of liver lesions per year, and the average percentage of lung lesions per year. Monetary values of the liver and lung were obtained from local butcheries.

Results: The analysis indicated that the percentage of lesions observed in the liver and lung per year was 6.9% and 5.8%, respectively. Hydatid cyst followed by hepatitis was the most frequent lesions identified in the liver, while pneumonia then hydatid cyst were detected in the lung, followed by worms, abscess, and miscellaneous lesions. Hydatid cyst was the most frequently observed lesions. The average total loss was 35,232 USD per year (mostly due to liver lesions), with ± 7046 USD sensitivity to the price change.

Conclusions: The percentage of lesions observed in the liver and lung per year is not negligible and can cause considerable economic losses.

KEYWORDS

hepatitis, hydatid cysts, pneumonia, slaughterhouse

1 | INTRODUCTION

Meat inspection at slaughterhouses is an important step in preventing the spread of diseases between animals or transmission of the infection from animals to humans. That is, meat inspection is considered an effective way for detecting most conditions in animals that appeared healthy during ante-mortem inspection (Stärk

et al., 2014). Different lesions and abnormal tissues or organs have been identified in apparently healthy slaughtered animals (Mesfin & Mekonnen, 2014; Okoli et al., 2006). Hydatidosis, for instance, is considered a major reason for partial condemnation of carcasses because of its zoonotic concern, leading to economic losses of the affected livers and lungs (Eckert & Deplazes, 2014; Solusby, 1986).

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Several studies have been conducted to investigate different pathological lesions in organs of slaughtered sheep at the slaughterhouse in Mosul, Iraq. In one study, 12% and 6% of examined lungs and livers, respectively, were affected with hydatid cysts (Al-Sultan et al., 1987). In another study, 2% of slaughtered sheep were positive for hydatid cysts, where 47%, 32%, and 21% of the cysts were detected in the liver, lung, and both liver and lung, respectively (Jarjees & Al-Bakri, 2012). On the other hand, 2%–18% of slaughtered sheep were infected with *Cysticercus tenuicollis* cysts mostly detected at the peritoneal cavity (Al-Bakri, 2012; Al-Sultan et al., 1999). In a more recent report, 13.5% of slaughtered sheep had liver and/or lung lesions (Thannon, 2017). In that study, the most predominant lesions were different types of inflammations, abscess, hydatid cysts, parasitic infestations and congestions.

The burden of pathological lesions in the livers and lungs of slaughtered sheep at Mosul abattoir has different knowledge gaps. That is, the seasonal burden and annual percentage of the lesions were not reported in the study by Thannon (2017) because it was limited to only two months. In addition, the burden of liver and lung lesions was limited to hydatid cysts (Al-Sultan et al., 1987; Jarjees & Al-Bakri, 2012) and *Cysticercus tenuicollis* cysts (Al-Bakri, 2012; Al-Sultan et al., 1999). Finally, the economic burden due to liver and lung lesions was not calculated in all previous studies in the city. Therefore, the current study was designated to examine the health and economic burden of pathological lesions in livers and lungs of slaughtered sheep at Mosul abattoir, Iraq.

2 | MATERIALS AND METHODS

2.1 | Study subjects and data collection

Apparent healthy sheep slaughtered between 2011 and 2013 at Mosul abattoir were considered for inclusion in this study. Data after these years are not available due to the destruction of the abattoir after the war that happened in the city in 2014 and later. Gross examination of the carcasses was performed by attending veterinarians directly after the slaughtering. Abattoir records were used to collect the following data: number of slaughtered sheep per month, pathological lesions reported in the liver and lung (including hydatid cyst, hepatitis, pneumonia, liver flukes, lungworms, abscesses and other miscellaneous lesions) and number of condemned carcasses. The pathological lesions in the liver and lung were identified according to standard definitions of the lesions observed during meat inspection (Herenda et al., 1994). In brief, a hydatid cyst is defined as a 5–10 cm cyst containing fluid; hepatitis is defined as an enlarged liver with swollen edges and pale or red in colour; pneumonia is defined as a sunken and congested lung with or without hepatisation or presence of exudate in the bronchioles; a liver fluke infection is characterised by the presence of leaf-shaped flukes have 2.5–5 cm by 1.3 cm dimensions found in thickened bile ducts and liver parenchyma; a lungworm infection is characterised by the presence of small fibrous nodules up to 5 mm in diameter containing only one live or dead worm; an abscess is defined as localised collected pus separated from the surrounding tissue by a fibrous capsule and the miscellaneous lesions are other than previously mentioned lesions.

2.2 | Statistical analysis

A descriptive analysis was performed to indicate the proportion of lesions observed in the liver and lung per year and the proportion of the lesions on a basis of the organ (liver/lung) and the lesion. Moreover, the proportion of different lesions diagnosed in the liver/lung was calculated for each season of the year. In this study, seasons were identified based on the mean of maximum and minimum temperatures (°C) for each month in Mosul city obtained from Iraqi meteorological organisation and seismology, station 608, Mosul, as previously described (Dahl et al., 2021). That is, autumn was from October 1 to November 30 with a minimum temperature of 10–20°C and a maximum of 20–35°C, winter was from December 1 to February 28 with a minimum temperature of <10°C and a maximum of <20°C, spring was March 1 to May 31 with a minimum temperature of 10–20°C and a maximum of 20–35°C and finally summer from June 1 to September 30 with a minimum temperature of >20°C and a maximum of >35°C. Chi-square for aggregate data was conducted using STATA 13.0 (StataCorp, College Station, TX) to compare the differences between the lesions over different seasons. Finally, numbers were reported as proportions, and a value of $p \leq 0.05$ (two-tailed) was considered significant.

2.3 | Economic analysis

In this analysis, the direct financial loss due to liver and lung lesions was estimated considering the average number of slaughtered sheep per year, the average percentage of liver lesions per year and the average percentage of lung lesions per year that were obtained from data of the current study. Monetary values of the liver and lung were obtained from local butcheries. The monetary value of a kilogram of the liver in the local market is 14,000 Iraqi Dinars (ID). The monetary value of the lung in the local market is 2000 ID. In this study, monetary values were adjusted for the average inflation rate for 3 years (2011, 2012 and 2013; <https://www.worlddata.info/asia/iraq/inflation-rates.php>) where the 1000 ID in 2011 to 2013, on average, worth 1128.59 ID in 2021. Thereupon, the average of the direct loss per year due to liver and lung lesions was calculated as: (average number of slaughtered sheep per year \times average number of liver lesions per year \times 15800.26 ID) and (average of slaughtered sheep per year \times average of lung lesions per year \times 2257.18 ID), respectively. The average of the total direct loss constituted the sum of both estimated prices. Final prices were exchanged to US dollars, with an exchange rate of 1 USD = 1450 ID. Finally, a sensitivity analysis was conducted by adjusting the values of kg of liver and the value of lung by $\pm 20\%$.

3 | RESULTS

The average number of sheep slaughtered per year at Mosul abattoir was 41,835. The percentage of lesions observed in the liver and lung per year was 6.9% and 5.8%, respectively (Figure 1). On a basis of the organ, the hydatid cyst followed by hepatitis were the most

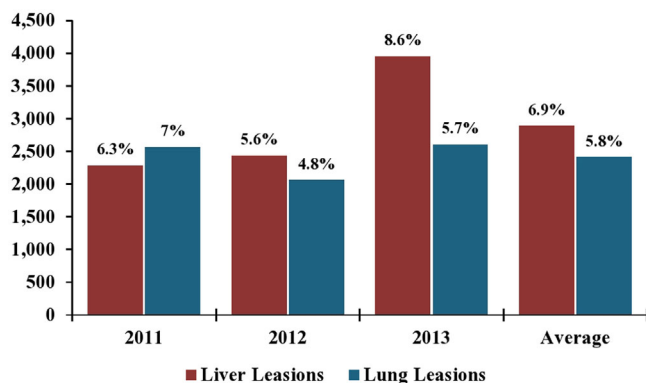


FIGURE 1 Proportions of liver and lung lesions observed per year in sheep slaughtered at Mosul abattoir

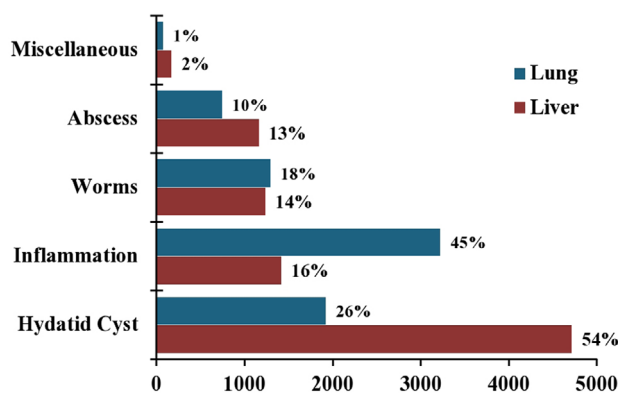


FIGURE 2 Proportions of different lesions on a basis of the organ (liver/lung) observed in sheep slaughtered at Mosul abattoir

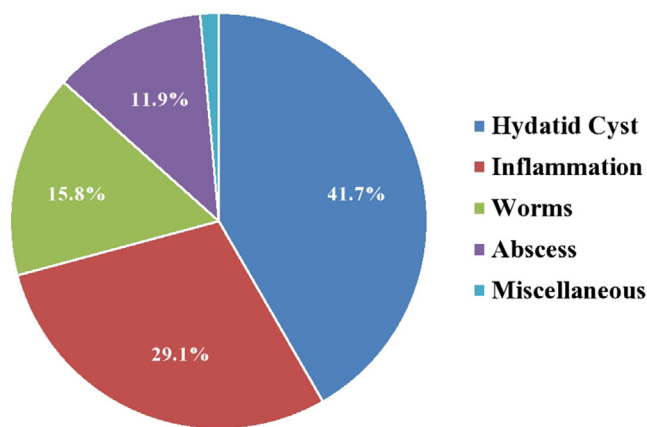


FIGURE 3 Proportions of different lesions on a basis of lesions observed in the liver and lung in sheep slaughtered at Mosul abattoir

common lesions identified in the liver, while opposite trend (i.e., pneumonia then hydatid cyst) was detected in the lung, followed by liver flukes/lungworms, abscess and miscellaneous lesions (Figure 2). On a basis of the lesion, the hydatid cyst was the most common lesion observed followed by hepatitis/pneumonia, worms, abscesses and miscellaneous lesions (Figure 3). On the other hand, the proportion of a

lesion observed in the liver or lung over different seasons was statistically different without a specific trend over the seasons (Table 1). Finally, the average direct financial loss due to liver and lung lesions was 31,455 and 3777 USD per year, respectively. The average total loss was 35,232 USD per year, with ± 7046 USD sensitivity to the change in the prices.

4 | DISCUSSION

Slaughterhouses can provide valuable information about animal diseases and their epidemiology. Potential human infection with zoonotic diseases can arise from consumption or manipulation of contaminated meat or offal; therefore, careful and proper ante- and post-mortem examination at abattoirs can prevent such infections (Raji et al., 2010). The current study indicated that the percentage of lesions observed in the liver and lung per year in the carcasses of apparently healthy sheep was 6.9% and 5.8%, respectively, with an average financial loss of 35,232 USD per year.

In this study, the hydatid cyst was the most lesions observed followed by hepatitis/pneumonia, worms, abscesses, and miscellaneous lesions. The current study confirms the results of previous studies for Al-Sultan et al. (1987) and Jarjees and Al-Bakri (2012) that the hydatid cysts in the liver and lung of slaughtered sheep in Mosul are highly prevalent. In a recent study, hydatid cysts were detected in 7.3% of sheep carcasses slaughtered at the abattoir of Basrah province (Abdulhameed et al., 2018). In that study, hydatid cysts were diagnosed in 54.3% of examined livers and lungs. The predominance of hydatid cyst in the liver and lung of apparently healthy slaughtered sheep indicated the spread of the infection among animals. One reason for this spread is that sheep owners usually have several dogs in their flocks, the definitive host for the *Echinococcus granulosus* (dog tapeworm) that is highly prevalent in local dogs (McAfee et al., 2010), which shed the eggs in their faeces, contaminating sheep food (Solusby, 1986). Consequently, the public health burden of this zoonotic disease is considerable.

The study reported here indicated that hepatitis/pneumonia was the second most common pathological lesion observed in the slaughtered sheep. One reason for the high rate of hepatitis in study carcasses is that local sheep rearing is based on grain feeding, which can cause acidosis followed by ruminitis and erosion of ruminal epithelia resulting in metastasis of pathogenic bacteria to the liver forming foci of inflammation and abscesses (Constable et al., 2017). On the other hand, pneumonia was the most common pathological condition detected in the lung in the current study. In a recent clinical study, respiratory infections were the second most frequent cases of sheep received at the Mosul' Veterinary Teaching Hospital (Dahl et al., 2021), which can explain the high percentage of lesions in sheep carcasses identified as pneumonia in the current study. The stressful environment, that is, hot and dry environment in the summer and the cold and rainy environment in the winter, can decrease the immunity of the animals and may increase the odds of development of respiratory infections (Muheet et al., 2019).

TABLE 1 Proportions of different lesions diagnosed in liver/lung in sheep slaughtered at Mosul abattoir over the season

Variable	Autumn (n = 20,480)	Winter (n = 25,549)	Spring (n = 27,668)	Summer (n = 51,809)
Total liver lesions	5.6 c	5.8 c	7.0 b	7.9 a
Hydatid cysts	50.2 c	51.2 c	58.3 a	54.8 b
Hepatitis	17.1 a	15.7 ab	13.5 b	17.6 a
Liver flukes	17.8 a	14.6 b	12.4 b	13.9 b
Liver abscess	13.9 a	13.8 a	14.1 a	12.6 a
Miscellaneous lesions	1.0 b	4.7 a	1.6 b	1.2 b
Total lung lesions	3.7 a	5.8 b	6.6 c	6.1 b
Pneumonia	45.7 ab	45.4 ab	46.6 a	42.6 b
Hydatid cysts	17.4 b	28.4 a	28.5 b	26.6 b
Lungworms	22.4 a	18.7 b	13.0 c	19.1 b
Lung abscess	14.4 a	6.8 c	9.8 b	11.1 b
Miscellaneous lesions	0.1 b	0.7 b	2.1 a	0.5 b

Note: Different letters horizontally indicates statistical difference ($p \leq 0.05$).

In this study, liver flukes and lungworms were diagnosed in many carcasses. This observation indicates the spread of parasitic infection among local sheep. Liver flukes and lungworms were previously identified in 21.47% and 12.37%, respectively, in infected livers and lungs (Thannon, 2017). On the other hand, seasonal differences of the liver and lung conditions did not have a trend for the increase or decrease in a particular season, indicating that a particular condition might not be predictable on a basis of the season. However, liver lesions, generally, showed a linear increase in the frequency recorded in the autumn to the next summer similar to that trend observed by Dahl et al. (2021) on a clinical basis. Summer is considered a stressful season on animals in Mosul because of the hot and dry weather which causes metabolic changes, oxidative damage and immune suppression (Lacetera, 2019) and thus increases clinical diseases and consequently, pathological lesions observed on the carcasses.

The current analysis indicated that the average total financial loss due to liver and lung lesions in sheep carcasses was 35,232 USD per year, with more loss due to liver lesions. Both liver and lung are edible; however, the burden of the financial loss due to liver lesions was greater because the liver is more commonly eaten compared to the lung. Thus, the local price is much higher. The study conducted here is considered the first local study in Mosul that calculated the financial losses due to such liver and lung infections. In Basrah province, the cost due to hydatid cysts diagnosed in the livers and lungs was estimated at 72,470 USD annually (Abdulhameed et al., 2018). Although it is difficult to compare the findings of the current study with those in different countries, our finding for economic burden due to liver and lung infections is in line with what has been found in other counties that condemnation of edible organs can cause not negligible economic loss (Abatemam et al., 2018).

5 | CONCLUSIONS

The current study indicated that the percentage of lesions observed in the liver and lung per year is not negligible and can cause considerable economic losses. Lesions that are of public health concerns constituted a considerable proportion. The proportion of such affections can reflect the spread of different diseases, whether clinical or subclinical, among living animals.

6 | POLICY OPTIONS

Although having slaughtered sheep free from pathological lesions observed on different organs is difficult, several procedures can reduce the proportion of partial condemnation. The most important lesions are that have public health concerns such as hydatid cysts. Consequently, the first step towards decreasing partial condemnation is to control animal disease on a clinical basis, particularly the *Echinococcus granulosus* in dogs to decrease the odds of forming the hydatid cysts in the intermediate hosts, particularly sheep. An additional possible option is the introduction of a surveillance program in local abattoirs to track different diseases in different animals, particularly for those most frequently observed in the carcasses.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest in the research.

AUTHOR CONTRIBUTIONS

Dh.M. Jwher: conceptualisation, methodology, data curation and writing initial draft. M. Dahl: conceptualisation, methodology, data curation, formal analysis and writing the final draft. Sh. Saeed and A. Abdalazeez: data collection.

ETHICAL STATEMENT

Ethical approval was not required for this study because data were collected from the records of the slaughterhouse.

DATA AVAILABILITY STATEMENT

All relevant data are within the paper.

PEER REVIEW

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