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Socio-Economic Impact Evaluation of Bovine Tuberculosis on Primary Meat Production at the Bobo-Dioulasso Slaughterhouse in Burkina Faso

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Abstract

Bovine tuberculosis is one of the zoonoses which has a very significant socio-economic importance due to the losses in agribusiness and hampers commercial exchange of animals and products. The present study highlights the risk of considerable potential economic and health impacts of this major zoonosis. It was carried out at the Bobo-Dioulasso slaughterhouse, in Burkina Faso over 3 years. A retrospective study was conducted based on bovine tuberculosis suspected carcass seizures during primary meat production between January 1st, 2020 and December 31st, 2022. The diagnosis and the criteria for suspecting bovine tuberculosis were addressed by post-mortem inspection. All carcasses were examined for tuberculosis lesions detection. All cattle slaughtered in the abattoir for primary meat production during the study period were included. Economic losses were determined from recorded seizure data and we included all the cattle slaughtered during the study period. Three thousand two hundred ten (3210) bovine carcasses were seized on a total of 180,827 cattle slaughtered

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with a prevalence of 19.48%. Economic loss was estimated to be 53,505,000 F CFA, while the average quantity of animal protein lost was 4746 kg, 435 kg, and 13,445 kg for the carcass, livers, and lungs, respectively. The various results show a real health issue linked to exposure to *M. bovis* for agents and stakeholders in the primary meat production chain, processors and consumers. In addition, the survey conducted over the study period, reveals important material seized and destroyed. This leads to significant loss in rural agriculture and also in the primary meat production industry for the population. The figures are enormous and impact both the nutritional intake linked to animal protein consumption and the livelihood of the beef industry. The Burkinabe administration should invest in biosecurity and biosafety measures to minimize the risks of the disease and also provide compensation for losses recorded among breeders and butchers.

Keywords

Cattle, Bovine Tuberculosis, Meat Production, Economic Loss, Bobo-Dioulasso Slaughterhouse

1. Introduction

Bovine tuberculosis (bTB) constitutes an enzootic disease with potential socio-economic significance in public health [1] [2]. This zoonosis is defined as an infection which is naturally transmitted from vertebrate animals to humans and vice versa [3]. It constitutes a global public health problem and is caused by *Mycobacterium bovis* [4]. Wide range of domestic and wild animals are more infecting [5] [6]. Transmission from animals can occur by inhalation, ingestion or direct contact through mucous membranes or broken skin [3] and numerous other factors including housing, feeding through the colostrum/milk to calves and watering of infected and non-infected animal together [7]. Older animals are commonly affects and the infection mainly confined to respiratory system [7]. The clinical signs include progressive weight loss, tubercle formation, primarily in lungs and occasionally in other tissues.

Low- and middle-income countries (LMICs) are most affected by the prevalence of bovine tuberculosis with a socio-economic impact mainly affecting poor, marginalized and rural communities where people live in close contact with animals, and have limited access to sanitation, healthy food and health care services [8].

Products from animal origin remain an important factor in food and nutritional balance both from their direct consumption and their use as a means of improving household food security. In 2018, the contribution of livestock sectors to household income was estimated at 38% compared to 22% for agricultural sector [9]. However, seizures and elimination of affected parts or all of animal carcasses, cause important economic losses due to the reduced of production at slaughter.

These economic losses are particularly linked to livestock deaths, losses in productivity due to chronic disease, and restrictions for trading animals both at the local and international levels [10].

In developed countries where the prevalence of bTB is generally low, the direct and indirect costs of the disease are mainly related to trade barriers imposed on the trade of animals and animal products as well as the financial costs of implementation of official eradication programs. However, in Africa, losses and mortalities due to bTB livestock cost economies are estimated to be 3 billion US dollars [2] [11]. In Burkina Faso, 86% of livestock professionals are small producers with an average of five animals. To cope needs for animal products, they invest in technologies to improve productivity and sell surpluses to national and regional neighboring markets. For 41% of these small producers, livestock farming is one possible way out of poverty. Indeed, the livestock sub-sector contributes greatly to job creation with over 900,000 full-time workers employed in production and substantial income generation with another 60,000 to 90,000 employed in processing and marketing activities [12]. In terms of average gross earnings, studies indicate an estimate of 59,000 FCFA per head for cattle producers, 33,000 FCFA gross earnings per head for cattle fattening and a gross margin of 40,000 to 85,000 FCFA for cattle exports. The slaughtering and marketing of red meat would generate gross margins of 100 to 191 FCFA per kilogram [12]. Benefits provided are mainly intended for health, children's schooling, the purchase of food, sociocultural ceremonies, as well as the purchase of agricultural equipment and inputs. In addition to monetary income, the self-consumption of livestock products is estimated to be 1.3 billion CFA francs, including 1.2 billion CFA francs in rural areas [9]. This only self-consumption represents 0.04% of the overall amount of income from beef production [9]. However, this production is currently threatened by parasitic, viral and bacterial diseases [13]. For example, brucellosis and bovine tuberculosis cause heavy economic losses each year, estimated at around 44 million US$ or 6% of the GDP value of cattle breeding [9]. Furthermore, agricultural productivity is also affected by the reduction of draught animals' labor and organic manure [13]. Given the socio-security situation that the country has been experiencing in recent years, the agro-pastoral sector is strongly affected by internal displacement and livestock theft [12] often forcing herders to live in confinement with their animals in unsanitary conditions. This can promote not only the spread of tuberculosis within the herd but also bovine-human transmission. In summary, bovine tuberculosis can have a negative impact on international trade in animals and animal products, it can lead to an increased morbidity rate and can induce by decreasing the financial capital of the farm and indirectly causing losses in agricultural productivity, due to the reduction of work of draft animals and organic manure in rural areas, not to mention the economic losses suffered by the meat industry due to the numerous seizures in slaughterhouses [14]. In view of the above, the evaluation of the socio-economic impact of bovine tuberculosis is therefore necessary. This study therefore contributes to the evaluation of the

socio-economic impact of bTB in terms of quantity and losses of consumable proteins in Bobo-Dioulasso (Burkina Faso).

2. Method

2.1. Study Design

The study was carried out at the Bobo-Dioulasso refrigerated slaughterhouse in Burkina Faso. A retrospective cohort study covering all seizures suspected of bTB was carried out on the post-mortem cattle slaughtered from January 1, 2020 to 31, December 2022. We have included all cattle slaughtered in the abattoir for primary meat production during the study period.

2.2. Data Source and Sampling Strategy

This study was carried out using data collected by the Bobo-Dioulasso slaughterhouse from 2020 to 2022. Annual reports and questionnaires were used to collect and cross-check the data from 2020 to 2022. The dataset compiled by year included the ID number, the total number of cattle slaughtered, the total number of carcasses seized for bTB and the post-mortem inspection for tuberculosis lesions diagnosis. Furthermore, the seizure registers by the Regional Direction of Animal and Fisheries Resources made it possible to have data related to the economic aspect and protein loss quantification. Additional information was collected from butchers and/or veterinary officers.

2.3. Post-Mortem Inspection for Tuberculosis Lesion Detection

The post-mortem inspection was reported according to the standard procedure described in previous studies [11] [14]. The sampling was exhaustive during the study period, so all carcasses were systematically inspected by two veterinarians and four veterinary technicians. To carry out, inspectors were instructed to estimate the carcass weight and carefully examined it. Anatomo-pathological examination was done by observation and palpation of lungs, mediastinal and thoracic lymph nodes, as well as all other lymph nodes or whole carcass to detect any lesion or alteration signs while respecting their commercial aspect. A macroscopic TB lesion was defined as the presence of pus in a lymph node or in any other organ.

2.4. Meat Production

Meat production was estimated by multiplying carcass or organ weights of the offtake with the value of one kilo of meat costs. We assumed an average weight of 113 kg [15] for carcass, and 5 kg for each liver and pluck (lung-heart-spleen assembly).

2.5. Statistic Analysis

Data were collected from Bobo-Dioulasso slaughterhouse monthly reports. A descriptive statistical analysis was used to determine meat production frequencies and percentages and bTB prevalence. All nutritional losses were estimated from

data collected in the slaughterhouse reports. Categorical data were summarized and compared using Pearson's Chi-square test or Fisher's exact test. The student t-test or Mann-Whitney and Wilcoxon tests were performed for continuous variables. A z-test was performed to compare proportions. A p-value < 0.05 was considered significant for all tests.

3. Results

3.1. Number of Cattle Breeds Slaughtered Per Year

A total of 180,827 cattle were slaughtered from 2020 to 2022 in this study. In 2020, cows were the most cattle breed slaughtered with a rate of 85.56% and Beef (42.80%). In 2021 and 2022, young bulls were the most slaughtered with respectively 44.93% in 2021 and 52.23% in 2022 (Table 1).

Table 1. Number of cattle slaughtered according to breed and year.

Cattle	2020 (%)	2021 (%)	2022 (%)	Total
Beef	11,688 (42.80)	7712 (28.24)	7911 (28.97)	27,311
Heifers	1948 (35.49)	1717 (31.28)	1824 (33.23)	5489
Bulls	8442 (28.67)	10,053 (34.14)	10,955 (37.20)	29,450
Young Bulls	1948 (2.83)	30,885 (44.93)	35,902 (52.23)	68,735
Cow	38,313 (85.56)	4640 (10.36)	1824 (4.07)	44,777
Calves	2598 (51.29)	1250 (24.68)	1217 (4.07)	5065
Total (%)	**64,937 (35.91)**	**56,257 (31.11)**	**59,633 (32.98)**	**180,827**

3.2. Annual Statistics Descriptive of Cattle Slaughtered from 2020 to 2022

On average, 418.58 cattle (median: 177, range: 32 - 2139, SD: 526.97) were slaughtered during these 3 years. The majority of cattle were slaughtered in 2020 with a total number of 64,937 (35.91%), an average of 450.95 (median: 193.5, range: 56 to 2139). The lowest number of animals slaughtered was in 2022 with a total number of 59,633 (32.98) average of 414.12 (median: 159, range: 32 to 2137) and in 2021 (median: 390.67, range: 34 to 1848) (Table 2).

Table 2. Annual statistics description of cattle.

Year	Minimum	Average	Median	Ecart-type	Maximum
2020	56	450.95	193.5	556.67	2139
2021	34	390.67	174	495.46	1848
2022	32	414.12	159	528.93	2137
Total	**32**	**418.58**	**177**	**526.97**	**2139**

3.3. Overall Prevalence of Seizures for Tuberculosis Lesions from 2020 to 2022

In total 3210 organs were seized during our study period with a global prevalence

of 19.48%. Of 64,937 cattle slaughtered in 2020, 1302 had tuberculosis lesions, representing a prevalence of 22.09%. In 2021, the prevalence was 21.42% on 56,257 cattle slaughtered with a total seizures of 962. The prevalence of seizures for tuberculosis lesions in 2022 was 15.52% for 946 organs seized with a total of 59,633 cattle slaughtered (Table 3).

Table 3. Prevalence of organ seizures for tuberculosis lesions at the Bobo-Dioulasso refrigerated slaughterhouse in Burkina Faso from January 2020 to December 2022.

Year	2020		2021		2022		Total	
Mouth	Cattle number	Lesion Prevalence (%)	Cattle number	Lesion Prevalence (%)	Cattle number	Lesion Prevalence (%)	Cattle number	Lesion Prevalence (%)
January	129	24.43	77	20.53	63	17.75	269	21.38
February	88	19.6	67	21.07	72	19.89	227	20.11
Marsh	96	22.43	83	27.39	57	14.11	236	20.79
April	84	19.09	81	20.98	72	13.14	237	17.25
May	92	19.83	59	16.03	76	13.69	227	6.37
Jun	112	18.95	103	19.54	68	9.66	283	15.53
July	93	16.17	66	18.38	119	15.93	278	16.54
August	134	23.39	96	26.02	102	19.1	332	22.49
September	125	24.61	96	27.35	126	19.24	347	22.92
October	142	29.83	88	23.59	64	13.5	294	22.22
November	104	21.4	85	20.99	57	15.12	246	19.4
December	103	27.47	61	17.09	70	18.32	234	21.01
Total	**1302**	**22.09**	**962**	**21.42**	**946**	**15.52**	**3210**	**19.48**

3.4. Annual Frequency of Organs Seized at the Bobo-Dioulasso Slaughterhouse

The infectious focus of bTB is diverse depending generally on the contamination way and the infection type. Table 4 reveals the different organs seized for tuberculosis lesions at the Bobo-Dioulasso refrigerated slaughterhouse in Burkina Faso throughout our study.

3.5. Economic Losses Estimation Linked to Organs Seized for Tuberculosis Lesions from 2020 to 2022

Table 5 presents the economic and animal protein quantity lost linked to different seized for suspicion of tuberculosis between 2020 and 2022. Considering the unit price/kg fixed to 2500 F CFA for the carcass, 3000 F CFA for livers and lungs, the average quantity of animal protein lost was respectively estimated to be 4746 kg, 435 kg and 13,445 kg. The total economic losses amounted to 53,505,000 FCFA.

Table 4. Frequency of bTB lesion location.

Organs with lesion	2020		2021		2022		Total	
	Number	%	Number	%	Number	%	Number	%
Carcasses	21	1.61	9	0.93	12	1.28	42	1.31
Liver	32	2.45	24	2.49	31	3.3	87	2.71
Lungs	999	76.72	758	78.79	739	78.86	2496	77.97
Kidneys	4	0.3	2	0.2	4	0.42	10	0.31
Heart	12	0.92	12	1.24	9	0.96	33	1.03
Spleen	25	1.92	32	3.32	16	1.7	73	2.28
Intestine	12	0.92	4	0.41	7	0.74	23	0.71
Tongue	2	0.15	0	0	0	0	2	0.06
Others	195	14.97	121	12.57	119	12.7	435	13.58
Total	1302	99.96	962	99.95	937	99.96	3201	100

Table 5. Assessment of economic and material losses of the TBb between January 2020 and December 2022.

Variables	Carcasses	Livers	Plunck*
Seized organs number	42	87	2689
Average weight	113 kg	5 kg	5 kg
Average quantity of animal protein lost (Kg)	4746	435	13,445
Unit price (FCFA)/kg	2500	3000	3000
Economic losses average (F CFA)	11,865,000	1,305,000	40,335,000
Total economic losses (F CFA)		53,505,000	

*lung-heart-spleen assembly.

4. Discussion

A total of 180,827 cattle were slaughtered from 2020-2022 with a variation between cattle breed and year. We noticed highest number (85%) of animals slaughtered was recorded in 2020, with a high rate in cows unlike in 2021 and 2022 where the most breeds slaughtered were young bulls. This variation could be explained by the security crisis in the country which generated internal migration of the population and caused losses of livestock [16]. Indeed, during transhumance, herders are exposed to difficulties such as harassment at border crossings, constraints on access to water or pasture, invasion of fields, livestock thefts, armed attacks and blockages on corridors that can cause conflicts and which are often resolved in cash (money) or in kind (animals). In addition, the decline in attendance, the closure of markets, the drop in the price of animals, kidnappings and executions by armed actors limit the animals' mobility from one region to another. This probably explains this selection of the breed and/or age of animals in slaughterhouses [17]. Overall, we noted a prevalence of 19.48% of 180,827 cattle

slaughtered with a periodic variation according to the monthly and annual seizures. These results are different from those observed in recent studies with 1.5% of 10,925 [18] and 1.75% of 1716 [14] cattle slaughtered. Other previous studies also reported a prevalence of lesions suggestive of bTB of 2.7% by Kanyala *et al.* [11] and up to 6.8% [19]-[21] of the investigated cattle carcasses showed bTB-suggestive lesions in Burkina Faso. These results are very low due to the few number of cattle slaughtered compared to the present study which had a considerable number of slaughtered cattle.

In this study, the bTB lesion was mostly localized in the lungs (78%) which could suggest a pulmonary transmission by inhalation. Indeed, previous studies showed that *M. bovis* is more likely to be transmitted when the respiratory tract is affected [3]. In addition, other studies suggest that 90% of tuberculous cattle have lesions in the thoracic cavity and head, therefore cattle-to-cattle transmission is generally considered to be the major route of transmission through aerosol [22] [23]. However, further studies are still needed to determine all routes and mechanisms of transmission between cattle. Similar results were found in former studies by Ouedraogo *et al.* with 70.28% in the urban commune of Koudougou [14] and Tialla *et al.* with a prevalence of 2% in the rural commune of Tanghin-Dassouri [18]. According to Kanyala *et al.*, these confined bTB lesions in the lungs suggest that bTB is less severe in Burkina Faso [11] but remains a non-negligible risk for cattle breeders and other actors in this sector.

Beef plays a major role in food security in Burkina Faso by being a source of products with high nutritional value for the population and by allowing them to cope with the irregularity of agricultural production and climatic hazards [9]. The losses induced by this zoonosis could, in the current socio-political context already undermined by a sharp drop in agricultural production, aggravate the issue of food insecurity. Foods of bovine origin today constitute a more than credible alternative to achieving any kind of food security. Furthermore, tuberculosis causes a huge shortfall amounting to 53,505,000 CFA francs. Even though the distribution of its impacts on contributions to household income is difficult to establish in Burkina Faso due to the lack of specific studies and databases, the FAO in 2018 declared that this loss occurs in a context where the beef industry contributes 38% to household income. These recipes are intended for several uses such as health, education, the purchase of food, socio-cultural ceremonies, as well as the purchase of agricultural equipment and inputs. The observation is sad and alarming for professionals in the livestock sector because the activities of breeding, marketing and primary processing of dairy products constitute the main source of household monetary income. It thus contributes to improving the level of development and reducing poverty of rural populations in Burkina [9]. Significant average losses in animal protein related to bTB were estimated at 4746 kg for carcasses, 435 kg for livers and 13,445 kg for lung-heart-spleen assembly. This suggests a dietary deficit in terms of quantity and quality on a nutritional level. According to the Ministry of Animal Resources of Burkina Faso, although meat

production contributes to nutritional needs, coverage rates remain very low with 3.3% for energy, 7% for lipids and 10% for proteins indicating coverage of the population's needs well below international nutritional standards [12]. Furthermore, consumption of unhealthy animal proteins is a major risk factor for the transmission of tuberculosis to humans, who generally become infected by consuming infected foods such as undercooked meat, offal, unpasteurized raw or curdled milk, and fresh cheese [3] [13].

5. Conclusion

Bovine tuberculosis is a zoonosis that causes enormous economic losses among breeders and constitutes a public health problem in developing countries. It is very unfortunate to note that, like certain great nations, we have still not managed to control this scourge. Lesions suggestive of tuberculosis have been observed on several types of organs. This situation has generated a huge shortfall over the period from January 2020 to December 2022, which amounts to 53,505,000 CFA francs. This double observation concerns not only the quantity but also the quality of consumable proteins as well as the average subsistence of professionals in the meat production sector (butchers, breeders, sellers). This study calls on the Burkinabe authorities to inform farmers about bovine tuberculosis and the consequences it can have on their meat production system. They must also commit to investing in biosecurity and biosafety measures for farmers. Decisions must also be taken in the supervisory administrations to calculate compensation to be granted to farmers and butchers to mitigate their losses.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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