

RESEARCH PAPER

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Abattoir-based surveillance reveals geographic clustering and risk factors for bovine tuberculosis in Tanzania**Yohana Siyajali Anatory^{*1,4}, Beatus Lyimo¹, Blandina T. Mmbaga^{2,3}, Joram Buza¹**¹*School of Life Sciences and Bioengineering, The Nelson Mandela African Institution of Science and Technology (NM-AIST), Arusha, Tanzania*²*Kilimanjaro Clinical Research Institute, Moshi, Kilimanjaro, Tanzania*³*School of Medicine, KCMC University, Moshi, Kilimanjaro, Tanzania*⁴*School of Agriculture, Mwalimu Nyerere University of Agriculture and Technology, Tanzania***Key words:** Bovine tuberculosis, Postmortem inspection, Prevalence, Tuberculous lesions, TB-like lesions, Abattoir surveillance**Received:** August 16, 2026 **Accepted:** August 26, 2026 **Published:** September 04, 2026**DOI:** <https://dx.doi.org/10.12692/ijb/29.3.11-19>**ABSTRACT**

Bovine tuberculosis (bTB) is an important threat to livestock and public health in Tanzania. This study was conducted to estimate the prevalence and identify risk factors for gross tuberculous lesions as a proxy for bTB using abattoir surveillance in the Mbeya region, in Tanzania. A cross-sectional study was conducted from July 2024 to January 2025, where thorough postmortem examinations of 19,270 cattle were carried out at three abattoirs. Animal characteristics and geographic origin data were obtained. We also examined a five-year retrospective dataset from these abattoirs (2019-2023) for the determination of temporal trends. The overall prevalence of gross tuberculous lesions was 0.11%. High prevalence of bTB lesions was associated with poor body condition 0.74% and cattle sourced from Sumbawanga district 0.20%. There was marked variation between abattoirs, with Utengule having the highest prevalence of 0.19%. No significant associations were found with breed or sex. Analysis of the retrospective data from 2019-2023 indicated a fluctuating trend which declines from 0.79% in 2019 to 0.66% in 2020; peaking at 0.93% in 2021 before at 0.60-0.65% in 2022 and 2023. Although the prevalence of visible bTB lesions is low, the findings indicate a continued, but silent, disease burden. The marked clustering of the cases at the Utengule abattoir and in cattle originating from Sumbawanga provides a clear evidence base for targeted interventions. We recommend enhanced surveillance in these high-risk areas in order to understand the true infection pressure and prevent the potential zoonotic threat.

Corresponding author:** Yohana Siyajali Anatory ✉ anatoryy@nm-aist.ac.tz*  <https://orcid.org/0000-0002-7453-2152>**Co-authors:*Beatus Lyimo:** <https://orcid.org/0000-0002-6743-4546>**Blandina T. Mmbaga:** <https://orcid.org/0000-0002-5550-1916>**Joram Buza:** <https://orcid.org/0000-0002-4661-5225>

INTRODUCTION

Bovine tuberculosis (bTB) is an important animal disease which inflicts both economic and health impacts to livestock and public health sectors (Kwaghe *et al.*, 2023; Sawyer *et al.*, 2023). This disease threatens millions of animals in the world, even as developing countries bear a disproportionately high burden because of challenges in effective surveillance and control (WHO, 2020). According to Zhang *et al.*, 2022, bTB causes economic losses in the animal sector through trade embargoes and reduced productivity due to animal mortality, reduced milk yield, and condemned carcasses/organs.

Although Tanzania is one of the holders of the largest cattle herds in Africa, bTB remains a persistent but poorly quantified problem. Coexistence of various methods of husbandry, from pastoralist to intensive farming, creates intricate dynamics of transmission that complicates efforts for its control. The literature to date is sparse and often outdated on the epidemiology, with the reported prevalence varying dramatically between regions, from as low as 0.2% to over 13%, as stated by Katale *et al.*, 2012. This heterogeneity means that there is an urgent need for updated, site-specific data to guide national strategies for the control of the disease.

In resource-constrained countries like Tanzania, abattoir-based meat inspection is the cornerstone of bTB surveillance. While acknowledging the recognized lack of sensitivity of post-mortem examination for gross

lesions, this approach remains a high value-for-money and practical method to monitor disease trends and establish baseline epidemiological data (Ntivuguruzwa *et al.*, 2022). Systematic and detailed meat inspection may give good information on geographical hotspots, temporal patterns, and animal-level risk factors and hence offer a tenable platform for evidence-based policy and targeted interventions (Mckinley *et al.*, 2018; Woldemariam *et al.*, 2021).

To address the critical gap in recent and structured bTB data in southern Tanzania, this study was conducted in the Mbeya region. We aimed to leverage abattoir surveillance to: (1) determine the current prevalence of gross tuberculous lesions; (2) identify key animal-level and geographic risk factors associated with lesion detection; and (3) analyze a five-year retrospective dataset to elucidate temporal trends. The findings from this study are intended to provide crucial, evidence-based information to guide the development of effective, localized bTB control policies in Tanzania and similar settings.

MATERIALS AND METHODS

Study design and area

This cross-sectional abattoir-based study was conducted from July 2024 to January 2025 at Utengule, Ilemi, and Uyole abattoirs in the Mbeya region (Fig. 1). The three surveyed abattoirs were chosen based on their high volume of slaughtered animals, which makes them among the major entry points for cattle within the Mbeya region.

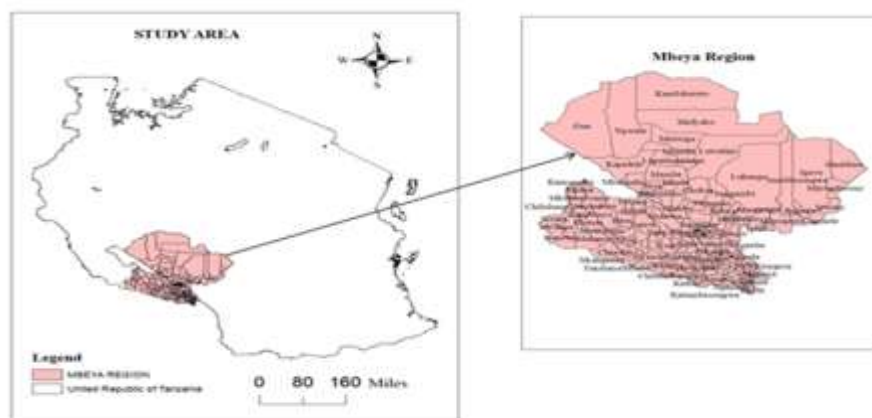


Fig. 1. Map of Tanzania showing Mbeya region (represented by pink color) located in southwest of Tanzania

On average, Utengule abattoir (Mbeya district council) slaughters 55 cattle per day, whereas Ilemi and Uyole abattoirs (Mbeya city council) are reported to slaughter approximately 30 and 20 cattle per day, respectively. Cattle slaughtered at these abattoirs come from Mbeya and neighboring regions, mainly Rukwa; and are predominantly indigenous breeds from pastoralist systems.

Study population and data collection

All cattle slaughtered at Utengule, Ilemi and Uyole abattoirs from July 2024 to January 2025 were inspected and tissue samples were obtained from all carcasses that had bovine TB-like lesions.

Ante mortem inspection and cattle characteristics

Prior to slaughter and post mortem inspection, physical examination was carried out on each cattle to obtain data on age, sex, breed, origin (livestock market/region). Additional information collected were body score, nasal secretion and total number of animals slaughtered at the abattoir each day. Age of an animal was estimated using the dental eruption and wear patterns.

Post mortem inspection

All cattle slaughtered during the period of study were detailed inspected for tuberculous lesions. The lungs, liver, and kidneys, lymph nodes of the thoracic and head regions, the mesenteric lymph nodes, and other lymph nodes of the carcass were examined (Awah-Ndukum *et al.*, 2016). The specimen was examined regionally, including the head, thoracic, and abdominal regions. Special attention was given to lymph nodes (LN) and associated organs in those regions. In the head region: parotid, lateral retropharyngeal, medial retropharyngeal and submandibular lymph nodes were examined. In the thoracic region: mediastinal (cranial, middle, caudal), bronchial, tracheobronchial lymph nodes; lungs (right cranial/apical, middle, right diaphragmatic and accessory, left cranial, cardiac and left diaphragmatic); and pleural surfaces were inspected. In abdominal region: liver, hepatic and mesenteric LNs and kidney were examined. Additionally, prescapular, prefemoral

and popliteal LNs were also examined. All bTB-suspected organs were collected for a more detailed inspection where each organ was cut into numerous slices using separate scalpel blades and examined visually under a bright light source (Fig. 2). Cattle carcass with tuberculous lesions indicative of bTB, was classified as bTB-positive and those with no tuberculous lesions suggestive of bTB were recorded as bTB-negative.



Fig. 2. Tuberculous lesions on lymph nodes, lungs and liver

Retrospective data

To contextualize the obtained results within a longer-term trend, we gathered and analyzed retrospective data from routine meat inspection findings throughout the Mbeya district and city councils from 2019 through 2023. The data comprised anonymized records of gross tuberculous-like lesions identified in slaughtered cattle during standard abattoir operations. While they were not bacteriologically confirmed, these data serve as consistent proxy for monitoring long-term trends over bTB-suspected pathology in the region.

Statistical analysis

Data management was performed in Microsoft Excel and analyzed in R (version 4.5.0) where graphical illustrations and statistical analysis were carried out. Prevalence of gross tuberculous lesions was determined as a proportion with 95% CI. Associations between lesion status and animal characteristics such as sex, age, breed, origin, abattoir, and body condition were determined by Chi-square tests.

For retrospective data from (Mbeya district council (MDC) and Mbeya city council (MCC), a Lowess smooth curve was used to illustrate a five-year temporal trend in tuberculous lesion reporting. Poisson regression model was done as additional analysis of the time trend in tuberculous lesion reporting using incidence, year, total cattle slaughtered and abattoir as an outcome variable, the explanatory variable, exposure variable and a random effect variable respectively. The likelihood ratio test and corresponding p-value were used to assess model fit to the recorded data. Statistical significance was taken at $p < 0.05$.

RESULTS

The study inspected a total of 19,270 cattle carcasses from selected Mbeya region abattoirs in Tanzania, which revealed an overall bTB lesion prevalence of 0.11% (95% CI: 0.08-0.17).

Substantial differences in prevalence were found across various key cattle characteristics (Table 1). For example, lean-bodied cattle recorded the highest prevalence rate of 0.74% (95% CI: 0.29-1.89), while medium and fat cattle had a low prevalence of 0.08% (95% CI: 0.05-0.14) and 0.15% (95% CI: 0.06-0.35), respectively ($\chi^2 = 20.21$, $p < 0.001$).

Abattoir and cattle geographic origin were the geographical factors which influenced greatly bTB prevalence. Cattle slaughtered at Utengule abattoir post higher lesion rates of 0.19% (95% CI: 0.12-0.30) compared with Ilemi abattoir (0.02%) and Uyole abattoir (0.03%) ($\chi^2=11.95$, $p= 0.0025$). Equally, cattle originating from Sumbawanga (Rukwa) showed high prevalence (0.20%, 95% CI: 0.13-0.32) than those sourced from within Mbeya region (0.04%) and neighboring region of Tabora (0%) ($\chi^2=12.41$, $p=0.002$).

Table 1. Animal characteristics and bTB proportion in slaughtered cattle in Mbeya region

Animal factor	Category	Total carcass inspected	bTB lesions (+)	Prevalence % (9% CI)	χ^2	df	p-value	Sig.
All animals		19270	22	0.11 (0.08-0.17)				
Sex	Male	14635	14	0.1 (0.06-0.16)	1.83	1	0.18	ns
	Female	4635	8	0.17 (0.09-0.34)				
Age	Young (<2 years)	1148	2	0.17 (0.05-0.63)	0.78	2	0.68	ns
	Young adult (2-4 years)	14612	15	0.1 (0.06-0.17)				
	Adult (>4 years)	3510	5	0.14 (0.06-0.33)				
Breed	Local	19149	21	0.11 (0.07-0.17)	5.54	2	0.063	ns
	Cross	119	1	0.84 (0.15-4.61)				
	Exotic	2	0	0 (0-65.76)				
Body condition	Lean	540	4	0.74 (0.29-1.89)	20.21	2	<0.001	***
	Medium	15434	13	0.08 (0.05-0.14)				
	Fat	3296	5	0.15 (0.06-0.35)				
Abattoir	Utengule (Mbalizi)	10452	20	0.19 (0.12-0.30)	11.95	2	0.0025	**
	Ilemi	5398	1	0.02 (0.00-0.10)				
	Uyole	3420	1	0.03 (0.01-0.17)				
Origin	Mbeya	11818	5	0.04 (0.02-0.10)	12.41	2	0.002	**
	Sumbawanga (Rukwa)	8452	17	0.20 (0.13-0.32)				
	Tabora	573	0	0 (0-0.67)				

Additionally, the cattle carcasses showed no significant differences by either sex (males (0.10%) against females (0.17%)) ($\chi^2=1.83$, $p=0.18$) or age ($\chi^2=0.78$, $p=0.68$). Also, breed differences had no statistical significance ($\chi^2=5.54$, $p=0.063$) in terms of prevalence of bTB lesions, regardless of higher prevalence (0.84%) in cross-breeds compared to local

breeds (0.11%). Sample size for exotic breeds was too small ($n=2$) for any noteworthy analysis.

We observed, as shown by the Lowess smoother curve, a fluctuating five-year trend in reported cases of tuberculous lesions in the Mbeya region (Fig 3a). The trend is characterized by fluctuating pattern that

begins with a decline from 0.79% in 2019 to 0.66% in 2020; an obvious peak in 2021, reaching 0.93%, possibly due to an outbreak or intensification of surveillance; and then stabilization at 0.60-0.65% in 2022 and 2023, indicative of persistent low-level endemic transmission.

The retrospective data of bTB lesion cases in slaughtered cattle in the abattoirs of Ilemi, Uyole, and Utengule from 2019 to 2023 indicated varying levels

of prevalence trends (Fig 3b). Ilemi recorded the highest annual prevalence of 0.93% in 2021, declining to 0.60% in 2023. Utengule abattoir on the other hand, the cases started off at 0.38% in 2019 rising to 0.79% in 2022, before insignificantly decreasing to 0.77% in 2023. In contrast, Uyole consistently reported the lowest prevalence of 0.02% in the course of the five-year period, in spite of slight increase in numbers of slaughtered animals in subsequent years (Table 2).

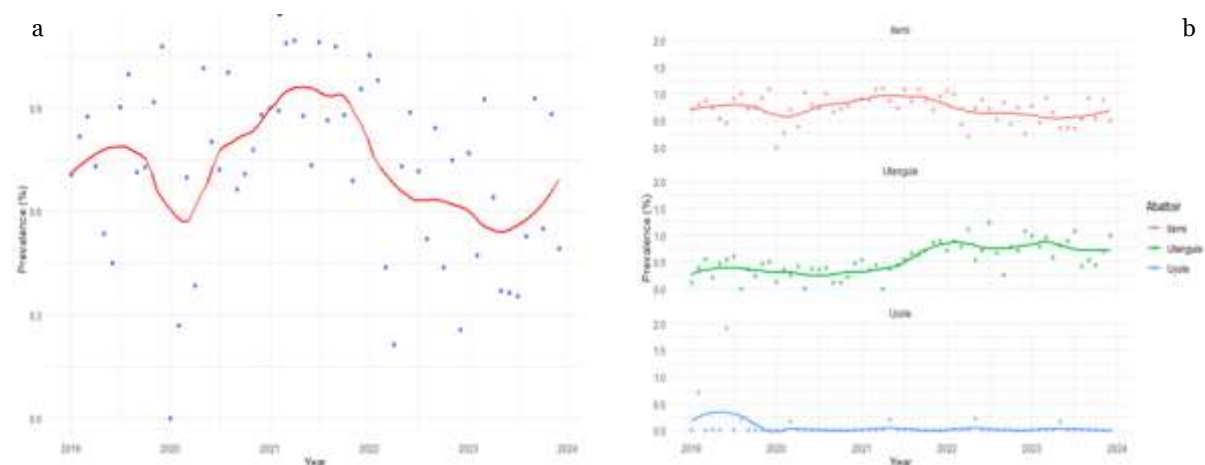


Fig. 3. Lowess smoother graphs showing (a) general trend in cases due to bovine tuberculosis (b) trend of TB-like lesions at Ilemi, Utengule and Uyole abattoirs in Mbeya region

Table 2. Five-year retrospective prevalence of bTB in slaughter cattle at Ilemi, Uyole and Utengule abattoirs in Mbeya region

Year	Abattoir								
	Ilemi			Uyole			Utengule		
	Slaughtered	bTB	Prev %	Slaughtered	bTB	Prev %	Slaughtered	bTB	Prev %
2019	13212	104	0.79	5750	16	0.28	10003	38	0.38
2020	13136	87	0.66	5995	1	0.02	10071	27	0.27
2021	11277	105	0.93	6158	1	0.02	11174	63	0.56
2022	10076	65	0.65	6366	1	0.02	13106	103	0.79
2023	10425	63	0.60	6105	1	0.02	12977	100	0.77

The Poisson regression with random intercepts for abattoir, which indicated significant temporal variation in the rates of bTB lesions. Overall, the baseline rate for bTB lesions was 0.3 cases per 100 animals slaughtered in 2019 (95% CI: 0.1–1.1). There was also significant variation between abattoirs, as reflected by the ICC of 0.26. Relative to the baseline year (2019), the IRR was significantly lower in 2020 (IRR = 0.73, 95% CI: 0.57–0.93, $p = 0.009$), indicating a 27% reduction in tuberculous cases. Subsequent years showed non-significant fluctuations: 2021 (IRR = 1.12, 95% CI: 0.90–

1.39, $p = 0.30$), 2022 (IRR = 1.10, 95% CI: 0.89–1.37, $p = 0.37$), and 2023 (IRR = 1.06, 95% CI: 0.85–1.32, $p = 0.60$). The intraclass correlation coefficient (ICC) of 0.26 (derived from the random intercept variance, $\sigma^2 = 1.07$) indicated that 26% of the total variance in tuberculous lesion rates was attributable to abattoir-level differences, independent of temporal trends (Table 3).

The full model showed significantly better fit to the recorded data than the null model ($\chi^2 = 17.13$, $p = 0.0018$), this was supported by evidence from both

AIC ($\Delta = 9.13$) and BIC ($\Delta = 6.30$). This confirms that a meaningful temporal variation in tuberculous lesion rates exists beyond random abattoir effects, consistent with the observed 27% reduction in 2020

(IRR = 0.73, $p = 0.009$) and subsequent stabilization (Table 4). The likelihood ratio test and corresponding p-value were used to assess model fit to the recorded data. Statistical significance was taken at $p < 0.05$.

Table 3. Poisson mixed-effects model results for bTB temporal trends in selected abattoirs in Mbeya region

Term	IRR (95% CI)	p-value
Intercept	0.003 (0.001–0.011)	<0.001
Year 2020	0.73 (0.57–0.93)	0.009**
Year 2021	1.12 (0.90–1.39)	0.301
Year 2022	1.10 (0.89–1.37)	0.371
Year 2023	1.06 (0.85–1.32)	0.601
Random effects		
Abattoir SD (σ)	1.07	-
ICC	0.26	-

Table 4. Model fit statistics and likelihood ratio test results

Model	npar	AIC	BIC	logLik	-2*log(L)	χ^2	Df	p-value
Null model	2	186.3402	187.7563	-91.1701	182.3402	-	-	-
Full model	6	177.2055	181.4538	-82.6027	165.2055	17.13474	4	0.00182

DISCUSSION

This abattoir-based study provides a snapshot of bovine tuberculosis (bTB) surveillance in the Mbeya region, revealing an overall prevalence of gross tuberculous lesions of 0.11%. This figure is notably lower than many national and regional estimates (Katale *et al.*, 2012; Nalapa *et al.*, 2017; Belete *et al.*, 2021). Nevertheless, meat inspection as a diagnostic method is known to be less sensitive and underestimates the true disease prevalence; therefore, this finding must be interpreted as the prevalence of visible bTB lesions rather than actual disease burden (Singhla and Boonyayatra, 2022). Within this context, the most valuable findings of this study are not the low overall prevalence, but rather the significant geographic and temporal variations that highlight heterogeneous risk and identify specific targets for intervention.

The substantial disparity in visible lesion prevalence between abattoirs, with Utengule recording a significantly higher rate (0.19%) than the rest abattoirs, highlights the role of catchment area epidemiology (Alton *et al.*, 2010). The observed pattern is in congruence with findings from Uganda and Ethiopia, where abattoir specific risks are influenced by cattle origin and local practices (Nalapa

et al., 2017; Woldemariam *et al.*, 2021). The high prevalence in Utengule abattoir was solely contributed by cattle sourced from Sumbawanga in the Rukwa region.

Geographic origin became the highest risk factor, since cattle sourced from Sumbawanga presented a prevalence rate of 0.20%, higher than that from other origins. The encroachment of pastoralist communities into areas like Rukwa and Katavi in recent years (Awinia, 2020; URT, 2022) would probably provide ideal ecological conditions for bTB transmission, as it does in other pastoral settings elsewhere (Woldemariam *et al.*, 2021). Therefore, Utengule abattoir and the Rukwa region should be prioritized as higher risk targets for enhanced bTB surveillance and tailored biosecurity and control measures.

The investigated five-year retrospective abattoir data showed a significant decrease of 27% in the number of lesions reported during the year 2020, insignificant fluctuations thereafter, and final stabilization at a low level during 2022–2023. This trend evidences the role of an abattoir as one surveillance point in time to monitor temporal trends of the disease bTB. A further evidence of important heterogeneity within surveillance data was provided by significant abattoir-

level variation $ICC = 0.26$ after accounting for confounders on variables such as consistency in inspection activities and the geographic origin of the slaughter stock (Woldemariyam *et al.*, 2021). This recent stabilization may indicate increased veterinary efforts toward animal disease control with a persistent low-level endemic status for detectable bTB lesions.

Animals in poor body condition were more likely to have bTB lesions, the established link fostered a known interrelationship that exists between malnutrition, compromised immunity, and disease susceptibility (Broughan *et al.*, 2016). The finding potentially highlights the importance of nutritional management as part of integrated bTB control.

Our study found no statistically significant associations between bTB lesion prevalence and breed, sex, or age. It is critical to emphasize that the apparent numerical difference between cross-breeds (0.84%) and local breeds (0.11%) was not statistically significant ($p=0.063$), and our study therefore provides no conclusive evidence for a breed-specific effect in this population.

This contrasts with studies from intensive systems where exotic breeds show higher susceptibility (Fioravanti *et al.*, 2020); the difference may be that cross-breeds in our study area are not managed in high-intensity, high-exposure settings that would unmask genetic susceptibility (Vordermeier *et al.*, 2012).

Similarly, our finding of no significant age trend conflicts with research carried out in other countries like China and Malawi, which identified age as a risk factor for bTB because of accumulative exposure (Zhu *et al.*, 2023; Kapalamula *et al.*, 2023). The inconsistency could be related to our visible lesions methodology, as this would detect only advanced disease, whereas the serological and molecular tests would detect some evidence of cumulative exposure (Smith *et al.*, 2021). Younger animals could have developing lesions, while older animals have a localized infection and may thus not be as easily detected, obscuring an age-related trend that would

have been obvious with more sensitive diagnostic tools (Rua-Domenech *et al.*, 2006).

These non-significant findings, and the study as a whole, must be viewed in light of important limitations. The primary constraint is the low sensitivity of meat inspection for detecting bTB, which means our prevalence is a substantial underestimate (Garcia-saenz *et al.*, 2015) and our analysis lacks power to detect weaker risk factors. Furthermore, the slaughter population is a biased sample of the general herd, and our univariate analysis could not control for potential confounding between variables like origin, breed, and management system.

CONCLUSION

Although the true prevalence is most likely underestimated, this study effectively finds distinct and helpful epidemiological patterns. Gross bTB lesions in cattle clustering in Sumbawanga and the Utengule abattoir provide a sound evidence base for focused intervention. We recommend that the veterinary public health authorities give these high-risk areas highest priority for enhanced surveillance that should involve the use of higher-sensitivity diagnostic tests. Efforts in the future need to be focused on integrated studies that incorporate abattoir data and on-farm investigations with molecular typing to thoroughly elucidate the dynamics of bTB transmission in southern Tanzania and inform the development of an affordable, targeted control program.

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