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Assessment of physical facilities and detection of post-mortem lesions in public abattoirs in selected districts of Wolaita zone, Ethiopia

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Abstract

Background Participatory abattoir appraisals and observational analysis were conducted in selected local abattoirs in the Wolaita, Ethiopia with the aims of assessing (i) the physical facilities available in these abattoirs and (ii) the detection of post-mortem gross lesions upon routine meat inspection that may have been due to infectious diseases.

Methods Our study surveyed public abattoirs to evaluate meat inspection services and facility standards. Gross lesions in slaughtered animals were categorized by consistency, prioritized using a scoring matrix, and analyzed for anatomical distribution. Concordance in prioritization was assessed with Kendall's W test.

Results Our investigation revealed that almost all public abattoirs surveyed had substandard physical facilities for conducting meat inspection services. According to statistics from the studied abattoirs, 26.6% of slaughtered animals exhibited at least one grossly visible lesion, of which 65% were considered by the local veterinary inspectorate to have potential animal or public health significance. Among the identified lesions, 10% were classified as having a 'soft' consistency (e.g., cystic or caseous/abscess), while 5% were categorized as 'hard' (e.g., fibrotic, firm, fibrous, or mineralized). The remaining 85% of lesions were uncategorized. Using a prioritization matrix scoring method, the overall mean proportional priority rank data indicated that 'mineralized/calcified' hard lesions were assigned the highest priority (0.67), followed by 'cystic' lesions (0.58). The evidence for group concordance in prioritization was moderate ($W = 0.275$; $p = 0.019$). Regarding anatomical distribution, the survey groups ranked gross lesions in the lungs and associated mediastinal and bronchial lymph nodes as the top priority (0.67). Lesions in the small intestine and mesenteric lymph nodes (0.33) were ranked second, followed by lesions in the hepatic lymph nodes (0.42). There was strong concordance in the overall mean ranking of these lesion sites within the survey groups ($W = 0.518$; $p = 0.0001$). Some of the gross lesions detected in this study may pose a potential zoonotic risk (e.g. tuberculosis).

Conclusions This study highlights how infrastructural deficiencies and operational procedures in abattoirs can contribute to poor quality and potentially diseased meat entering the human food chain, features which need to be addressed locally to safeguard public health.

Keywords Abattoir, Appraisal, Bovine, Cattle, Local, Meat inspection, Survey, tuberculosis

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Introduction

Ethiopia is a low-income country, where agriculture remains the backbone of the economy. With over 70 million cattle [1] the country has the largest population in Africa. Livestock contribute to 16.5% of the national GDP, 35.6% of the agriculture GDP and 15% of export earnings [2]. Ethiopia's large cattle population is a key contributor to household nutrition and income for the rural population, serving as a milk and meat provider, or as a draft capacity in mixed crop-livestock systems which remain largely un-mechanized [3, 4]. In Ethiopia, constraints on efficient livestock production include endemic disease, poor nutrition, traditional husbandry practices, and limited market access [5–7].

Beef is central to the diet of the human population [8]. The Wolaita community traditionally consume raw beef (termed "*hot*" or unrefrigerated by local consumers) through a long-established backyard slaughtering system (termed '*amuwa*'). The Veterinary Quarantine division of the municipal government provides an abattoir meat inspection service to minimize the risks of zoonotic disease resulting from the preparation and consumption of uncooked meat. However, unauthorized 'backyard' slaughter of cattle also takes place (by systems known as '*lekuanda*', *medeb*', and '*amuwa*') because of a commonly held perception that public abattoirs provide an inadequate service to both beef producers and consumers.

Meat inspection is central to control and prevention of several zoonoses, such as *bovine tuberculosis* and *cysticercosis*. As such, public abattoirs in low-income countries such as Ethiopia play a crucial role in public health. The main purposes of the government veterinary service are to ensure animal health and welfare, mitigate the spread of zoonoses, and to provide safe animal products [9]. The lack of standard operating procedures in public abattoirs that serve the local, zonal administrations across Ethiopia, together with the absence of laboratory confirmation of the identified lesions, currently undermines the full potential of abattoir inspection of carcasses as a vital, cost-effective method of disease surveillance at the local level (it should be noted that none of the abattoirs studied served export markets). As the federal Ethiopian government is investing in public abattoirs, the extent of constraints and deficiencies in this surveillance system should be highlighted to further improve public and animal health. Also, anecdotal evidence suggests that local butchers and meat retailers often prefer to use backyard premises because of the perceived poor service delivery of public abattoirs. Over-reliance on backyard slaughter premises can result in substandard meat inspection procedures and high levels of meat contamination.

A key objective of the current research was to survey the physical facilities available in public abattoirs as a basis on which to assess and then address abattoir deficiencies. Previous studies performed in this region [10, 11], reported on the major causes of organ condemnations in cattle slaughtered in a single Sodo abattoir. However, as these studies were exclusively conducted at one abattoir, a more comprehensive survey was deemed necessary to achieve a more comprehensive overview of local disease epidemiology. Hence, a second objective of this study was to determine what type of broad classifications of pathological lesions were being identified through the routine meat inspection process in these public abattoirs.

Methods

Study area descriptions

This study was conducted in the district municipal abattoirs of Wolaita, southern Ethiopia between September 2019 and April 2020. The Wolaita zone has a total area of 4471.3km^2, of which 6.4% is cultivatable and 51.7% is cultivated land, 11.9% is grazing land, and 30% represents other land usage. The average crude population density is 425 people/km^2. Wolaita is about 390 km south of the capital Addis Ababa (Fig. 1). Government administration is centered in Sodo, the capital town. The area is 1500–2738 m above sea level (m.a.s.l.) and is characterized by bimodal rainfall that is highest from July to September with the second peak between March and May; average annual rainfall is 1200–1600 mm. The yearly temperature range is 20-35°C. According to the Wolaita zone Bureau of Livestock and Fish Resource report (BoLFR) from 2018/19, the average livestock population in the area was over 5.6 million of which 35.3% were cattle. In the Wolaita zone there are twelve municipal abattoirs and over thirteen 'backyard' slaughterhouses where approximately 22,342 cattle are slaughtered annually (BoLFR 2018/19). The survey was conducted in twelve municipal/public abattoirs located across three distinct agro-ecological zones, classified based on altitude above sea level (Fig. 1): (i) the lowland region ('Kola') at < 1700 m.a.s.l. ($n = 5$), (ii) the midland region ('Woynadega') at 1700–2000 m.a.s.l. ($n = 3$), and (iii) the highland region ('Dega') at > 2000 m.a.s.l. ($n = 4$). The average distances of the abattoirs from Sodo, the closest main town, and the district's main road were 34.25 km and 2.29 km, respectively (Table 1).

Study participants

The study targeted the abattoir workers and attendant veterinarians involved in the meat inspection procedures in the study abattoir. These participants volunteered, and each had been working for at least one year in their respective premises. Orientation was given to each of the participants on the method and purpose of the assessment and the survey was conducted as per the research ethics approval by the Wolaita Sodo

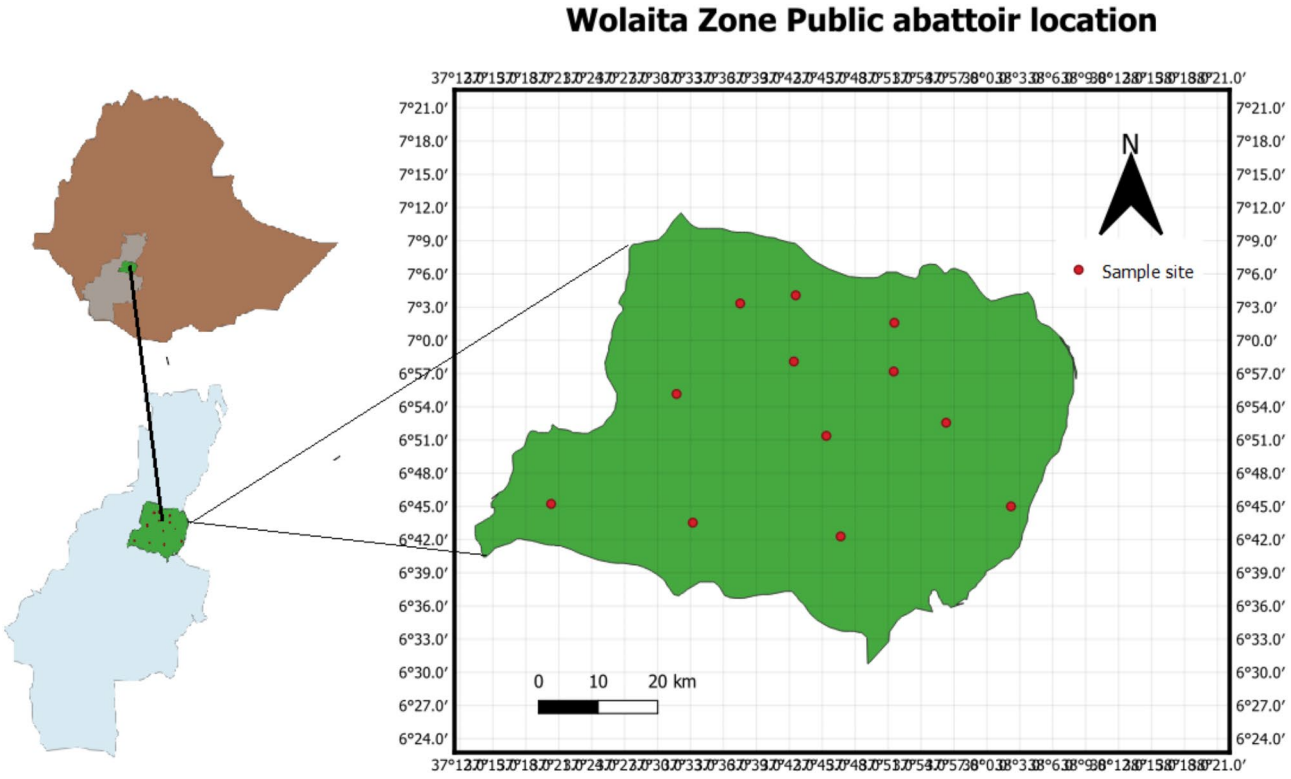

Fig. 1 The public abattoir locations in Wolaita zone. The left-hand upper panel shows the broad geographical context with a map of Ethiopia (brown) and a 'zoom-in' showing the Wolaita zone in the southwest (green section). The right-hand panel shows the Wolaita zone where the red dots indicate the 12 public abattoir locations that formed the basis for our study. The inner scale bar on the right-hand panel shows distance in kilometers, with the external grid markings showing latitude and longitude

Table 1 Wolaita zone cattle population and annual slaughtered service information at the selected public abattoirs

Abattoir location	Distance from the main town sodo (km)	Distance from the district main road (km)	Metric GPs data (m.a.s.l)	Agro-ecological zone (AEZ)	Number of active staff	Number of slaughter service days/week	Cattle population (2018/19)	Number of VAT registered butchers (2018/19)	Number of cattle slaughtered in public abattoirs annually
Sodo Zuria	0	2.5	2375	Highland	35	5	269,920	25	6,720
Boloso sore	29	3	1803	Midland	25	4	118,211	15	3,024
Damota Gale	18	2.5	2015	Highland	24	4	158,444	12	2,520
Boloso Bombe	60	2	1603	Lowland	15	2	74,623	13	784
Damota Fulasa	25	3	1958	Midland	13	2	83,452	7	1,680
Damota Woide	38	1.5	1724	Midland	14	2	96,113	5	780
Duguna Fango	45	2	2173	Highland	12	1	198,048	2	823
Humbo Tabala	16	2	1645	Lowland	16	3	228,385	7	1,680
Gesuba Ofa	35	3	1560	Lowland	14	2	203,702	6	1,568
Damota Sore	15	2.5	2081	Highland	13	2	129,913	9	1,344
Kindo Koysha	50	1.5	1231	Lowland	12	2	221,123	5	728
Kindo Didaye	80	2	2296	Highland	11	1	219,592	2	691
Total							2,001,526	133	22,342

BoLFR, Bureau of Livestock and Fish Resource; VAT, Value added tax; ALT: altitude (< 1700 m above sea level (m.a.s.l.) lowland (Kola); 1700–2000 m.a.s.l. midland (Wonadega); and > 2000 m.a.s.l. highland (Dega) districts)

Data source: Wolaita zone BoLFR 2019 for cattle population data and butcher house information in the zone

University Institutional Research Ethics Review Board (WSUIRERB).

Study design

A cross-sectional visit to 12 public abattoirs was carried out to assess the availability and condition of physical facilities and to evaluate the detection of significant gross lesions during routine meat inspections. The survey was conducted in the selected public abattoirs using participatory abattoir appraisals and observation. The study context aimed to generate baseline information to support a PhD study in the abattoirs by the lead researcher (MYZ) which focuses on tuberculosis in cattle in Wolaita.

Data collection

The participatory abattoir appraisal and observational analysis were conducted in local abattoirs ($n = 12$) within Wolaita. At each site, an abattoir appraisal group comprising ten key informants was formed. Participants were selected based on their willingness to participate and having at least one year of experience working in the local abattoir. Prior to the survey, informed consent was obtained after explaining the study's objectives. The veterinarian overseeing meat inspections assisted participants in completing the checklist, which included lesion prevalence and their potential health significance.

A matrix scoring and ranking method (proportional piling) were employed to prioritize the potential significance of grossly visible lesions in each organ examined. As an appraisal method, a fixed number of beans ($n = 100$) were provided to the group. Participants were asked to allocate the beans to reflect the relative importance of gross lesion, visceral organs affected/ observed in beef cattle slaughtered in the abattoir. The allocation for each lesion categories were recorded by converting the count into proportions using the formula z = x/n, where x is the number of beans allocated to a specific lesion, visceral organ etc. category, and n is the total number of beef cattle slaughtered and inspected in the abattoir (100). All data generated by the methods were coded and stored in Microsoft Excel and subsequently used for data analysis (see section below).

Physical facility assessments were recorded during working hours (8:30 am to 5:30 pm), and photographs were taken of abattoir buildings and infrastructure. Facility status was graded on a scale of 1 to 3, following the method of [12], where: grade 1 = good (functional within conventional standards); grade 2 = satisfactory (existing but non-functional); and grade 3 = poor (dilapidated and non-functional).

Data analysis

The data collected was entered into Microsoft Excel sheets and analyzed using SPSS Ver.27. The mean score of the proportion value of the response was used to prioritize the grossly visible lesions deemed of potential significance to human/animal health, and of the organs/tissues in which these lesions were identified. Data on the top and subsequent priorities, in terms of lesion rank, were retrieved as 1st, 2nd, and 3rd rank etc. The concordance of the response agreement of the mean proportion score was tested using Kendall's coefficient of concordance (W) with $p < 0.05$ taken as the level of significance (each participant independently performed the ranking exercise, ensuring that the assumptions of Kendall's W were met). The W coefficient for evidence of agreement between the group response in each of the three agro-ecological zones was categorized as "weak" where $W < 0.26$; "moderate" where $W = 0.26–0.38$; and strong where $W > 0.38$ at 95% confidence interval as used by [13].

Results

This study was conducted in selected public abattoirs across three agro-ecological zones (AEZs) in Wolaita, southern Ethiopia. The survey involved twelve appraisal groups, each comprising ten participants: 108 abattoir workers and 12 veterinarians, totaling 120 participants. Also, physical observation was conducted in the selected municipal abattoirs, including Halala, Gununo, Boditti, and Sodo in the highland ('Dega'); Areka, Fulasa, and Bitana in the midland ('Woynadega'); and Badessa, Bombe, Bele, Humbo, and Gasuba in the lowland ('Kola'), representing AEZs within the administrative boundaries of Wolaita. Based on the slaughter service capacity in the municipal abattoirs, namely Sodo, Areka, Boditti and Humbo were large to medium while the remaining eight grouped as small scale.

Observational analysis

This study conducted observation into the abattoir physical infrastructure availability and functionality was evaluated using a three-point scale as described in the method Sect. [12]. In this regard one of the facilities evaluated was the lairage system. Regarding the lairage facilities, 25% (3/12: Bedessa, Betana and Halala) of municipal abattoirs had no lairage, while in the remaining nine municipal abattoirs, a lairage facility, while present, was non-functional. Problems identified included non-cement floors that could not be adequately cleaned, insecure (which is poorly fenced (Fig. 2). Following antemortem inspection, animals are typically returned to their owners prior to slaughter, a process observed to vary in timing depending on abattoir protocols and logistical factors (i.e. distance from abattoir). However, in four abattoirs (Sodo, Areka, Boiditti and Humbo) beef cattle were kept in the lairage after completing the reception and ante-mortem examination, even though the lairages in these study abattoirs were graded as poor.

Fig. 2 Exterior of selected public abattoirs. Photos show the exterior physical condition of abattoirs in (**a**) Damota Fulasa, (**b**) Humbo Tabala, and (**c**) Boloso Sore Areka

Fig. 3 Open air disposal of solid waste in public abattoirs. This image shows the physical condition of wild bird and domestic carnivores' access to disposed bones and meat; (**a**) dog and (**b**) vultures rummaging through contaminated abattoir disposed waste

Among the key pillars of a well-functioning veterinary abattoir is insuring both animal welfare and public safety [14]. In almost all public abattoirs assessed in the present study, the most common stunning method applied used a puntilla knife to sever the spinal cord. However, our observations revealed that the public abattoirs did not have a stunning box; thus, manual restraint of animals was required which can often lead to injury of the workers [15].

A fundamental requirement in preserving carcass hygiene is the elevation of the carcass off the floor; not only does this maintain the cleanliness of the carcass but it also facilitates inspection procedures [16]. Over 83% (10/12) of the abattoirs surveyed did not have a functional rail system for elevating and manipulating carcasses. While two abattoirs (Areka and Sodo) had a rail system, these did not function optimally and were given a '3'grade.

In terms of the abattoir building material and design, 41.67% (5/12) of the public abattoirs had cement walls and corrugated iron sheet roofs. Almost all the buildings were poorly compartmentalized with little post-harvest handling rooms (chilling, storage, or condemnation). The drainage systems had a poor design, in which the liquid waste drained directly to nearby small rivers and communities. However, the extent of environmental waste contamination and the impact of this contamination on the river catchment area was not investigated as part of our current study. None of the abattoirs had an incinerator facility for disposing of condemned carcasses and offal; while access to an incinerator is not mandated in the Ethiopian Abattoir Service requirements (*as per* Institute of Ethiopian Standards), condemned material was frequently kept in the open air where it could be scavenged by both domestic and wild cats and dogs as well as vultures (Fig. 3). Such buildup of waste maintains the sylvatic cycle of parasitic diseases such as hydatidosis and neosporosis.

Regarding water and electricity supplies, 10/12 abattoirs had well supplies (Table 2); however, during our

Table 2 Assessment of physical infrastructure in Wolaita zone public abattoirs

Abattoir components*	Facility grading											
	Sodo	Areka	Bombe	Boditt	Fulasa	Bedesa	Betena	Humbo	Gesuba	Gununo	Bale	Halala
Lairage	3	3	3	3	3	-	-	3	3	3	3	-
Examination crash	3	-	-	-	-	-	-	-	-	-	-	-
Stunning box	3	-	-	-	-	-	-	-	-	-	-	-
Rail system	3	3	-	-	-	-	-	-	-	-	-	-
Gut & tripe room	-	-	-	-	-	-	-	-	-	-	-	-
Cold room	-	-	-	-	-	-	-	-	-	-	-	-
Detained meat room	-	-	-	-	-	-	-	-	-	-	-	-
Condemned meat room	-	-	-	-	-	-	-	-	-	-	-	-
Drainage system	3	3	3	3	3	3	3	3	3	3	3	3
Veterinary laboratory	-	-	-	-	-	-	-	-	-	-	-	-
Water supply	2	2	3	3	3	3	-	3	3	-	3	-
Electricity supply	2	3	3	3		-	-	-	-	-	3	-
Hide& skin room	3	3	-	3	-	-	-	-	-	-	-	-
Concrete floor	3	3	3	3	-	-	-	3	3	-	3	-
Cemented wall	3	3	3	3	3	3	-	3	3	-	3	-
Walls & floor disinfection aid	3	3	3	3	3	3	-	3	3	3	3	3
First aid room	-	-	-	-	-	-	-	-	-	-	-	-
Storeroom	3	-	3	-	-	-	-	-	-	-	-	-
Toilet	3	3	-	-	-	-	-	-	-	-	-	-
Incinerator	-	-	-	-	-	-	-	-	-	-	-	-
Veterinary staff office	3	-	-	-	-	-	-	-	-	-	-	-
Carcass transport car	3	-	-	-	-	-	-	-	-	-	-	-

* Abattoir components as per requirements of the Institute of Ethiopian Standards (https://www.ethiostandards.org/home); Absent–; Poor: 3; Satisfactory 2; Good 1

Table 3 Cattle slaughtered in public Wolaita abattoirs over 12 months with visible lesions potentially significant for animal and public health

Carcass category	Number of slaughtered cattle (2018/19)	Proportion of total (%)
Healthy (fully fit for consumption)	16,399	73.4
≥ 1 grossly visible lesion detected	5,943	26.6
Overall total	22,342	100

(Wolaita Zone BoLRF, 2019)

observations the supply was inconsistent, and shortages were reported by the survey group. Almost all public abattoirs were connected to a main road with a weather-resistant surface. In terms of veterinary facilities, none of the twelve abattoirs had access to laboratory supports, veterinary staff offices, cafeterias, or toilet facilities. Such lack of basic infrastructure affects the workers' performance since the slaughter process is mostly conducted at nighttime due to logistics of cattle movement and to provide fresh meat for the morning markets. Thus, meat inspectors travel to the abattoir in the middle of the night and back home at the end of their work. Furthermore, the carcasses are transported using human labour, donkey carts (*'gari'*), or small vans (*'bajaj'*) to the retailers during which time the carcasses risk being contaminated.

Participatory abattoir appraisal of postmortem gross lesion

According to secondary data from BoLFR, 26.6% of the 22,342 cattle slaughtered during the study period exhibited at least one grossly visible lesion, leading to the condemnation of affected tissues or organs (Table 3). Of these lesions, 65% were identified by the abattoir veterinary inspectorate as having potentially negative implications for animal or public health. The remaining 35%, comprising abrasions, bruises, and branding scars, were attributed to ante-mortem handling, transport, and/or inadequate animal husbandry practices. Assessing the consistency, the lesions were classified into two broad categories, i.e., (a) 'soft' and (b) 'hard' lesions. Thus, from the important lesions (Fig. 4), 10% were deemed to have 'soft 'consistency' (i.e., cystic', and 'caseous/abscess'), whereas 5% of lesions were 'hard' (i.e., 'fibrotic', 'calcified' and 'firm, fibrous/mineralized'); the remaining 85% of lesions remained uncategorized by the appraisal groups. It is possible that a proportion of these 'soft' and 'hard' lesions represented tuberculous granulomas, a finding that may be significant in terms of the local epidemiology of tuberculosis in cattle (and which forms the basis the PhD thesis of MYZ).

Within agro-ecological zones, the survey response from abattoirs located in the highland ($N=4$) showed that among 'soft 'lesion types, those classed with 'caseous/

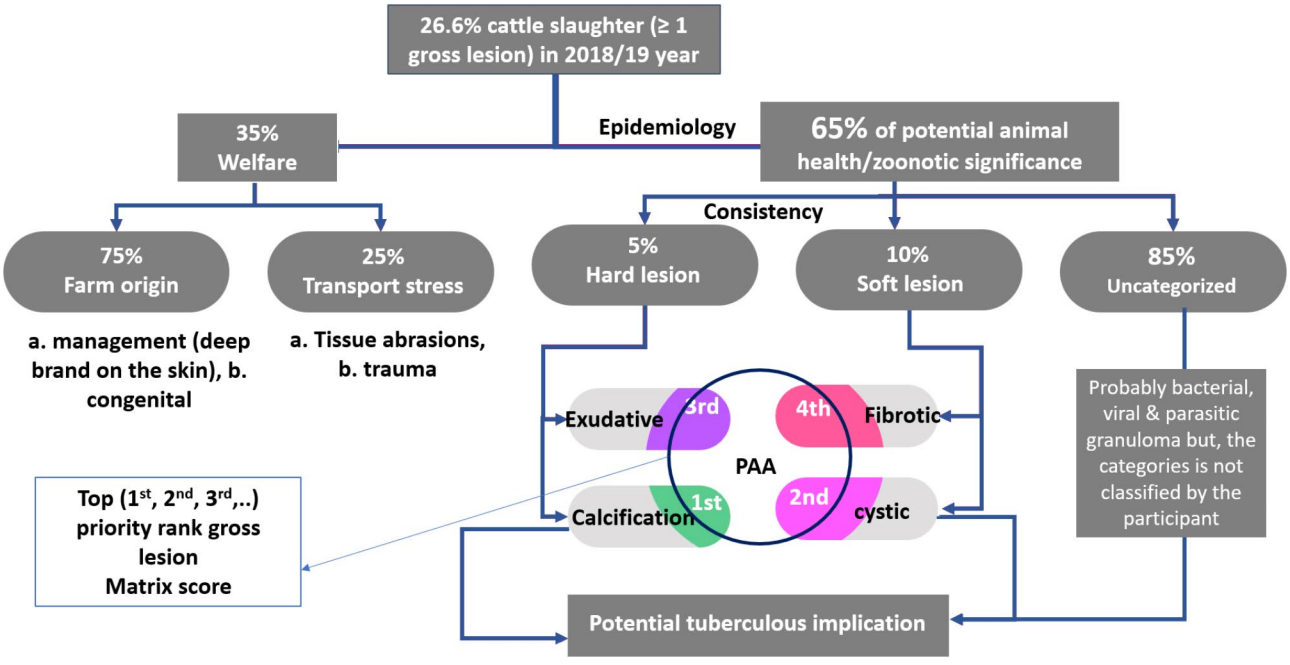

Fig. 4 Flowchart for classification of lesions identified at public abattoirs. Gross lesion categorization from cattle slaughtered in 2018/19 showing epidemiological distribution, welfare concerns, and potential animal health/zoonotic implications. Lesions are grouped by origin (farm or transport-related), consistency (hard, soft, uncategorized), and types (exudative, fibrotic, calcification, cystic). The potential priority ranking of gross lesions is shown with a matrix score, highlighting the most significant findings and their potential linkage to tuberculosis in cattle. The data were obtained from the participatory abattoir appraisal

abscess' consistency were ranked with the top priority, followed by 'cystic' and 'calcification' lesion (Table 4). Between groups the evidence of concordance was strong ($W=0.425$; $p=0.165$) (Table 5). The survey responses from abattoirs located in midland agroecology ($N=3$) showed that among 'soft' lesion types 'caseous/ exudate' lesions were ranked with top priority (0.33), while for the 'hard' lesion category 'mineralised/calcified lesions' (0.67) was the top priority. The evidence of concordance between the groups was strong ($W=0.422$; $p=0.284$) but was not statistically significant (Table 5). The data from lowland abattoirs ($N=5$) showed that among the lesion types 'calcification' was ranked as the top priority (0.6), followed by 'watery cyst' and 'caseous' (0.6, 0.4, respectively) (Table 4). The evidence of concordance between groups was weak ($W=0.152$; $p=0.516$) but this was not statistically significant (Table 5). The overall mean proportional priority rank data showed that the 'hard' lesion type rank was ranked with top priority (0.67), followed by 'cystic' type lesions (0.58), and that the evidence for group concordance was moderate ($W=0.275$; $p=0.019$).

The survey groups ranked gross lesions in the lungs and associated mediastina and bronchial lymph nodes as their first priority (0.67; Table 6). Lesions in the small intestine and mesenteric lymph nodes (0.33), and the hepatic lymph nodes (0.42), were ranked second and third, respectively (Table 6). There was a strong agreement of the overall mean rank ($W=0.518$; $p=0.0001$) within the survey groups. For abattoirs located in the highland region, the survey group ranked organs that were frequently positive for gross pathology by placing lungs first, followed by intestine and mesenteric lymph nodes, then liver and periportal lymph node (0.75, 0.5, 0.25, respectively; Table 6). There was statistically significant agreement among groups ($W=0.612$; $p=0.044$) of the mean ranking of the organ distribution of lesions. The lungs and their associated lymph nodes frequently featured at least one suspect tuberculous lesion (Table 7). These findings are consistent with pathological descriptions of tuberculosis in cattle [17].

Cattle originating from highlands, where mixed crop-livestock production is practiced, were found to have lesions at slaughter more frequently than lowland-sourced cattle (Table 8). In the highlands, cattle are fattened indoors in traditional barns (termed '*gatata*') which are poorly ventilated and where animals are in close contact with each other. In contrast, in lowland regions cattle are fattened on pasture with consequently less potential exposure to infectious aerosols. Traditionally, beef cattle are fattened after prolonged use as traction animals and thus are relatively old at the time of slaughter. Because of market demand farmers tend not to castrate male animals since intact bulls are more useful for traction. Overall, strong concordances of agreement were found among

Table 4 The summary proportion ranking (1st, 2nd, 3rd, and 4th) of postmortem pathology at selected municipal abattoirs

Grossly visible lesion categories	Lesion designations†	Proportion of abattoir lesion priority in different agro-ecological regions															
		Overall priority rank				Highland (Dega)				Midland (Wonadega)				Lowland (Kola)			
		$N=12$				$N=4$				$N=3$				$N=5$			
		1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
Soft	a	0	0.58	0.25	0.17	0	0.5	0.25	0.25	0	0.67	0	0.33	0	0.6	0.2	0.2
	b	0.25	0	0.42	0.33	0.25	0	0.25	0.5	0.33	0	0.33	0.33	0.2	0	0.4	0.4
	c	0.08	0.17	0.25	0.5	0	0.25	0.5	0.25	0	0	0.67	0.33	0.2	0.2	0.4	0.2
Hard	d	0.67	0.25	0.08	0	0.75	0.25	0	0	0.67	0.33	0	0	0.6	0.2	0	0.2

†Lesion designations: (a) cystic: cystic lesions with aqueous content – these are likely parasitic in nature (i.e. tapeworm cysts, hydatidosis); (b) caseous/abscess: potentially include tuberculous lesions, but a proportion could also be caused by pyogenic bacteria; (c) fibrotic: fibrosis of the biliary system and the lungs; and (d) mineralised/calcified lesions – possible suspect tuberculous lesions

Table 5 Level of agreement between 12 abattoirs of categories of grossly visible lesions (top and next rank)

Grossly visible lesion category	Overall districts		Agro-ecological location of municipal abattoir					
			Highland (Dega)		Midland (Wonadega)		Lowland (Kola)	
	Mean rank score	Test statistics	Mean rank score	Test statistics	Mean rank score	Test statistics	Mean rank score	Test statistics
a	2.67	*N* = 12	2.75	*N* = 4	2.67	*N* = 3	2.60	*N* = 5
b	2.92	Kendall's *W* = 0.275	3.00	Kendall's *W* = 0.425	2.67	Kendall's *W* = 0.422	3.00	Kendall's *W* = 0.152
c	2.92		3.00		3.33		2.60	
d	1.50	Chi-Square = 9.900	1.25	Chi-Square = 5.100	1.33	Chi-Square = 3.800	1.80	Chi-Square = 2.280
		Df = 3		Df = 3		Df = 3		Df = 3
		Asymp. Sig = 0.019		Asymp. Sig = 0.165		Asymp. Sig = 0.284		Asymp. Sig = 0.516

(a) cystic; (b) caseous/abscess; (c) fibrotic; (d) hard/fibrous/mineralized (see footnote Table 4 for lesion descriptions)

*Kendall's *W* = coefficient of concordance; the evidence of agreement between informant groups was categorized as "weak" for $W < 0.26$ and $p > 0.05$; "moderate" for $W = 0.26–0.38$ and $p < 0.05$; and strong for $W > 0.38$ and $p < 0.01$ according to the published guidelines on the interpretation of *W* and *p*-values (Siegel and Castellan, 1988 *Nonparametric Statistics for the Behavioral Sciences* (2nd ed.) McGraw-Hill)

focus groups ($W = 0.524$; $p = 0.0001$) for grossly visible suspect tuberculous lesions, or more general lesions, over various beef production parameters such as age, breed, and geographical source (Table 8).

Discussion

According to the Wolaita Zone Bureau of Livestock and Fisheries Resources (BoLFR), public abattoirs reported approximately twenty-two thousand cattle being slaughtered between May 2018 and July 2019, equating to an average of 5.17 cattle per day per abattoir. This figure is significantly lower compared to operational abattoirs in other parts of Ethiopia. For instance, the Hossana Municipal Abattoir in the Hadiya Zone slaughtered 1,502 animals between November 2002 and February 2003 [18], the Woldiya Municipality Abattoir in North Wollo Zone processed 2,456 animals between April 2009 and April 2010 [19], and the Hawassa Municipal Abattoir handled 1,126 animals between November 2016 and April 2017 [20]. The relatively small number of annual slaughters reported in the public abattoirs would not account for the anticipated consumer demand for meat [21]; this suggests that a large amount of unregulated/unauthorized 'backyard slaughter' was also taking place. The use of backyard slaughter appears to reflect stakeholder concerns regarding inefficiencies in the public abattoir system, as reported during group discussions. However, other factors, such as cultural preferences and consumer demands, may also play a role, and further studies would be required to confirm this.

From our observations the abattoirs were poorly graded and had inadequate operational facilities, which severely limited their ability to conduct effective meat inspections and monitor animal diseases. Despite these limitations, our study underscores the role of abattoirs in zoonosis control and enhancing animal disease surveillance in the area [10, 11].

The management and handling of animals at the time of slaughter has implications not only for their welfare but also for subsequent meat quality (e.g. features such as increased pH, coloration, toughness, or shelf life, see Njisane et al. [22]). In this context, the current survey found that abattoir handling facilities were in general old and poorly designed, findings that would negatively impact on both outcomes. Live cattle purchased from the market were transported to abattoirs by walking, or sometimes using a pick-up truck, and were held in lairages for, on average, 9 h. These sub-optimal conditions of loading, shipping, and unloading are likely to result in stress on cattle going for slaughter and are likely to account for the carcass abrasions and bruise identified by our survey [23–25].

From the retrospective BoLFR data (May 2018 and July 2019), 26.6% of beef carcasses had gross lesion prevalence, a value that aligns closely with the 22.1% prevalence reported in the Tigray region [26]. However, it is higher than the 17.4% prevalence observed in the Amhara region (Wollo) by Bizuwork et al. [27] and lower than the 38.3% gross lesion prevalence recorded at the Kombolcha Abattoir in Northeast Ethiopia [28]. These variations likely reflect differences in study methodologies.

Table 6 The summary proportion ranking (1st, 2nd, 3rd,4th, and 5th) of inspected organs/tissue featuring grossly visible lesions at the 12 surveyed public abattoirs

Organ/tissue	Ranking of carcass lesion distribution in three agro-ecological regions																			
	Overall priority rank *N* = 12					Highland (Dega) *N* = 4					Midland (Wonadega) *N* = 3					Lowland (kola) *N* = 5				
	1st	2nd	3rd	4th	5th	1st	2nd	3rd	4th	5th	1st	2nd	3rd	4th	5th	1st	2nd	3rd	4th	5th
a	0.67	0.25	0.08	0	0	0.75	0	0.25	0	0	0.67	0.33	0	0	0	0.6	0.4	0	0	0
b	0.17	0.25	0.42	0.17	0	0.25	0.25	0.5	0	0	0	0.33	0.33	0.33	0	0.2	0.2	0.4	0.2	0
c	0	0.17	0.17	0.33	0.33	0	0.25	0	0.25	0.5	0	0	0.33	0.33	0.33	0	0.2	0.2	0.4	0.2
d	0	0	0.17	0.33	0.5	0	0	0	0.5	0.5	0	0	0.33	0	0.67	0	0	0.2	0.4	0.4
e	0.17	0.33	0.17	0.17	0.17	0	0.5	0.25	0.25	0	0.33	0.33	0	0.33	0	0.2	0.2	0.2	0	0.4

LN = lymph node

a = Lung, mediastinal and bronchial LN; b = Liver and hepatic LN; c = Spleen; d = Kidney; e = Intestine and mesenteric LN

Among the gross lesions, 65% were potentially infection-related (caused by bacteria, viruses, parasites, or protozoa), with 10% presenting as soft or caseous exudates and 5% as firm or hard upon gross examination. Although slaughtered cattle were managed under similar production systems, soft or caseous lesions were observed more frequently in cattle from lowland regions compared to midland or highland areas. This finding, based on stakeholder appraisals, warrants further investigation to confirm the association. Furthermore, 85% of lesions were uncategorized in the BoLFR report. Such lesions would be expected to represent a significant economic loss due to reduced carcass value, highlighting the need for further investigation to quantify and characterize their etiology and implications [29, 30]. Additionally, detailed postmortem findings were largely undocumented, as abattoir records primarily focused on slaughter numbers. To address this gap, in this study we conducted an abattoir appraisal using structured group discussions with veterinarians and abattoir workers. A limitation of our study is that data on grossly visible lesions were derived retrospectively from office reports and validated through group perceptions, which may affect the true granularity of our findings. However, our aim was to establish baseline information to support of further studies on tuberculosis in cattle in Wolaita (MYZ, PhD thesis).

Conclusions

Our survey of public abattoirs in the selected districts of the Wolaita zone of southern Ethiopia revealed that abattoir facilities were small in scale and substandard in physical infrastructure. Structural limitations meant both ante- and post-mortem abattoir examinations were not optimal, and in general record-keeping was found to be inadequate. A consequence of these deficiencies is an increased risk of zoonotic or parasitic disease because the facilities do not support good slaughter hygiene. This highlights how infrastructural deficiencies in abattoirs can potentially contribute to poor quality, potentially diseased meat entering the human food chain and having a negative environmental impact. Future research should focus on how facilities and training in public abattoirs can be improved to support monitoring of carcass condition and lesion detection; this would help to both improve passive surveillance for animal diseases and decrease the risk of spreading zoonotic infections to the local human population.

Table 7 Level of agreement between surveyed groups on ranking of organs/tissue within which a grossly visible lesion was detected (top and next rank) at 12 public abattoirs

Organ/ tissue	Overall districts		Agro-ecological zone					
			Highland (Dega)		Midland (Wonadega)		Lowland (Kola)	
	Mean rank score	Test statistics	Mean rank score	Test statistics	Mean rank score	Test statistics	Mean rank score	Test statistics
a	1.42	*N* = 12	1.50	*N* = 4	1.33	*N* = 3	1.40	*N* = 5
b	2.58	Kendall's *W* = 0.518	2.25	Kendall's *W* = 0.612	3.00	Kendall's *W* = 0.600	2.60	Kendall's *W* = 0.456
c	3.83		4.00		4.00		3.60	
d	4.33	Chi-Square = 24.867	4.50	Chi-Square = 9.800	4.33	Chi-Square = 7.200	4.20	Chi-Square = 9.120
e	2.83	Df = 4	2.75	Df = 4	2.33	Df = 4	3.20	Df = 4
		Asymp. Sig = 0.0001		Asymp. Sig = 0.044		Asymp. Sig = 0.126		Asymp. Sig = 0.058

LN = lymph node

a = Lung, mediastinal and bronchial LN; b = Liver and hepatic LN; c = Spleen; d = Kidney; e = Intestine and mesenteric LN

*Kendall's *W* = coefficient of concordance (the evidence of agreement between informant group was categorized as "weak" for $W < 0.26$ and $p > 0.05$; "moderate" for $W = 0.26–0.38$ and $p < 0.05$; and strong for $W > 0.38$ and $p < 0.01$ according to the published guidelines on the interpretation of *W* and *p*-value (Siegel and Castellan, 1988 *Nonparametric Statistics for the Behavioral Sciences* (2nd ed.) McGraw-Hill)

Table 8 Levels of agreement among focus groups by proportional piling (priority rank) on the association of grossly visible lesions with production parameters

Beef production parameter	Proportional piling of mean weighted score of the association Postmortem pathology to beef production parameter					
	Cystic	Caseous/abscess	Fibrotic	Mineralized/ Calcified	Overall weighted score	
	1st Prior	2nd prior	3rd prior	4th prior	Mean rank score	Test statistics
Cattle > 6 years old		0.17	0.5	0.33	5.17	*N* = 12
Cattle type (bull, dairy, heifers)	0.8			0.09	2.33	Kendall's *W* = 0.524
Bull type (castration)	0.5	0.17	0.17	0.09	5.17	Chi-Square = 31.423
Cattle sex			0.08	0.36	3.04	Df = 5
Cattle breed	0.25	0.33		0.27	3.08	Asymp. Sig = 0.0001
Cattle origin (market source)	0.17	0.33	0.25	0.18	2.21	

HF: Holstein Friesian, JC: Jersey cross; the importance on postmortem lesion rating is score 1 to 4 where 1 is less important and 4 more important based on the frequency of pathology detection per head of slaughter cattle up on postmortem inspection,

*Kendall's *W* = coefficient of concordance (the evidence of agreement between informant group was categorized as "weak" for $W < 0.26$ and $p > 0.05$; "moderate" for $W = 0.26–0.38$ and $p < 0.05$; and strong for $W > 0.38$ and $p < 0.01$ according to the published guidelines on the interpretation of *W* and *p*-value (Siegel and Castellan, 1988 *Nonparametric Statistics for the Behavioral Sciences* (2nd ed.) McGraw-Hill)

Abbreviations

CSA	Central Statistical Agency
PAA	Participatory Abattoir appraisal
WSU	Wolaita Sodo University
SNNPR	Southern Nation Nationality People Region
BoLFR	Bureau of Livestock and Fish Resource

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Author contributions
MYZ performed surveys, data analysis and drafted the manuscript. AA, JC and SG contributed research supervision, drafting the manuscript and overview of data analysis. All authors have read and approved the manuscript.

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Data availability
The datasets used and/or analyses during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical approval
This study has been granted ethical approval by the University College Dublin Animal Research Ethics Board (AREC-E-19-19-Gordon) and the Wolaita Sodo University Institutional Review Board (Reference No. ΦሶዩH114532).

Consent to participate
All participants involved in this study provided informed consent to participate. Prior to data collection, the purpose, procedures, and potential benefits of the study were explained to the participants. Written informed consent was obtained from the participants. Additionally, permission to

conduct the abattoir appraisal was granted by the Wolaita Zone (Ref. No: Liv/FM/R/D0/8/Mt11) in accordance with ethical standards.

Consent for publication
Not applicable.

Prior publication
Data have not been published previously.

Competing interests
The authors declare no competing interests.

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