

## Impact of bovine tuberculosis on socio-economic status of livestock farmers in selected parts of Zambia

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### Abstract

**Introduction:** Bovine Tuberculosis (bTB) is a significant zoonotic disease that affects the human population and livestock globally. In Zambia, bTB poses substantial economic and social challenges to livestock farmers.

**Aim:** The purpose of this study was to assess the impact of Bovine Tuberculosis on the social-economic status of livestock farmers.

**Methodology:** The study was qualitative and quantitative in nature and concurrent triangulation design guided the study. The study had 280 participants who were selected through heterogeneous purposive sampling. The production of data was through semi-structured interviews, structured questionnaires, and document analysis. Quantitative data analysis was performed in R software, while qualitative data was analyzed using Nvivo® and content analysis.

**Findings:** The results revealed that there was a significantly high impact of bTB on monthly income ( $p < 0.001$ , OR = 0.99, CI = 0.997-0.998). For every 0.99 odds of a decrease in monthly income, the impact from bTB increased, an indication of a reduction of monthly income resulting from the high impact of bTB. Our results also indicated that for every one-unit increase in monthly income, the log of the odds associated with low milk production decreased by 3.38. Therefore, the more income generated from milk sales the lesser milk production incurred. The results revealed that there was a significantly high impact of bTB on monthly income ( $p < 0.001$ , OR = 0.99, CI = 0.997-0.998). For every 0.99 odds of a decrease in monthly income, the impact from bTB increased, an indication of a reduction of monthly income resulting from the high impact of bTB. Further, participants were faced with carcass contamination at abattoirs. They suggested that the government working together with other stakeholders should initiate an insurance scheme to cover livestock. However, the contributions should be minimal. Finally, participants reported having experienced social-economic discriminatory statutes, as they were not rendered eligible to be part of cooperatives where they would borrow money for empowerment (surety) due to losing of source of income (animal) at an abattoir.

**Keywords:** Bovine Tuberculosis; Cattle Farmer; Human Population; Social-Economy; Zoonotic Disease

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## 1. Introduction

Bovine Tuberculosis presents a significant challenge to beef and dairy farmers. The social impacts of bTB are mostly connected to trade barriers for live animals and animal products, in addition to the financial costs of implementing compulsory bTB eradication programs. The test and slaughter programs would affect the social living standard of the farmer. It was for this reason that this study was conducted to determine the impact of Bovine Tuberculosis on the social-economic status of people in the Eastern and Southern provinces of Zambia.

The name Tuberculosis originates from the nodules, called 'tubercles', which form in the lymph nodes of affected animals. Not until the 1920s that control measures began in developed countries. It was one of the major diseases of domestic animals globally. Today TB remains an important disease in cattle, and wild animals, and is a significant zoonosis (17).

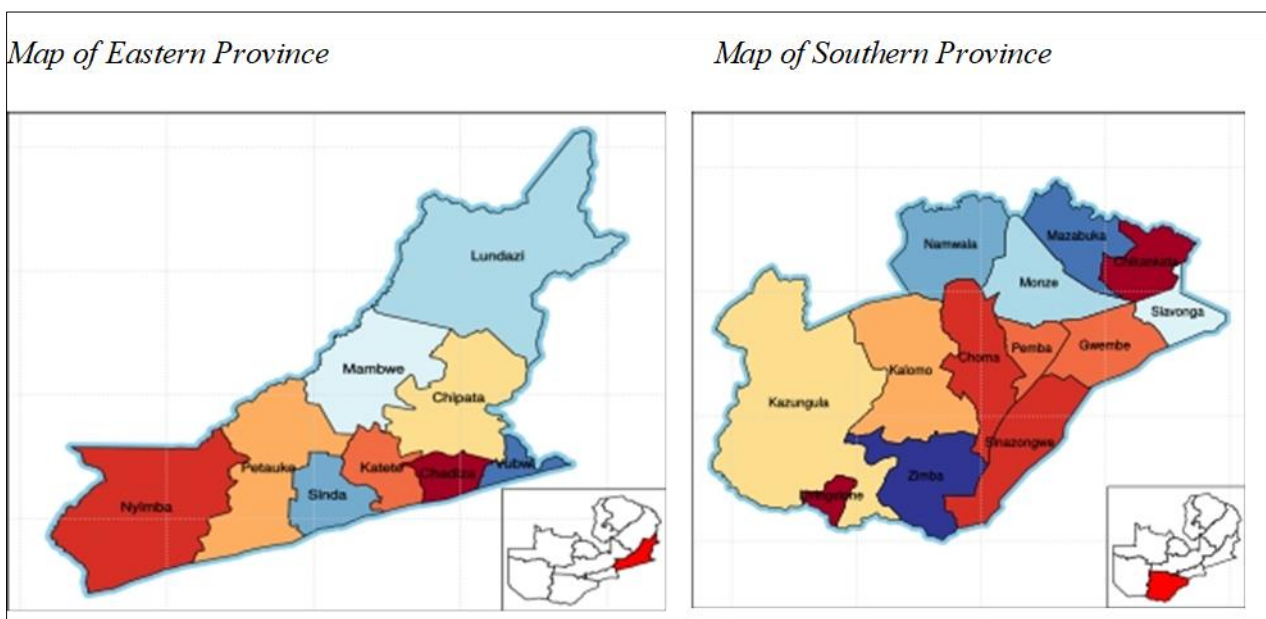
In nations where the majority of poor pastoral communities rely upon dairy cattle for survival, bTB is regarded to be the main risk (15). It has high economic relevance in the context of stock farming because it directly has an effect on animal productivity and influences the international trade of animal products (16).

Further, social-economic implications of bTB are felt in the control and eradication of the human disease that it may cause (13). In the pre-pasteurization age, *M. Bovis* contributed considerably to human T.B., primarily the extra-pulmonic type. The management of the 3.1 % portion of all human TB cases involves a huge value of money to the government as well as the affected people. Bovine Tuberculosis affects the economic items of drug expenses and expenses of health care (26).

## 2. Methods

This study used a mixed-methods approach and concurrent triangulation was its research design employed in order to determine the impact of Bovine Tuberculosis on the social-economic in Zambian Cattle Farmers from an interpretive point of view to make sense of the meanings the participants had about the impact of social-economics based on their lived experiences. An interpretive paradigm espouses "relativist ontology (there are multiple realities), a subjectivist epistemology (knower and respondent concrete understandings), and a naturalistic (in a natural world) set of methodological procedures" (9).

### 2.1. Study Site



Source: <https://mapcarta.com/14157762> Source : <http://www.maplandia.com/zambia/eastern/lundazi/lundazi/>

**Figure 1** Maps of Eastern Province and Southern Province

This study was conducted on selected cattle owners and respondents of Lundazi in the Eastern province and Monze Southern Province of Zambia. Lundazi (12.2849° S, 33.1745° E) and Monze (16.2803° S, 27.4733°) (Figure 1) The proposed study sites were chosen because they constitute one of the areas in Zambia, with a large population of cattle. There is also well high dependency on cattle for everyday living. Further, residents tend to sell cow milk for survival. Lundazi district is located in the Eastern province of Zambia, which has a total cattle population of 597,149 with Lundazi district contributing 63,144 of this total number. Monze district is located in the Southern province of Zambia which has a total cattle population of 1,225,090, and Monze district contributes 284,713 17 (24). The Livestock and Aquaculture Census, main report. Additionally, people in these respective areas use cattle to pay the bridal prices at large.

## **2.2. Sample Size**

According to Cooper (8), cost considerations influence decisions about the size and type of sample and data collection method. Due to limitations in resources, this research only focused on the households in Lundazi and Monze districts. Cooper (8) further explained that the basic idea of sampling is that selecting some elements in a population, may draw conclusions about the entire population. The targeted sample size of 374 was not attainable due to respondent's farming activities and impassable roads (Lundazi data was collected in February, during the rainy season). In making a decision on the number of participants to be included in the sample, a number of factors as proposed by Morse (14) were considered in this study. The factors included the scope of the study, the quality of the data that is to be gathered, and the design of the study. The sample included 280 participants. The sample was distributed into these categories 11 veterinary officers, 10 medical doctors, 23 social workers, 28 commercial businessmen, and 208 cattle farmers

## **2.3. Sampling procedure**

Since the sample was heterogeneous in nature where systematic sampling technique was applied as it enabled the researchers to draw a sample with rich and varied insights into the phenomenon that was being studied. Structured and semi-structured questionnaires and structured and semi-structured interview guides were the instruments that guided the process of data production.

## **2.4. Data collection procedure**

Before the commencement of the data generation process, permission was obtained from respective village headmen. A triangulated approach was used to generate data through structured, semi-structured interviews and document analysis. The interviews took place within the premises of their households to give participants some level of empowerment and control of the research process. All the interviews were conducted in the English, Chichewa, and Chitonga languages and lasted for approximately 60 minutes, which was within the 90-minute recommended duration for a qualitative interview (22). For recording purposes, two methods were used. Firstly, the researcher took up both roles of the recorder and interviewer by recording the responses in a field notebook. Secondly, the researcher made use of a voice recorder to record the interviews with permission and consent from the interviewees

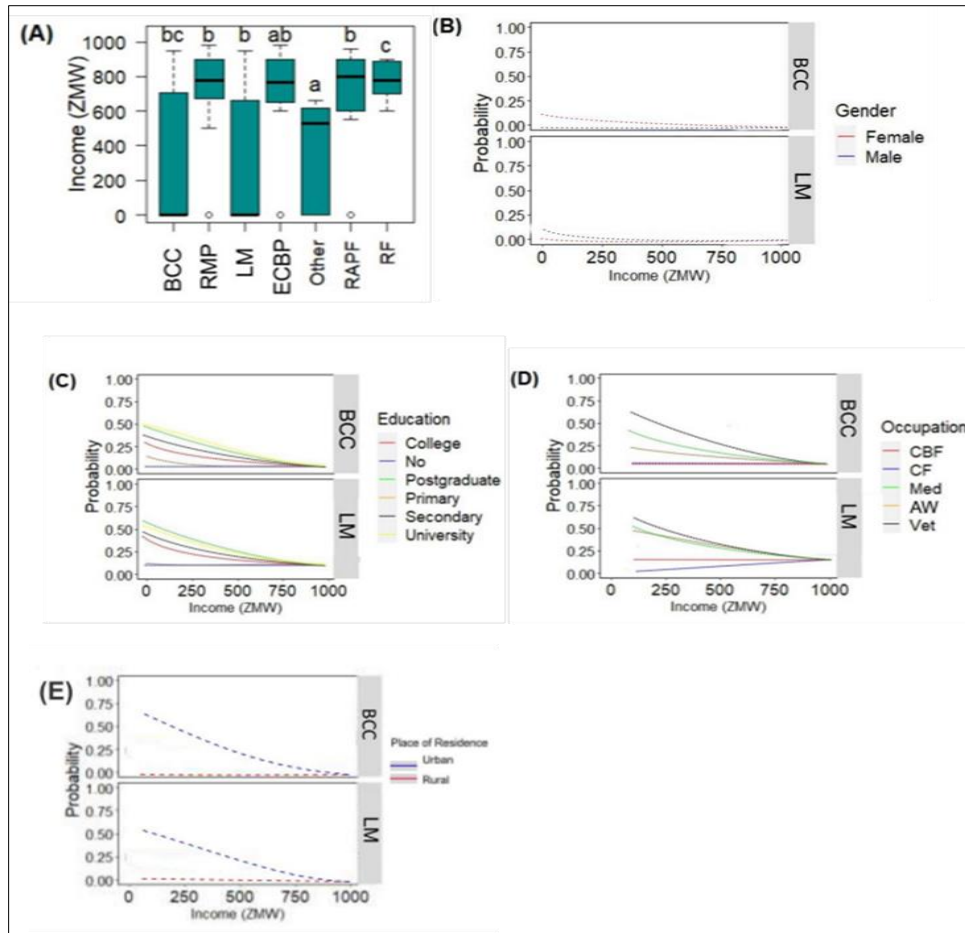
The structured and semi-structured interviews and structured and semi-structured questionnaires were used to gather data from participants. Additionally, data from interviews were recorded using a voice recorder after participants' consent and a diary.

## **2.5. Data Analysis**

To determine the impact of bTB on gender, occupation, education, and residential, the researcher constructed an ordinal logistic regression models using the "ordinal" R package (7). Prior to conducting ordinal logistic regression, the regression parallel assumption was checked using the "brant" function from the "brant" R package. Qualitative data that were generated from participants were analyzed using NVivo software, which was used to analysis of unstructured text, audio, video, and image data. For anonymity and confidentiality purposes, participants were given pseudonyms.

## **2.6. Ethical Considerations**

The study was approved by the University of Zambia's Biomedical Research Ethics Committee. Ethical approval and clearance number 2102-2021. Permission to conduct a study was further sought and granted by the respective village Headmen in the communities. The participants were told about the nature of the study and their rights, which included the right to personal privacy, the right to withdraw from the research at any time without providing a reason, and the right to review and withhold interview content, all following the principles of informed consent and voluntary participation. Furthermore, there was no physical or emotional damage to the participants.



**Figure 2** The impact of bTB (BCC: Beef Carcass Condemnation RMP: Reduced Meat Production, ECBP: exchange cattle for bride price, LM: Low milk production, ECBP: Exchange Cattle for Bridal Price, Other: unspecified reasons, RAPF: Reduced Animal Power for farming and RF: Reduced Fertility) on monthly income (ZMW) analyzed from a generalized linear model with lower case letters showing significant differences at  $p < 0.05$  (A). The change in predicted mean probabilities of income attributed to bTB impact factors of BCC and LM on Gender (B), Education levels (C), Occupation levels (D), and Place of residence (E) are provided from multinomial models

### 3. Result and Discussion

Bovine Tuberculosis has been shown in many countries to be a social-economic burden to society due to economic losses. Loss of productivity of infected animals such as reduced milk yields and meat production, animal market restrictions, human health costs, etc. The socio-economic impact of bTB on the agriculture and health sector in Turkey has been estimated at between 15 and 59 million US\$ annually (4) whilst in Africa, the social-economic losses as a result of bTB have not been examined sufficiently or have not been studied either (3).

This study determines the impact of Bovine Tuberculosis on the social-economic status in the Eastern and Southern Provinces of Zambia. The results revealed that there was a significantly high impact of bTB on monthly income ( $p < 0.001$ , OR = 0.99, CI = 0.997-0.998). For every 0.99 odds of a decrease in monthly income, the impact from bTB increased, an indication of a reduction of monthly income resulting from the high impact of bTB.

#### 3.1. Impact of bTB on gender, occupation, education and residential

The results findings indicated that for every one-unit increase in monthly income, the log of the odds associated with low milk production decreased by 3.38 (Figure 2A). The study revealed that for every unit sold of milk to support the family, there would be minimal milk production due to the effect of bTB. The study findings are similar to the findings in a study done in former East Germany by Meisinger (11) it was reported that Bovine Tuberculosis impacted animal productivity and affected milk production by 10%. Further, in a study done by Bernues et al., (5) milk loss of 12% and a reduction in fertility of 5% were attributed to bTB infections in animals. The Meisinger and Bernues figures have since

then been extensively used to describe productivity and economic losses in cattle due to bTB. However, these figures are now outdated and do not take into account other factors such as breed, husbandry, and environment.

More recent small-scale studies showed diverging or sometimes inconclusive results. Boland et al.,(6) showed a significant decrease in milk production in bTB reactors in Irish dairy farms ranging from 120 to 573 kg milk loss per lactation. In a study conducted by Rahman et al., (20) revealed a 17% decrease in milk yield in Bangladesh, however in more recent findings in Mexico, it was reported that only a marginal decrease in some reproductive performances and milk yields in bTB-positive animals (12). It is from this premises that the more income you would get from the selling of milk the lesser production of milk it becomes. In agreement Allan et al., (2) revealed that daily cattle tend to accrue the greatest losses during a bTB occurrence, there is very little milk production to sustain the farmer. Further, the log of the odds associated with abattoir beef carcass condemnation and reduced meat production decreased by 3.22 and 2.86 respectively for every one-unit increase in income. In this study, as cattle farmers increase their livestock herds, it was revealed that there was some animal condemnation at an abattoir that led to a reduction of meat production after slaughtering due to bTB infection. (Figure 2A) Similarly, in a study done by Jemalo (10), it was postulated that income in terms of animals for the cattle farmers was drastically affected by the impact of Btb. In the same study, it was revealed that animals at the abattoir had shown a reduction in meat production because of the confiscation of carcasses and organs due to visible TB-like lesions. The findings also revealed that the more herds of cattle farmers had the more expenses incurred for purchases of medicine to treat zoonotic diseases. The study revealed that farmers treated their animals for bTB unknowingly that the disease is untreatable in animals. Farmers spent a lot of money in treating the disease but in vain. The findings are also similar to the study done by Rosario et al., (21) which postulated that livestock farming generated income for the farmers with limited resources and was key to biodiversity conservation. However, costs derived from a lack of knowledge of fighting Bovine Tuberculosis can make the farmer spend more money on buying medications. Study findings showed that the model predicted mean probabilities of males had higher probabilities for reduction in income than females attributed to Beef Carcass Condemnation (BCC) (Figure 2 B). Contrary to BCC, the loss in income due to Low Milk production (LM) showed minimal differences in probabilities between males and females although the females showed slightly higher predicted mean probabilities (Figure 2B). Similarly, according to Tangka et al.,(23), men are largely engaged in the business of cattle selling and at times may be affected by beef and carcass condemnation at an abattoir hence affecting their financial capabilities as opposed to women who are mostly responsible for milking, processing of milk and marketing of surplus milk and dairy products. In the production of milk, they may face a reduction in milk production due to bovine tuberculosis. In contrast to gender, the impact of bTB on income among the different education levels showed different patterns (Figure 2 C). Income patterns associated with BCC showed observable changes in income for primary school which is similar to LM in which individuals with primary education and those without education exhibit detectable changes in monthly income (Figure 2 C). The study findings revealed that farmers without formal education had their income negatively affected because of minimal awareness levels about the transmission of the disease. Similarly, in a study conducted by Zhao, (25) it was postulated that livestock keepers with a secondary or higher level of education were about three and five times, respectively, more likely to have adequate knowledge about bovine tuberculosis hence their income was not affected by any zoonotic disease. Further, reported that higher education was found to be linked with appropriate bTB control and prevention practices. The findings were also conducted on a comparison of the reduction in income associated with BCC and LM which indicated that higher probabilities of reduced income were observed in cattle farmers and commercial businessmen (Figure 2 D). Mean predicted probabilities in income changes due to the impact of bTB were lowest in medical and veterinary personnel. The study findings are in agreement with the study conducted by Otte et al., (18) reported that Bovine Tuberculosis and other zoonotic diseases pose a negative impact on incomes and socioeconomic and public health outcomes of those involved in the livestock business, ultimately placing risks on trade as well as individual costs of disease prevention, control, and total loss as opposed to the professionals who are not directly involved in the rearing of cattle. Similarly, Africa Sustainable Livestock 2050, (1) reported that zoonotic diseases, which cross the animal-human species barrier, are a major threat to the social economy as they could affect cattle farmers' and butcher's income negatively, whilst medical technologist income is merely influenced by zoonotic diseases because their job is to offer services as well as guidance.

A comparison of reduction of income associated with BCC and LM indicated a reduction of income which had been observed in the rural areas as opposed to urban areas. (Figure 2 E) Findings revealed that those in rural areas depended on livestock rearing and agriculture as a main source of income generation as opposed to those residing in urban areas. As most of them are in employment and have a stable monthly income. Similarly, in a study done by, Pateman, (19) findings revealed that rural residents have a larger number of people who have never worked and depend on livestock keeping, than those residing in urban areas. Most rural people have migrated to urban residents searching for employment and running away from the hardships of farming.

#### 4. Conclusion

The study revealed the significant socio-economic impact of bovine tuberculosis (bTB) due to the condemnation of infected carcasses at abattoirs resulted in substantial income losses for livestock farmers. bTB affected milk production which further exacerbated economic hardship. Disparities in the impact of bTB were evident, with farmers having only primary school education, those without formal employment, males, and rural residents being disproportionately affected. There is a need for targeted interventions, including education and training programs, to improve bTB management and mitigate its socio-economic consequences, particularly among vulnerable populations. Additionally, the government working together with other stakeholders should initiate an insurance scheme to cover livestock farming.

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#### Compliance with ethical standards

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##### *Declarations*

The study was conducted according to the guidelines of the Declaration of Helsinki and was approved by the University of Zambia's Biomedical Research Ethics Committee. Approved on the 29<sup>th</sup> of November, 2021.

##### *Consent for publication*

The data in this manuscript have not been previously reported by the authors for publication elsewhere. All authors participated, reviewed, and approved the final submitted version of the manuscript.

##### *Disclosure of conflict of interest*

The authors have declared that no conflicts of interest exist.

##### *Availability of data and materials*

The datasets used and/ or analyzed during the current study are available from the corresponding author upon reasonable request.

##### *Authors' Contributions*

A.P. conceptualized the study and designed the methodology and performed Statistical analyses A.P., M.M., J.S.S.M., S.K, I.N.L and S, M, performed the formal analysis, reviewed and edited the manuscript. A.P. prepared the tables and performed the visualization. S.M. supervised the data analysis and drafted manuscript. S.M Conceptualized and supervised the study All the authors have read and agreed to the published version of the manuscript.

##### *Statement of ethical approval*

The study was approved by the University of Zambia's Biomedical Research Ethics Committee. Ethical approval and clearance number 2102-2021.

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