

**RISK FACTORS ASSOCIATED WITH THE OUTBREAK OF CONTAGIOUS BOVINE
PLEUROPNEUMONIA IN CHISAMBA DISTRICT, ZAMBIA.**

By;

Oscar Kamaya Kamasongo;

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requirements of the Degree of Master of Science in Tropical Infectious Diseases and
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Declaration

I, Oscar Kamaya Kamasongo, do hereby declare that this dissertation is entirely my own work and that all this work has never been presented or submitted to this institution or any other for similar purposes. All similar research has been cited and dully acknowledged.

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Certificate of approval

This dissertation of OSCAR KAMAYA KAMASONGO, has been approved as fulfilling the requirements for the award of **MASTER OF SCIENCE IN TROPICAL INFECTIOUS DISEASES AND ZOONOSIS** by The University of Zambia.

Examiner	-----	-----
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Abstract

Contagious bovine pleuropneumonia (CBPP) is a highly contagious and severe infectious disease of cattle that is listed as a notifiable disease by the World Organisation for Animal Health (WOAH). CBPP is caused by *Mycoplasma mycoides* subspecies *mycoides* small colony, which can lead to severe cattle losses. In 2022, two districts in Zambia, Chibombo and Chisamba, recorded outbreaks of CBPP. To halt the spread of CBPP to nearby districts, a mass slaughter exercise was conducted in which livestock farmers lost their cattle. It was thus the objective of this study to determine the risk factors that facilitated the occurrence of the disease in the district of Chisamba and assess the knowledge of cattle farmers on CBPP. Chisamba district is known for having many farms and for its agricultural activities hence the impact of a CBPP outbreak on the economy cannot be ignored. Data was collected using a pre-tested semi-structured questionnaire. The questionnaire comprised a total of 42 questions, divided into three sections namely, demographic information of the participants, cattle management practices on the farms, and knowledge of CBPP of the participants. The questionnaire was administered to 55 participants who comprised both commercial (10) and small-scale (45) livestock farmers in Chisamba district. Only adults (18 years and above) who owned cattle or farm workers actively involved in cattle management, and had agreed to participate by way of a signed consent, were enrolled in the study. A snowball sampling technique was employed to select the individual participants and purposive sampling was used to select the farms.

Of the 55 farms from which the participants were drawn, only 2 farms had recorded positive cases of CBPP. Eight risk factors were assessed and these were the age of cattle, sex of cattle most affected, herd size, mode of feeding, source of water, cattle trading, access to veterinary services, and housing facility of cattle. In the current study, only trading of cattle ($p\text{-value} = 0.039$; $RR = 1.238$, 95% CI), was strongly associated with the occurrence of CBPP, suggesting that trade and movement of infected cattle which were mixed with the old healthy herds could have precipitated the CBPP outbreak in the district. Moreover, the low numbers (13.8%) of participants with some knowledge of CBPP and the factors associated with it were worrying. Hence the study recommends that the government, relevant bodies, as well as farmers must strictly check the health status of animals before they can engage in cattle trading. Furthermore, there is a need to regularly engage livestock farmers and educate them about diseases of economic importance such as CBPP. The study will help raise awareness on better cattle trading practices and knowledge of farmers.

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List of Abbreviations

CBPP	Contagious Bovine Pleuropneumonia
GDP	Gross Domestic Product
MNDP	Ministry of National Development and Planning
ENDP	Eighth National Development Plan
TAD	Transboundary Disease
WOAH	World Organization for Animal Health
OIE	International des Epizooties
ACEIDHA	African Centre of Excellence for Infectious Diseases of Humans and Animals
<i>Mmm</i>	<i>Mycoplasma mycoides</i> subspecies <i>mycoides</i>
ROS	Reactive Oxygen Species
TLR	Toll-Like Receptors
IL	Interleukin
DVS	Director of Veterinary Services
cELISA	Competitive Enzyme Linked Immunosorbent Assay
CFT	Complement Fixation Test
PCR	Polymerase Chain Reaction

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1.0 INTRODUCTION

1.1 Background

The agricultural sector plays an important role in contributing to the food security and growth of the Zambian economy. Due to its importance in driving the economy, the Zambian government through the implementation of the Eighth National Development Plan (ENDP), strives to improve livestock production by setting up community-run livestock service centres, provincial insemination centres, and veterinary laboratories (Ministry of Finance and National Planning, 2022). According to a study done by Odubote (2022), it was noted that in rural areas, 42% of Zambia's gross domestic product and 50% of employment were as a result of the contribution of the livestock sub-sector. Globally, livestock plays a crucial role in the economy at various levels and ways including household income, food security, agricultural draft power, high-quality animal proteins and vitamins (meat and milk), manure, hides and skins, and the sustenance of livelihoods (Negash and Dubie, 2021).

All animal species are prone to respiratory diseases which affect their productivity (Di Provvido et al., 2018). Contagious Bovine Pleuropneumonia (CBPP) is a severe notifiable, infectious and highly contagious respiratory disease of cattle which is caused by *Mycoplasma mycoides* subspecies *mycoides* small colony (Molla et al., 2021). The World Organisation of Animal Health (WOAH) has listed CBPP as a notifiable disease (Thiaucourt et al., 2024). It is one of the most important diseases of economic significance in Southern Africa. The disease has serious effects on food security in the affected communities as it is one of the major threats to cattle health and growth of livestock. CBPP can lead to the loss of a household's entire income from cattle keeping (Aligaz and Munganga, 2021).

There are many risk factors associated with CBPP and these include the age of cattle, sex of cattle, breed, water points, communal grazing, illegal cattle trade and movement, crowding, agro-ecological zone, stressful conditions, access to veterinary services, and transportation (Molla et al., 2021; Aligaz and Munganga 2021; Mamo et al., 2018).

A study conducted in 2018 to determine the seroprevalence of CBPP in Western and Southern provinces of Zambia found an overall seroprevalence of 2.75% (Muuka, 2023). The herd seroprevalence of all other provinces was determined in which Western province had a higher seroprevalence of 30.4% while Southern province was the lowest with 3.20% (Muuka, 2023). Comparing Shang'ombo district in Western province to Kazungula district in Southern province,

Shang'ombo district had the highest seroprevalence of 4.9% while Kazungula district had the lowest with 0.5% (Muuka, 2023). The overall prevalence of CBPP in Zambia is 2.56% (Muuka, 2023). The epidemiology of CBPP in Zambia is influenced by ecological and anthropological factors such as traditional practices (Muuka et al., 2013b). Environmental stressors such as droughts have been associated with outbreaks of CBPP in Zambia. For example, floods that affected the Kazungula district in 2005 led to the displacement of households and their livestock into Sesheke (a CBPP endemic area) (Muuka et al., 2013b). When the floods had reduced and cattle herds were returned to the Kazungula district in 2006, an outbreak of CBPP was recorded in Kazungula (Muuka et al., 2013b). Traditional practices like *mafisa*, and *lobola* also play an important role in the epidemiology of the disease (Muuka et al., 2013b). *Mafisa* is a traditional practice in Western province in which cattle owners with a lot of cattle lend to those with few cattle and in times of disease, the owners can recall their animals (Muuka et al., 2013b). Cases of CBPP in endemic areas in the Western province have been linked to the traditional practice of *mafisa* (Muuka et al., 2013b). *Lobola* is another traditional practice widely practised in Zambia in which a groom pays a dowry in the form of cattle (Muuka et al., 2013b). The cattle released make movement from one area to another (Muuka et al., 2013b). The 1998 CBPP outbreak that was recorded in Shang'ombo district was as a result of a traditional healer who, after being paid oxen in Angola, came to Zambia with his cattle and mixed them with the local cattle thus spreading the disease (Muuka et al., 2013b).

CBPP is not endemic in the Chisamba district but Western province (Muuka, 2011). The CBPP outbreak that was recorded was the first outbreak to be ever recorded in Chisamba district (Nalishuwa et al., 2024), and it was the third time the disease was reported outside the traditional areas of Western, North Western, and Northern Provinces (Committee on Agriculture, Lands and Natural Resources, 2023). Since that was the first outbreak in Chisamba district, the study sought to determine the potential risk factors that could have led to its occurrence and also to assess the level of knowledge of the livestock farmers in the district.

1.2 Statement of the problem

A survey conducted in 2022 indicated that Central Province had a total of 689, 117 cattle population as of 30th April, 2022 (Ministry of Fisheries and Livestock et. al, 2022). Following an outbreak of CBPP in the two districts of Central province; Chisamba and Chibombo, the Government of the Republic of Zambia through the Ministry of Livestock and Fisheries

slaughtered 11, 187 cattle in the two affected districts (Committee on Agriculture, Lands and Natural Resources, 2023). The unprecedented loss of cattle negatively affected the farmers economically as they lost their cattle due to the slaughter exercise. The outbreak also negatively affected the government as K7.2 million was spent on the slaughter exercise in the two districts. CBPP has a mortality rate of up to 50%, which can be a cost to the economy if not addressed promptly, as well as causing food security concerns (Alhaji et al., 2020). Furthermore, there was a trade ban on live animals that was imposed, prohibiting the movement of cattle into and out of the two districts. As CBPP is a transboundary disease, imposing trade bans is one method of preventing the spread of CBPP to areas that are non-endemic. However, a trade ban has serious drawbacks to the livestock sector as it is a barrier to trade. Some households entirely depend on cattle keeping for their survival thus, an outbreak of CBPP would cause huge economic losses. Molla et al (2021) reported that the African continent losses approximately US \$ 2 billion per year due to the death of animals as a result of the disease, posing serious impacts.

Despite CBPP being recorded in 2022, the factors that could have led to the outbreak in Chisamba district remain unclear. Furthermore, there is limited literature available on the knowledge of livestock farmers on CBPP in Chisamba district. It was thus the objective of the study to identify the risk factors that could have led to the outbreak of CBPP in Chisamba district, and assess the knowledge of livestock farmers on CBPP in Chisamba district.

1.3 Significance of the study

Identifying the risk factors associated with CBPP is crucial for effective disease management and prevention. To prevent the loss of animals due to CBPP, farmers need to be aware of the risk factors associated with the disease. By understanding the factors that contribute to the occurrence of CBPP, appropriate control measures can be implemented to reduce the risk of any future outbreaks. Furthermore, identifying the risk factors allows for targeted interventions and the development of strategies that can mitigate the impact of CBPP on cattle populations. Furthermore, the study would address any knowledge gaps with regard to livestock farmers having a limited understanding of CBPP in the district by educating the farmers.

It was expected that at the end of the study, the risk factors associated with the occurrence of CBPP in the Chisamba district were going to be identified and it could help in increasing surveillance, and response measures as well as help prevent any future outbreaks of CBPP in the district. It was

also expected that at the end of the study, livestock farmers would have an enhanced understanding of CBPP as a disease and factors that drive its spread.

1.4 Justification of the study

Livestock production is a vital economic activity in the Chisamba district, providing income and employment. The study will provide valuable insights into the development of effective disease control programs and policies in the Chisamba district. Understanding the risk factors of CBPP in the Chisamba district will help inform targeted interventions to reduce the incidence of the disease, thereby improving animal health and control measures. The study will also add to the existing body of knowledge on CBPP risk factors in Zambia, assess the farmers' knowledge about CBPP in the Chisamba district, and educate livestock farmers on the various aspects of CBPP.

1.5 Research questions

1. What are the associated risk factors that enabled the occurrence of CBPP in the Chisamba district?
2. What do the farm owners and farm workers know about CBPP?

1.6 Research hypotheses

The study tested the following hypotheses:

Null hypothesis;

There is no association between the risk factors of CBPP and the occurrence of CBPP in the Chisamba district.

Alternative hypothesis;

There is an association between the risk factors of CBPP and the occurrence of CBPP in the Chisamba district.

An overall *Chi-square* test of independence was performed to determine whether there was an association between the risk factors and the occurrence of CBPP in the Chisamba district.

Rejection rule: reject H_0 if calculated value is greater than $p = 0.05$.

1.7 Study objectives

1.7.1 General objective of the study

To identify the risk factors associated with the outbreak of contagious bovine pleuropneumonia in cattle of Chisamba district and evaluate the knowledge of farmers on CBPP.

1.7.2 Specific objectives of the study

The specific objectives of the study are as follows:

1. To determine the risk factors associated with the occurrence of CBPP in Chisamba district.
2. To assess the knowledge of farmers on CBPP.

1.8 Scope of the study

The scope of the study focused on investigating risk factors that could have led to the occurrence of CBPP in the Chisamba district, and assessment of the livestock farmers' knowledge of CBPP. The study targeted commercial, small-scale and traditional cattle owners within the district.

2.0 LITERATURE REVIEW

2.1 Definition and aetiology of disease

Contagious Bovine Pleuropneumonia (CBPP) is a severe notifiable, infectious and highly contagious respiratory disease of cattle and water buffalo (Molla et al., 2021; Anjum et al., 2020). It is caused by the bacterium *Mycoplasma mycoides* subspecies *mycoides* small colony found in the Class Mollicutes (Molla et al., 2021; Anjum et al., 2020). The World Organisation of Animal Health (WOAH) has listed CBPP as a notifiable disease (Thiaucourt et al., 2024).

2.2 Distribution of Contagious Bovine Pleuropneumonia in Africa and Zambia

Contagious Bovine Pleuropneumonia (CBPP) is a notifiable disease of economic importance. It remains one of the most threatening diseases of cattle in sub-Saharan Africa (Yansambou et al., 2018).

The World Organization for Animal Health (WOAH), formally known as International des Epizooties (OIE) noted that CBPP has become a long-eradicated disease in developed countries, while remaining an endemic disease in many parts of Africa. CBPP spread from Europe to America, Africa and Australia in the mid-19th century (Xin et al., 2012). Distribution of the disease in the 1980s was limited and outbreaks were rarely recorded. In the 1990s, the disease was re-introduced in many countries such as Botswana, Tanzania, and Rwanda that had successfully eliminated it in the past. By the end of 1999, 27 countries in equatorial, central and southern Africa report an increase in the incidence of the disease. Cattle that were traded from India in the 19th century are believed to have introduced the disease in East, Central, and West Africa. Since 2006, 18 countries in West, Central, East, and Southern regions of Africa have been recording CBPP, except Congo DR, and Gabon which were disease free and only started reporting CBPP cases in 2010. Between 2007 and 2008, CBPP was widespread in 12 African countries. Gambia reported the disease in 2013, after 45 years of not recording any case. In 2015, CBPP was considered to be present in all sub-Saharan African countries. Namibia and Zambia are the only two countries in Africa that have an official WOAH endorsed control programme for CBPP (Alhaji et al., 2020; World Organization for Animal Health, 2023). Despite having a control programme, Namibia still recorded a number of outbreaks in 2019, 2020 and, 2021 while Zambia has been recording outbreaks since CBPP was first identified recorded in 1914 (Food Agriculture Organization, 2023). This therefore demonstrates that there is a gap between having endorsed CBPP control

programmes and the actual implementation and enforcement, that have led to lack of progress in managing the disease. WOAHA listed CBPP as a transboundary disease (TAD) (Clemmons et al., 2021). Transboundary animal diseases are diseases that are highly contagious or transmissible, epidemic diseases that have the potential of spreading rapidly. They also tend to cause negative socioeconomic and public health consequences (Clemmons et al., 2021).



Figure 2. 1 Distribution of CBPP in Africa (red = present; yellow = suspected; green = absent). WOAHA-WAHIS composite map (2005 – 2019). Map generated on 5 April 2022 (World Organization for Animal Health, 2023).

In Zambia, CBPP was first introduced in the Western Province in 1914 and only got to be eradicated in 1947. It was again re-introduced in 1969 and eliminated in 1972, re-introduced again in 1997 (Food Agriculture Organization, 2016). By 2002, CBPP had spread to North-Western Province and the northern parts of Zambia. The affected districts in North-Western Province were Zambezi, Chavuma, Kabompo, Mufumbwe and Mwinilunga, while Mbala and Nakonde were the affected districts in the northern parts of Zambia. Later in 2004 and 2006, it was also recorded in Kazungula district, Southern Province (Food Agricultural Organization, 2016; Muuka et al., 2013b). CBPP outbreaks were later recorded in 2022 in the two districts, Chisamba and Chibombo, both located in Central province. The western province has been known to be a CBPP-endemic

area for a long time (Muuka, 2011). This therefore means that the study area, Chisamba district is non-endemic. Historically, the study area, Chisamba district had never recorded any CBPP outbreak before the 2022 outbreak (Nalishuwa et al., 2024). Currently, there is limited understanding of the epidemiology of CBPP in the study area. A search of available literature shows that no study on CBPP has ever been conducted in the study area. There is also a lack of data on the risk factors associated with CBPP which therefore makes the development of effective disease control strategies challenging.

2.3 Host range of CBPP

The disease CBPP is a contagious respiratory disease of cattle (*Bos taurus* and *Bos indicus*), water buffalos (*Bubalus bubalis*) and yaks (*Bos grunniens*). Occasionally, sheep and goats can become infected though they are not thought to transmit the disease nor play an important epidemiological role in its transmission (Nielsen et al., 2022).

2.4 Transmission of CBPP

Through direct and indirect contact between an infected and a susceptible animal, CBPP is transmitted and eventually leads to infection. The main method of transmission is via inhalation of droplets by the susceptible animal, disseminated through coughing by an infected animal (Aligaz and Munganga, 2021). Other sources of infection and transmission include excretion of infective droplets by the infected coughing animal, nasal discharge, foetal fluids, and urine of sick animals can also serve as sources and modes of transmission.

2.5 Pathogenesis of CBPP

A study by CABI (2019), revealed that despite the causative agent of CBPP being known, it is not possible to say with certainty how *M. mycoides* SC causes disease. Studying the pathogenesis of *M. m. mycoides* SC in cattle has been a challenge due to the high cost of experimental studies using cattle, as well as the absence of any small animals in which the disease can reproduce itself (CABI, 2019). However, studies by Alhaji et al (2020) and Di Teodoro et al (2020) highlighted the pathogenesis of CBPP which is outlined in the subsections below.

2.5.1 Adhesion to and invasion of the host cells and tissues

Firstly, susceptible cattle must inhale *Mmm* through infected aerosols from the infected cattle (Di Teodoro et al., 2020). The *Mmm* adhere to the cells of the respiratory tract (Di Teodoro et al., 2020). Adhesion has been considered to be both host and tissue-specific, and is very important in ensuring successful colonization of the host (Di Teodoro et al., 2020). Non-ciliated cells lining the

bronchioles and the alveoli have been regarded as the earliest targets of *Mmm* infection (Di Teodoro et al., 2020). In various mycoplasma species, several adhesins and/or a specialized “terminal organelle” have been responsible for adhesion though they have never been found in *Mmm*. A protein (“P19”) has also been suggested to be involved with *Mmm* adhesion in vitro (Di Teodoro et al., 2020). However, the adhesion of *Mmm* is more complex and multistep on its own (Di Teodoro et al., 2020). After the colonization of bronchioles and alveoli, *Mmm* invade blood and lymphatic vessels, targeting endothelial cells, which have been linked to stimulating thrombosis (Di Teodoro et al., 2020). On the contrary, Alhaji et al (2020) state that the cause of thrombosis formation remains unknown; however, it is believed to be mediated by the induction of cytokines.

2.5.2 Host damage

Among the virulence factors produced by *Mmm*, galactans are considered the major factors (Di Teodoro et al., 2020). Galactans induce vascular and cytopathic effects (Di Teodoro et al., 2020). *Mmm* belong to the class Mollicutes Alhaji et al (2020). Mollicutes are known to produce substances that are vital in the pathogenesis of CBPP like peroxides and super-oxides that can disrupt the integrity of host cells (Alhaji et al., 2020). Further damage to host cells is due to reactive oxygen species (ROS) which are produced via the metabolism of glycerol (Di Teodoro et al., 2020). Glycerol metabolism is mainly controlled by two main principals: the glycerol transport ABC (GtsABC) protein, which is responsible for the transport of glycerol inside the cell, and L-alpha-glycerophosphate oxidase (GlpO), which catalyses the production of dihydroxyacetone phosphate and hydrogen peroxide (H_2O_2)-known to be one of the most important ROS (Di Teodoro et al., 2020). In comparison with the European strains, African strains of *Mmm* have a more efficient GtsABC and produce larger amounts of ROS (Di Teodoro et al., 2020). The ROS can damage host cells through different mechanisms directly, by affecting the integrity of cellular membranes, and indirectly, by activating the nuclear factor-kB molecular pathway (Di Teodoro et al., 2020). As *Mmm* are able to produce low quantities of H_2O_2 , close contact between *Mmm* and the host cell is needed for ROS to cause their cytotoxic effect otherwise, H_2O_2 will be rapidly destroyed by the host catalase activity (Di Teodoro et al., 2020). Additionally, mycoplasmas are known to induce the production of ROS by phagocytic cells, which could also amplify cell and tissue damage (Di Teodoro et al., 2020). Generation of ROS by *Mmm* could prime the respiratory burst of neutrophils in a “dose-dependent” manner. The amount of ROS produced by neutrophils

is way greater when compared with *Mmm*, thus likely playing a more important role in tissue damage (Di Teodoro et al., 2020). Mycoplasma phospholipases, which may play a significant role in pneumonia, have the potential to decrease the surface tension of the alveolar surfactants which are crucial for maintaining lung function, thereby causing atelectasis (Alhaji et al., 2020).

2.5.3 Immune response

Recent immune system related studies suggests that *Mmm* adhesion molecules are immunogenic and that attachment of organisms is inhibited by immune sera (Di Teodoro et al., 2020). The capsular galactan (a polysaccharide made of 6-O- β -D-galactofuranosyl-D-galactose) has been shown to reduce the attachment of *Mmm* to host cells, which probably masks the adhesion molecules hence they become less exposed to the immune system (Di Teodoro et al., 2020). In addition, the galactan polymer modulates the immune response against *Mmm* and promotes its dissemination (Alhaji et al, 2020).

Some mycoplasmas like *Mycoplasma gallisepticum* and *M. agalactiae*, induce the mucosal infiltration of lymphocytes in an ordered way: (1) CD8⁺/TCR⁻ natural killer (NK) lymphocytes prevail during the first week post infection; (2) CD4⁺/TCR⁺ helper T cells and CD8⁺/TCR⁺ cytotoxic T lymphocytes arrive at 2 to 3 weeks; (3) B lymphocyte infiltration occurs and becomes dominant later, the antigenic variation of mycoplasma lipoproteins likely inducing a long-term stimulation of the immune response (Di Teodoro et al., 2020). The role of the immune response in the pathogenesis of respiratory mycoplasmosis including CBPP remains controversial (Di Teodoro et al., 2020). A study conducted after a *Mycoplasma pulmonis* infection showed that cytotoxic T lymphocytes controlled the immune-mediated mechanisms of the disease, while the depletion of helper T cells reduced the severity of the disease (Di Teodoro et al., 2020). Regarding CBPP, helper T cells have been shown to play a primary role during the early stages of *Mmm* infection, thereby greatly contributing to the production of interferon- γ (IFN- γ), while cytotoxic T lymphocytes are considered protective during CBPP (Di Teodoro et al., 2020). Depletion of CD4⁺ lymphocytes did not affect the clinical outcome (Di Teodoro et al., 2020).

Data concerning humoral immune response after *Mmm* infection are few and conflicting (Di Teodoro et al., 2020). Studies have shown no positive correlation between the antibody response to *Mmm* (immunoglobulin isotypes and titres, both in serum and in bronchoalveolar lavage fluid), and clinical signs or the severity of lesions (Di Teodoro et al., 2020). Recent studies have shown that high levels of serum anti-*Mmm* antibodies did not prevent the occurrence of CBPP (Di

Teodoro et al., 2020). On the other hand, the mucosal immune response seemed more effective, with higher levels of anti-*Mmm* secretory IgA conferring a positive outcome of the disease (Di Teodoro et al., 2020).

2.5.4 Inflammatory response

Mycoplasmas stimulate monocytes and macrophages to synthesize cytokines, after the interaction between membrane lipoproteins and Toll-like receptors (TLRs) (Di Teodoro et al., 2020). Macrophages are known to produce pro-inflammatory (TNF- α) or anti-inflammatory (interleukin [IL]-10) cytokines after in vitro stimulation with *Mmm* or galactan. TNF- α , IL-1 β , and IL-17A have been shown to contribute to the inflammatory response in CBPP-affected lungs, with plasma levels of TNF- α being positively correlated to the severity of the disease (Di Teodoro et al., 2020). Characteristic inflammatory reactions lead to bronchitis, bronchiolitis, and alveolitis, while neutrophils and mononuclear cellular response predominantly constitute early inflammation (Alhaji et al., 2020). Furthermore, *Mmm* has demonstrated the ability to induce apoptosis of bovine leukocytes including monocytes and polymorphonuclear cells (Di Teodoro et al., 2020).

Pathological changes associated with CBPP cause unilateral pulmonary necrosis, marked sero-sanguineous fluid accumulation in the interstitia and pleura, and at times sequestration (Alhaji et al., 2020). An important pathological change, vasculitis, causes marked exudation and pleurisy (Alhaji et al., 2020). Thrombosis can cause ischemic necrosis and infarcts of the lung while anoxia and toxemia can ultimately lead to death of the affected cattle (Alhaji et al., 2020).

2.6 Clinical signs and symptoms of CBPP

The manifestation of the different signs and symptoms of CBPP depends on the stage in which it manifests itself (Alhaji et al., 2020). During epidemics, the hyper-acute and acute forms of the disease predominate at the onset while the sub-acute and chronic forms become more apparent as the epidemic progresses (Alhaji et al., 2020). Hyperacute CBPP is rare and cattle may suddenly die due to the abundant pleural and pericardial effusion, thus there are no significant clinical signs other than fever. Acute CBPP is characterised by high fever (of up to 42°C) and severe respiratory distress (Di Teodoro et al., 2020). In the subacute stages, CBPP is characterised by severe fibrinous bronchopneumonia and pleural effusion while the chronic stage is characterised by pulmonary sequestra (referred to as encapsulated lesions) (Di Teodoro et al., 2020). Other symptoms include anorexia, fever, dyspnoea, cough and nasal discharges (Anyika et al., 2021). In young calves less than six months old, arthritis tends to manifest itself (Anjum et al., 2020).

2.7 Diagnosis of CBPP

The methods used in the diagnosis of CBPP are clinical examination, post-mortem inspections, laboratory analyses through culture and isolation, serological analyses, and molecular analyses (Alhaji et al., 2020).

Using clinical signs in the diagnosis of CBPP is more feasible during the acute stage of the disease when symptoms are apparent, with adult cattle showing persistent cough and respiratory distress due to pleuropneumonia while calves show lameness due to arthritis (Alhaji et al., 2020). However, it is important during clinical diagnosis to rule out other differential diseases that could present similar clinical manifestations such as acute pasteurellosis, haemorrhagic septicemia, actinobacillosis, bovine tuberculosis, abscesses or hydatid cysts, or traumatic pericarditis (Alhaji et al., 2020).

On post-mortem inspections, animals will show gross pathological lesions such as sequestra (encapsulated necrotic pulmonary lesions) (Alhaji et al., 2020). The gross pathological lesions are characterized by fibrinous deposits on the parietal surfaces and interlobular spaces distension in the acute stage due to accumulation of straw coloured serofibrinous exudates (Alhaji et al., 2020). Usually, only one lung is affected by the pathological lesions which are often localized in the diaphragmatic lobe, and have a characteristic marbling appearance (Alhaji et al., 2020). The pleural cavity may contain large quantities of clear, yellow-brown fluid with pieces of fibrin. Upon palpation, lesions can be detected while red and grey areas of hepatisation can be seen upon incision (Alhaji et al., 2020). In subacute stages, gross lesions can be seen as they are characterized by the formation of necrosis in the lobules and interlobular septa (Alhaji et al., 2020). Early sequestrum formation can also be seen in the subacute stage (Alhaji et al., 2020). In post-mortem examination of chronic cases, gross lesions are characterized by well-defined sequestra surrounded by fibrous capsules, and adhesions which connect thickened viscera and parietal pleura (Alhaji et al., 2020).

For laboratory analyses, *Mmm* can be isolated from nasal swabs or discharges of live animals (Alhaji et al., 2020).

Two serological tests namely; complement fixation test (CFT) and competitive Enzyme-Linked Immunosorbent Assay (c-ELISA) are recommended by the OIE for use during herd-level diagnosis of CBPP (Alhaji et al., 2020). The CFT and C-ELISA are based on monoclonal anti-*Mmm*SC antibodies (Alhaji et al., 2020). The CFT sensitivity to *Mmm* infection varies with the

clinical stage of CBPP manifestation, which tends to be high in the acute stage due to the high level of circulating complement-fixing immunoglobulin (Alhaji et al., 2020). Sero-prevalence studies on vaccinated cattle herds have shown poor agreement between CFT and c-ELISA, thus, it is recommended to use both CFT and cELISA for diagnostic purposes (Alhaji, et al., 2020).

The introduction of the Polymerase chain reaction (PCR) has revolutionised the diagnosis of CBPP as it has provided a quicker and more sensitive diagnosis of the disease (Alhaji et al., 2020). The PCR has provided powerful diagnostic procedures for the specific identification of *Mmm* strains, fast robust detection, identification, and differentiation of members of the *M. mycoides* cluster (Alhaji et al., 2020). The use of Nested PCR has made diagnosis much easier as it is sensitive for the detection of *Mmm* in cultures and clinical materials with very low numbers of target organisms (Alhaji et al., 2020).

2.8 Treatment of CBPP

There is an increased usage of antibiotics in sub-Saharan Africa (Muuka et al., 2019). Nicholas et al (2012) reported that danofloxacin has successfully been used to treat and prevent the spread of CBPP in naturally infected herds. Oxytetracycline, danofloxacin and tulathromycin were used to demonstrate their effectiveness in biological matrices and artificial media in inhibiting the growth of *Mmm*, thus proposing that they could be used in the treatment of CBPP (Muuka et al., 2019). However, Muuka et al (2019) reported that findings by Provost et al (1987) do not entirely agree with the findings of Nicholas et al (2012) which reported that antibiotics cannot stop the spread of the disease even though they alleviated clinical signs. Niang et al (2010) observed the formation of sequestra following treatment with oxytetracycline, and suggested the probability of a cure because the drug prevented the evolution of the disease to chronicity in the treated group, thus treatment with antibiotics is discouraged (Muuka et al., 2019; Kairu-Wanyoike et al., 2017).

In Zambia, the Director of Veterinary Services (DVS) has officially prohibited the treatment for CBPP due to a lack of scientific evidence that the use of antibiotics leads to the cure of infected cattle (Muuka, 2023). Extension work has been done through community farmer groups in order to ensure that farmers do not use antibiotics to treat CBPP (Muuka, 2023).

2.9 Control of CBPP

Currently, sub-Saharan countries rely mainly on live attenuated vaccines T1/44 and/or the streptomycin-resistant derivative (T1sr) to control CBPP (Muuka et al., 2013a). However, these vaccines come with limitations (Sacchini et al., 2020). Some of these limitations that have come

with the CBPP vaccines include inadequate handling of vaccines by inoculators during vaccination campaigns and usage of vaccines with sub-optimal quantities of *Mmm*-strains (the minimum quantity recommended by OIE is 107 viable *Mmm* per dose) (Alhaji et al., 2020). For example, despite the live attenuated T1/44 is the most commonly used vaccine, it does not confer 100% immunity (Alhaji et al., 2020). The conferred immunity only lasts for a short period of 6 months and can also induce severe adverse post-vaccination reactions which can occasionally lead to death (Alhaji et al., 2020). *Mycoplasma mycoides* subspecies belongs to a cluster of six *Mycoplasma mycoides* (*Mm* cluster) members, which can cause “MAKePS” (Mastitis, Arthritis, Keratoconjunctivitis, Pneumonia, Septicemia) syndrome in ruminants (Zhang et al., 2022). Other control methods that are employed include movement restrictions, quarantine, antibiotic treatment, vaccination and stamping out policies, which have had varying successes (Alhaji et al., 2020). Despite the disease being listed as one of the notifiable diseases, Mamo et al (2018) recorded that CBPP has been eradicated in developed parts of the world through the application of restrictions to the movement of cattle, as well as test and slaughter policies combined with compensation for livestock owners during the mid-20th century. In Zambia, the legal framework governing the livestock sector has embedded control measures with regards to CBPP through the Animal Health Act No. 27 of 2010, The Animal Identification Act No. 28 of 2010, and The Veterinary and Veterinary Para-Professionals Act No.45 of 2010. The Acts provide for testing and slaughter of all herds that test positive to CBPP as a means of eradication of CBPP from Zambia. For neighbouring countries where the disease is endemic, buffer zones have been created to prevent re-introduction of the disease into Zambia (Muuka, 2023). Other control measures include erection and maintenance of cordon lines, animal movement restrictions, and vaccinations (Muuka, 2023). In areas that areas that close to neighbouring countries that are endemic to CBPP, vaccination is free, and T1/44 is the vaccine that is used. Mass vaccinations of cattle in designated areas are conducted once a year (Muuka, 2023).

Despite having laid down control measures, failure to control the disease in both Zambia and other sub-Saharan countries have been attributed to the many reasons ranging from social (which include illegal cattle movement by farmers, negative attitudes towards laid down regulations), political issues which include weak or lack of laid down contingency plans that deals with elimination of CBPP, and economic issues such as lack of funding in veterinary services (Committee on Agriculture, Lands and Natural Resource, 2023; Jores et al., 2020).

2.10 Impact of CBPP

The disease CBPP is devastating and associated with high morbidity and mortality (Alhaji et al., 2020). Beyond its impact on animal health, it negatively impacts the livelihood and well-being of a substantial proportion of livestock-dependent people by affecting their culture, economy, trade and nutrition (Hussien et al., 2024; Jores et al., 2020). It also leads to reduced productivity on the farm, disruption in the food supply system, and reduces draft power (Hussien et al., 2024; Molla et al., 2021; Negash and Dubie, 2021). Furthermore, implementation of control programs such as mass vaccination, test and slaughter, are activities which are costly to conduct and implement (Hussien et al., 2024; Negash and Dubie, 2021; Kairu-Wanyoike et al., 2017).

2.11 Risk factors of CBPP

There are known risk factors that have been associated with occurrence of CBPP. These factors include crowding of cattle, age of cattle, sex of cattle, access to veterinary services, water points, communal grazing, trading in cattle, agro-ecological zone, stressful conditions, and transportation (Molla et al., 2021; Aligaz and Munganga 2021; Mamo et al., 2018).

Crowding of cattle is one of the direct means in which cattle get infected with CBPP. CBPP is a highly contagious disease that is easily transmitted through aerosols from infected cattle to susceptible animals. The close mixing of cattle infected with CBPP and susceptible cattle, thereby increases direct contact of animals and the close proximity facilitates the direct transmission of CBPP (Alhaji et al., 2020; Molla et al., 2021).

Age of cattle is also one of the important risk factors of the occurrence of CBPP. A study by Negash and Dubie (2021) reported that young animals are more susceptible to acute forms of CBPP than adult cattle, and thus acutely infected young animals may die of CBPP and not be available for testing. Bashiruddin et al (2005) also reported that infection resistance may vary with age (Mamo et al., 2018). Experimental studies that were conducted showed that animals less than 3 years of age are less resistant to CBPP, while cattle over 3 years of age were more resistant to CBPP infection than younger animals (Mamo et al., 2018). Another study conducted by Swai et al (2013) reported that sero-positivity in adults was relatively higher than in young animals.

Sex of cattle has also been found to be another contributing risk factor of CBPP. Studies have shown a relatively higher prevalence of CBPP in female cattle than males (Negash and Dubie, 2021; Mesha, 2016; Teshale et al., 2015; Schnier et al., 2006)

Poor access to veterinary services is another risk factor that is associated with the occurrence of CBPP. Alhaji et al (2020) noted that a decrease in veterinary services by pastoralists, deterioration of quality veterinary services and limited financial resources have led to the increase of CBPP cases. A study by Muuka et al (2013 b) indicated that in the 1990s, failure to deliver veterinary services in Zambia was one of the factors that led to failure of CBPP control and a rise of various diseases which were anthrax, brucellosis, bovine tuberculosis, and CBPP inclusive.

The source of water or water points is also one of the risk factors that can lead to the occurrence of CBPP in cases where the water points are communal or shared by different herds in an area. Hussien et al (2024) reported that canal water can facilitate the spread of CBPP through the mixing of infected and susceptible animals.

Animals that share communal grazing pastures are at increased risk of getting infected with CBPP (Negash and Dubie, 2021). Infected cattle come into contact with the susceptible, and the aerosols from infected cattle are inhaled by the healthy animals hence spreading CBPP to uninfected herds (Negash and Dubie, 2021).

Trading in cattle is another risk factor that is associated with the occurrence of CBPP. When infected cattle have been traded, introduced to areas that are CBPP-free, and allowed to be integrated into healthy herds, they spread the disease to the healthy cattle hence it leads to the occurrence of CBPP. An increase in livestock trade since the second half of the 16th century has led to a worldwide spread of CBPP from Europe (Di Teodoro et al., 2020). Moreover, even when diseased cattle are identified, containment of the disease is complicated by the high density of the trading area in which separation of diseased and healthy cattle is challenging (Muuka et al., 2019). Another risk factor that has been associated with the occurrence of CBPP is the agro-ecological zone. Studies done by Gedlu (2004) and Teshale et al (2015) have reported significant differences in the seroprevalence of CBPP in cattle found in different agroecology zones. This might be because in lowland areas, there is a lack of good pasture, and water, and the presence of concurrent diseases could predispose cattle to CBPP infection. Animals in lowland areas move long distances in search of pasture and water, and they interact with other infected herds (Mamo et al., 2018). Furthermore, lowland animals are more confined to grazing areas and watering points, facilitating the easy spread of CBPP (Mamo et al., 2018).

Stressful conditions such as drought and compromising on food like lack of protein, have also been identified as a predisposing factor to the occurrence of CBPP (Kairu-Wanyoike et al., 2017).

The transportation or movement of cattle is another factor that has been identified as one of the risk factors of CBPP. The spread and impact of CBPP are favoured by long-distance trekking of cattle along stock routes. During the transportation of animals, several stops are made on the way which leads to exposing animals along the various routes, thus it provides opportunities for frequent contact of cattle within and between herds and the dust generated by mass movement increases pathogen spread. Outbreaks of CBPP occur more extensively in cattle on transits (Muuka et al., 2013; Alhaji et al., 2020; Mamo et al., 2018).

Studies on CBPP in Chisamba District have never been conducted before. However, from the available literature on studies that have been conducted in Zambia, no study has ever focussed on identifying the risk factors that have been associated with previous outbreaks that have been recorded anywhere else in Zambia and also no previous study to assess how knowledgeable livestock farmers are about CBPP. In order to prevent the introduction of CBPP on farms, farmers must be well acquainted with the risk factors that lead to the occurrence of CBPP and be able to know the various aspects of the disease such as signs and symptoms. The study therefore identified the risk factor(s) that led to the occurrence of CBPP in Chisamba district and assessed how knowledgeable livestock farmers were about CBPP.

2.12 Farmers knowledge about CBPP

Control of CBPP is very knowledge-dependent on awareness and understanding (Ouya et al., 2022; Kairu-Wanyoike et al, 2014). Inadequate knowledgeable by farmers about the disease, its mode of transmission, its signs and symptoms, and ways of curbing the spread, involuntarily creates an enabling environment for its outbreak, thus educating livestock farmers is critical in mitigating the risks associated with CBPP (Suleiman et al., 2018). A study by Cherinnat and Dibaba (2022) highlighted the importance of livestock farmers having knowledge of contagious infectious diseases like CBPP. Being knowledgeable of CBPP including its various aspects such as mode of transmission, signs and symptoms, helps in optimum prevention and controlling strategies at household levels (Cherinnat and Dibaba, 2022).

Farmers who are knowledgeable of how CBPP is transmitted can prevent their animals from getting infected with the disease as they will set up measures that prevent their animals from coming into close contact with animals from other farms, because they understand that CBPP is spread through close contact (Kairu-Wanyoike et al, 2014). This therefore helps demonstrate the

importance of being knowledgeable of a particular disease in prevention of outbreaks and formulating policies that could enhance animal health (Kairu-Wanyoike et al, 2014).

Farmers must possess a basic understanding of the dynamics of CBPP such as the incubation period. CBPP has an incubation period of over three weeks to six months (Di Teodoro et al., 2020). During this incubation period, asymptomatic cattle can act as reservoirs of infection and many animals may be moved away or sold during the incubation period before CBPP can be confirmed thus it is a potential way of introducing CBPP (Tweyongyere et al., 2024; Di Teodoro et al., 2020; EFSA Panel on Animal Health and Welfare et al., 2017). If the livestock farmers in Chisamba district are knowledgeable of the incubation period of CBPP, they can quarantine the cattle that they buy from other farmers for the whole six months, and have the cattle tested for CBPP before integrating them with the rest of the cattle that are already on the farm. If the cattle that are bought are infected, they can easily be slaughtered before integrating them with the old herd hence it can prevent infecting the already health animals on the farm.

Livestock farmers must be knowledgeable of the signs and symptoms that a cow presents when it is infected with CBPP. If a farmer is not knowledgeable of the signs and symptoms of CBPP, they might overlook the disease which can lead to delay in accessing veterinary care for the animals, which can lead to further spread of the disease (Nicholas, 2023).

Being knowledgeable of how CBPP is transmitted is also important in preventing outbreaks. Understanding the modes of transmission of CBPP can help reduce the risk of contagion by undertaking precautionary measures. For example, herders that understand how CBPP is transmitted can quarantine newly bought cattle or keep diseased ones separate from the rest of the herd thus reducing the transmission of the disease (Bashiruddin et al., 2005).

Besides, ignorance of the economic impact which CBPP has on cattle production is another circumstance that emboldens passive attitude and behaviour towards the management of the disease. CBPP leads to great losses of livestock, reduction of productivity, and restriction of trade (Hussien et al., 2024). However, in areas where little is known about the disease, such risks and impacts of the disease are underestimated (Kairu-Wanyoike et al., 2017). This may lead livestock farmers to fail to invest in CBPP prevention or control methods, thus accelerating the spread of the disease (Alhaji et al., 2020).

Ultimately, poor knowledge of CBPP also enhances the possibility of outbreaks by delaying disease recognition, allowing unsafe cattle movement, and reducing the adoption of preventive measures (Cherinnat and Dibaba, 2022).

Despite the number of studies on CBPP that have been conducted in Zambia, no previous studies have been conducted to assess how knowledgeable cattle farmers are about CBPP in Chisamba district and Zambia at large. Information on livestock farmers' knowledge of CBPP, including its various aspects in Zambia is very scanty. Furthermore, the limitation of published research on CBPP in Zambia creates research gaps in CBPP knowledge in the Zambian context. To better manage cattle on farms, farmers must be well knowledgeable of CBPP and know the various aspects of the disease such as its causative agent, mode of transmission, signs and symptoms, control, and impact of the disease. It was thus another aim of the research to assess how knowledgeable the cattle farmers were about CBPP. By addressing the knowledge gaps, the study will contribute to the knowledge base by identifying the risk factors associated with the outbreak of CBPP in the Chisamba district, as well as educate famers on CBPP.

3.0 METHODOLOGY

3.1 Study design

A retrospective study design was employed in the current study. A semi-structured questionnaire was used to identify the risk factors associated with the outbreak of CBPP. This approach was deliberately chosen because a semi-structured questionnaire allows for an in-depth exploration of the respondent's thoughts which can lead the interviewer to ask follow-up questions for clarity, and probe further for non-biased responses which is more likely to generate accurate information (Ruslin et al., 2022; DeJonckheere and Vaughn, 2019). A retrospective study design was chosen as it is suitable to examine outcomes and help gather data for events that occurred in the past.

3.2 Study site

The research was conducted in Chisamba district (14.8651° S, 28.5798° E), Central province of Zambia (Figure 3.1). The strategic location of Chisamba makes it easily accessible by both road and rail transport systems, as well as a natural transit point to other provinces. Chisamba district is economically known for its contribution to the livestock sector, and the major economic activity is livestock farming, thus it was the preferred study site (Provincial Administration Office Central Province, 2022). The 2022 livestock survey that was conducted by the Ministry of Fisheries and Livestock, in conjunction with the Ministry of Finance and National Planning, and the Zambian Statistics Agency reported that as of 30th April 2022, Central Province had a total of 689, 117 cattle population (Ministry of Fisheries and Livestock et. al, 2022). Major suppliers of beef and dairy products such as Chisamba Ranching Cooperation (CRC), Zambia Beef Company (ZAMBEEF), and Fringilla butchery are found in Chisamba. Chisamba district has over 32, 256 farmers (Provincial Administration Office Central Province, 2022). Of the about 32, 256 farmers, 32, 000 are small-scale farmers while 256 are commercial farmers (Provincial Administration Office Central Province, 2022). The 2022 CBPP outbreak that prompted the government to permit the slaughter of over 11, 000 infected cattle to halt the spread of the disease to neighbouring districts made Chisamba district a study site of choice.

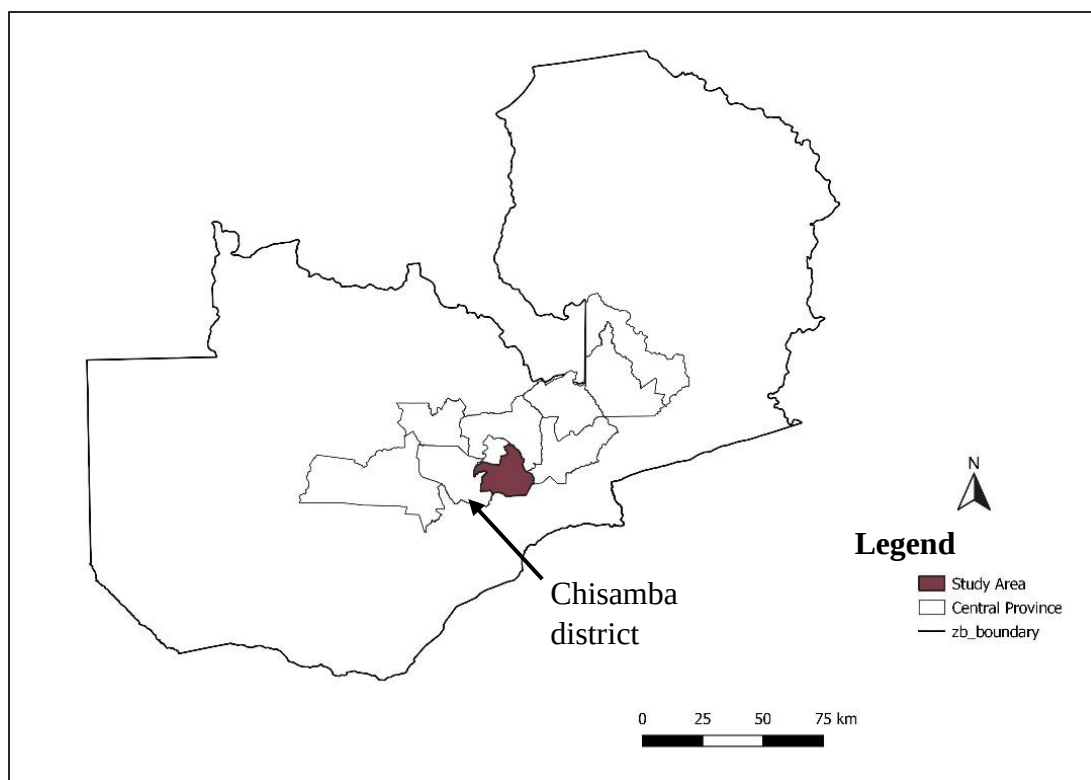


Figure 3. 1 Map of Chisamba district in Central Province, Zambia (Generated using QGIS)

3.3 Study population

The study population included Chisamba residents who were either farm owners who owned cattle or farm workers who were actively involved in taking care of cattle.

3.3.1 Inclusion criteria

Participants that were enrolled in the study were adults (18 years and above), who either owned cattle or were actively involved in taking care of cattle. Farms that were included in the study were those that had cattle on them.

3.3.2 Exclusion criteria

Individuals below the age of 18, who did not own cattle or were not directly involved in the management of cattle were excluded from participating in the study. Farms that were not involved in keeping cattle were excluded from the study.

3.4 Sample size

The study participants that were enrolled in the study were 55, drawn from 55 farms. To calculate the sample size, an estimated confidence level of 95%, a margin of error of 5%, the overall prevalence of CBPP in Zambia of 2.56% (Muuka, 2023), and a total population of 32,256 cattle

farmers (Provincial Administration Office Central Province, 2022) were used. Using the above assumptions, an online sample size calculator (Calculator.net, 2024) was used and the estimated sample size was 39. To increase the statistical power and be able to detect significant differences in respondents in the study, the number of respondents was conveniently increased to the number of participants that were available to participate in the study hence the total number of respondents reached 55.

3.5 Sampling techniques

The commercial and small-scale farms that were selected for the study were purposefully sampled using purposive sampling, to ensure that only respondents who were residents during the CBPP outbreak were selected. Participants were identified through key informants using the snowball sampling method. The snowball sampling technique was chosen as it is useful to easily identify and reach hard-to-reach eligible participants (Sadler et al., 2010). Other than searching for participants like other sampling techniques, snowball makes use of existing social networks to recruit participants thus respondents are more likely to participate when referred by someone they know (Sadler et al., 2010). Additionally, snowball is cost-effective, resources that could have been used to search for eligible participants can be saved. The key informants were veterinary officers that worked in Chisamba district. The veterinary officers assisted in identifying the potential participants of the study as they were well acquainted with the livestock farmers in the district. In the current study, farms selected included both commercial farms (10 farms) and (45) small-scale farms.

With the help of key informants, each participant who was interviewed was asked to suggest people who met the inclusion criteria. The referrals were then contacted and asked for potential participation in the study. A total of 55 participants took part in the study.

3.6 Data collection

The data collection period for the study was from February to April 2024. Participants were asked to sign an informed consent form; before a one-on-one interview was conducted. A pre-tested semi-structured questionnaire (Appendix 4) written in English, was used to collect data from the participants as it was a rapid collection method of large amounts of data (Ranganathan and Caduff, 2023). In cases where the participants to be interviewed did not understand English, the questionnaire was translated into various local languages spoken in Chisamba. The questionnaire comprised a total of 42 questions, divided into three sections. The three sections of the

questionnaire were demographic information, cattle management practices, and CBPP knowledge. In the demographic information section, the questionnaire helped to gather background information of the participants such as their gender, age, marital status, level of education, occupation, and whether they kept other animals apart from cattle. In the cattle management practices section, the questionnaire helped to gather information that pertained to the total number of cattle the farmer had, the age groups of the cattle, the facility where the cows were kept, mode of feeding, watering points, access to veterinary services, and whether the farmers were involved in trading of cattle. The last section of the questionnaire gathered information on the recent CBPP outbreak-how many cattle died on their own or were slaughtered due to the recorded outbreak. Furthermore, the participants were assessed as to whether they knew the aetiological agent of CBPP, the mode of transmission, signs and symptoms, and the impact of CBPP. This was done to determine the number of livestock farmers who knew an aspect of CBPP. All interviews were conducted in a private and secure environment to ensure confidentiality.

3.7 Data analysis

Data that was captured on the questionnaires was input into Microsoft Excel. Before the data was subjected to statistical analysis, it was screened for errors and coded accordingly. Data was analysed using Statistical Package for Social Sciences (SPSS) software version 29.0.2. Tables were formulated to summarize the collected data consisting of the risk factors. A total of eight risk factors were assessed and these were the age of cattle, sex of cattle most affected, herd size, mode of feeding, source of water, cattle trading, access to veterinary services, and housing facility of cattle. The risk factors were tested using the *Chi-square* (X^2) test, to determine whether there was an association between the explanatory variables (risk factors) and the dependent variable (recording CBPP on a farm). In all analyses, the confidence level was set at 95%, and $p < 0.05$ was set for significance.

To assess the knowledge of farmers on CBPP, participants were asked questions on the causative agent, mode of transmission, signs and symptoms, and the impact of CBPP on the livestock industry. Data was analysed using frequency analysis in which participants who gave the correct response on the aspect of CBPP were counted, as well as those who did not know or gave a wrong response on the various aspects of CBPP. Thereafter, a mean was calculated to show the overall general knowledge of participants about CBPP. Information that was generated was summarized and presented in tabular form.

3.8 Ethical consideration

Ethical clearance was obtained from the Excellence in Research Ethics and Science (ERES) Converge Ethics Committee IRB, reference number 2024-Feb-008 (Appendix 1). The researcher ensured that all participants provided informed consent before participating in the study (Appendix 3). All data collected during the study were stored securely and anonymized to protect participant confidentiality.

4.0 RESULTS

4.1 Participant demographics

For this study, a total of 55 participants (one from each of the 55 farms visited) were interviewed which comprised of both commercial farmers (10) and small-scale livestock farmers (45). The demographic information of the participants was summarized as presented in the table below.

Table 4. 1 Participants demographic information

Variable	Category	Number of participants
Gender of participant	Males	41
	Females	14
Marital status	Single	5
	Married	39
	Preferred not to say	11
Type of farmer	Small-scale livestock farmer	45
	Commercial livestock farmer	10
Category of participants	Farm owner	32
	Worker	23
Age groups of participants	18 – 29 years	3
	30 – 50 years	4
	Above 50 years	3
	Preferred not to say	45
Level of education of participants	Never went to school	3
	Primary level	4
	Junior secondary	5
	Senior secondary	5
	Tertiary level	8
	Preferred not to say	30

4.2 Associated risk factors and statistical tests

The total number of farms that were visited in the study was 55 of which, 2 farms had recorded cases of CBPP while 53 did not record any case. Eight risk factors were assessed and these were the age group of cattle, sex of cattle most affected, herd size, mode of feeding, source of water, cattle trading, access to veterinary services, and housing facility of cattle. Of all these factors, only one risk factor, trading in cattle ($p = 0.039$) was found to be statistically significant and associated to the occurrence of CBPP in Chisamba district. However, the other factors like age group of cattle ($p = 0.474$), sex of cattle most affected ($p = 0.185$), number of cattle ($p = 0.781$), mode of feeding ($p = 0.052$), source of water ($p = 0.205$), access to veterinary services ($p = 0.06$), and housing facility of cattle ($p = 0.057$) were found to have no significant association with the occurrence of CBPP in the district. The table below summarises the risk factors and their association with the occurrence of CBPP in the Chisamba district.

Table 4. 2 Risk factors associated with the occurrence of CBPP.

Variable	Category	Number of farms	No. of farms affected by CBPP	95% CI Risk ratio	P-value
Age group of cattle	$0 \leq 1$ years	12	0	0.565 (0.775-0.739)	0.474
	$1 \leq 3$ years	32	2		
	> 3 years	33	2		
Sex of cattle most affected	Males	5	1	0.799 (0.775-0.85)	0.185
	Females	13	0		
	Both males and females	24	1		
	No sex noticed	13	0		
Herd size	$1 \leq 100$	45	0	0.533 (0.495-0.625)	0.781
	$100 \leq 1000$	6	0		
	> 1000	4	2		
Mode of feeding	Go out grazing	38	0	0	0.057
	Provided within the farm	17	0		
Source of water	Provided within the farm	33	0	1.069 (0.975-1.172)	0.703
	Go out to drink in community dam or streams	22	0		
Cattle trading	Buys cattle	18	2	1.238 (0.955-1.325)	0.039
	Sells cattle	22	0		
Access to veterinary services	Every week	3	1	0.135 (0.112-0.142)	0.06
	Once a month	19	1		
	Only when a health condition is noticed	33	0		
Housing facility of cattle	Have a housing facility for cattle	21	2	0.913 (0.861-0.924)	0.057
	Does not have a housing facility for cattle	24	0		

4.3 Farmers Knowledge about CBPP

Furthermore, the study also assessed how knowledgeable the participants were about CBPP. Various aspects of CBPP that were assessed included; the aetiological agent, mode of transmission, signs and symptoms, and impact of CBPP. Information that was generated was summarized and presented in the table below.

Table 4.3 Farmer's knowledge about CBPP

Aspects of CBPP	Participant's responses	
	Yes (%)	No (%)
Have you ever heard of CBPP?	18 (32.7)	37 (67.3)
Do you know the aetiological agent?	4 (7.27)	51 (92.73)
Do you know the mode of transmission?	4 (7.27)	51 (92.73)
Do you know the signs and symptoms?	5 (9.09)	50 (90.91)
Do you know the impact of CBPP?	7 (12.7)	48 (87.3)
Overall mean	13.8%	86.2%

An overall mean value of 13.8% was obtained that indicated the percentage of the participants that were knowledgeable of CBPP.

5.0 DISCUSSION

The objectives of the study were to determine the risk factors that led to the occurrence of CBPP in the Chisamba district and to ascertain the knowledge of farmers on the disease CBPP.

The first objective of the study was to identify the associated risk factors that enabled the occurrence of CBPP in the Chisamba district. Eight risk factors were assessed and these were; age of cattle, sex of cattle most affected, herd size, mode of feeding, source of water, cattle trading, access to veterinary services, and housing facility of cattle. Among the hypothesized factors that were subjected to analysis, the study found a strong association between cattle trading and the occurrence of CBPP in the Chisamba district ($p\text{-value} = 0.039$; RR = 1.238, 95% CI). The findings of the study are consistent with the findings of Muuka et al (2013 a), who reported that cattle marketing is one of the factors that lead to the occurrence and transmission of CBPP.

In comparing the results of this study with other similar studies, the results of this study are in agreement with Mamo et al (2018), who reported that age was not significantly associated with the seroprevalence of CBPP, Molla et al (2021) and Mamo et al (2018) who reported that herd size, sex and age group are not associated with CBPP seropositivity. In contradiction to the results of this study, Molla et al (2021) identified the presence of trekking route from or through CBPP endemic/epidemic zone to the study area to be associated with CBPP seroprevalence, Negash and Dubie (2021) found age and district to be associated significantly with CBPP, Mamo et al (2018) identified altitude, Anjum et al (2020) found age and gender to be significantly associated with CBPP seroprevalence, and Hussien et al (2024) identified sex, locality and water to be significantly associated with the seroprevalence of CBPP.

The difference in the findings between this study and other studies could be attributed to the mode in which cattle trading was conducted. The two farms that recorded outbreaks of CBPP are large commercial farms that are involved in cattle trading. It should be noted however that trading of healthy animals does not lead to the introduction of diseases such as CBPP. However, it is the trading of infected cattle and mixing them with non-diseased herd that leads into the introduction of diseases on farms. According to Part III of the Animal Health Act of 2010, “A person shall not move any animal, animal product, animal by-product, article or anything as may be prescribed, without a permit” (National Assembly of Zambia, 2010). The act further states that “an animal suspected of being infected with any disease shall—as far as is practicable, keep such animal separate from other animals that are not infected; prevent the movement of such animal outside

the infected area; and prevent the sale of such infected animal” (National Assembly of Zambia, 2010). The act implies that all animals that are to be moved for whatever purpose be it trade, must be certified to be disease free. The findings of this study suggest that trading in cattle necessitated movement of infected cattle that were bought and mixed with the healthy herds, hence it could have attributed to the CBPP outbreak in the Chisamba district. This study further suggests that infected animals are sometimes traded and transported to different regions, and during transportation of the animals, the health status of the animals is not monitored thus introduction of diseases to non-endemic areas. In addition, the study also suggests that there was poor surveillance of CBPP, to monitor the health status of the animals that were bought before they were introduced into Chisamba district, as well as before they were integrated with the old herd in the Chisamba district. A study by Di Teodoro et al (2020) and the EFSA Panel on Animal Health and Welfare et al (2017) stated that the most prevalent circumstances leading to disease introduction relate to the weaknesses of veterinary infrastructure and inadequate disease surveillance to monitor the movement of infected animals, which could be the possible explanation as to why the two commercial farms in the Chisamba district recorded outbreaks of CBPP.

The implications of cattle trading as a risk factor are as follows: increased risk of disease transmission which is facilitated by the movement of infected cattle, the introduction of CBPP into areas that were not previously endemic, and trade restrictions thereby economically affecting the livelihood of farmers and traders.

The second objective was to determine the farmers’ knowledge about CBPP. The study showed that generally, livestock farmers did not know what CBPP was and the various aspects of the disease, as the overall mean value indicated that 13.8% of the study participants were knowledgeable about CBPP while an alarming 86.2% of the respondents were not knowledgeable. There are several dangers associated with a lack or low knowledge of diseases of importance such as CBPP among cattle owners, herders, and traders. With the low number of participants knowledgeable about CBPP, the study therefore also suggests that the lack of adequate knowledge of CBPP among the participants could have also precipitated the introduction of the disease in the Chisamba district. Despite having had an outbreak of the disease about a year before this study, participants still exhibited low knowledge levels of CBPP. Though the extent to which the low knowledge levels on CBPP contributed to this outbreak was not determined by this study, it is clear that having little to no knowledge of a disease is a risk factor for further disease outbreaks

occurring (Cherinnat and Dibaba, 2022). There is need to raise awareness among livestock owners and farm workers on factors that lead to disease outbreaks as such knowledge would eventually lead to better disease recognition and prevention practices.

The study suggests that cattle traders might not have known the incubation period of CBPP which is over three weeks to six months (Di Teodoro et al., 2020). Without knowing the incubation period, they might have quarantined the cattle they bought for a short period (that is if they quarantined) before they mixed them with the rest of the cattle that were on the farm, thus this could have also led to the outbreak of CBPP on the farms. If newly purchased cattle are quarantined for the whole six-months period before integrating with the old herd, infected cattle can easily be identified and slaughtered thus preventing the introduction of CBPP to the old healthy herd.

From the study, very few participants (4 of 55) knew the signs and symptoms. This might have also contributed to the outbreak of CBPP in the Chisamba district in the following way; cattle traders might have overlooked cows that were presenting with signs and symptoms of CBPP because of being ignorant, which could have led to the delay in veterinary care to the infected animals, eventually spreading the disease to healthy cattle on the two farms.

It was evident from the findings of the study that the cattle farmers lacked information on how CBPP is transmitted as 4 of the 55 participants knew the mode of transmission. The cattle farmers who might have been uninformed of the mode of transmission of CBPP, might have gone ahead and introduced the cattle that they had bought onto their farms and mixed them with their animals thus introducing CBPP onto their farms. The transmission of CBPP is even quicker under conditions of overcrowding (Alhaji et al., 2020). The two farms that recorded CBPP have housing facilities in which cattle on the farms are kept and locked in. Without understanding how CBPP is transmitted, cattle that were bought were mixed with the old herds on the farms in the housing facilities hence it could have precipitated the spread of CBPP to the healthy animals. If the cattle farmers and herders were knowledgeable about the different modes of transmission of CBPP, they would have put up measures such as not mixing their old herd with the newly purchased cattle which could have prevented their cattle from getting infected. From the study, it was observed that cattle often mixed in different environments such as water points and common grazing pastures in the community. These environments involve assembling animals from different locations, which provides opportunities for direct contact which could facilitate transmission of CBPP.

Cherinnat and Dibaba (2022) conducted a study on farmers' knowledge, attitude and practice towards the disease (CBPP) in selected districts of Western Ethiopia which noted that only 7% of respondents had heard or knew what CBPP was. On the signs and symptoms, 79.6% of respondents reported to knowing grunting during coughing or exhaling as the sign/symptom, 75.2% knew head extended coughing, 71.7% knew dilation of nostril and mucoid, 60.2% knew discharge swelled of throat and dewlap, 44.2% knew standing with back arched, 54.9% knew labored and painful breathing, 38.9% knew standing with the elbows abducted, 19.5% knew chest pain, 56.6% knew frothy saliva at the mouth, and 23% knew polyarthritis on young as signs and symptoms. Regarding transmission of CBPP, 77% of the respondents recognized that CBPP is transmitted through close contact with diseased animals, and 67.3% recognized that it is transmitted through coughing of infected animals. Only 8.8% of the participants were knowledgeable that contaminated diseased cattle fetal membranes and uterine discharge were associated with disease transmission. The majority of the respondents were aware of the economic importance of CBPP as 85.8% were aware that it causes loss of body weight, 78.8% knew that it causes loss of production, 74.3% knew that it reduces the working ability of cattle, 57.5% knew that it causes mortality of cattle, and 61% knew that it reduced growth rate. Cherinnat and Dibaba (2022) further stated that majority of the participants had basic knowledge on treatment of symptomized or diseased animal (93.8%) and vaccination (78.8%). 32% of the participants were aware of good management like decontamination. of infected premises. However, Cherinnat and Dibaba (2022) also noted that very few participants recognized test and slaughter/stamping out policy (16.8%) and isolation of newly purchased animals from the herd (19.5%) as methods of controlling CBPP. A study conducted by Kairu-Wanyoike et al (2014) in the Narok district of Kenya, indicated that up to 25.5% of the pastoralists resisted subjecting their cattle to subsequent vaccinations against CBPP due to post-vaccination reactions, while another study by Kairu-Wanyoike et al (2017) attributed low vaccination coverage to lack of knowledge on CBPP and its impact as well as low funding from the government.

A report by the National Assembly of Zambia stated that in Chibombo district, there was lack of cooperation from some livestock farmers who in some instances were not willing to have their animals dipped or vaccinated (Committee on Agriculture, Lands and Natural Resources, 2023). The negative attitude of livestock farmers could have also contributed to the outbreak in Chibombo district. In the study area, Chisamba district, unwillingness on the part of livestock farmers was

not observed hence it was not suggested to have had any effect on the outbreak in Chisamba district.

Having low knowledge of CBPP among the respondents has several implications. Firstly, there is an increased risk of disease transmission to other cattle in the same herd and with other herds in the community. Farmers with limited knowledge on CBPP may not take adequate measures to prevent the spread of the disease, thereby leading to wider outbreaks. Secondly, farmers with limited knowledge on CBPP may not recognize the symptoms of the disease, thus leading to delayed diagnosis and treatment, which can further result in higher mortality rates and more severe disease outcomes. Additionally, farmers with low knowledge on CBPP can also exacerbate cattle losses by delaying or preventing effective disease control measures. Furthermore, farmers with CBPP infected cattle may face restrictions on market access and trade due to trade bans that would have been imposed to control the spread of the disease.

A study by Suleiman et al (2018) showed that farmers educated on CBPP are more likely to control the disease. The study therefore provided an opportunity where participants were educated on CBPP. Knowledge on what the disease is, the aetiological agent of the disease, how it is transmitted, signs and symptoms, impact of the disease, and how it is controlled, was shared to the participants.

Therefore, there is a need for the District Veterinary Office in Chisamba district to organize training sessions for herders and traders, to educate livestock farmers on diseases of importance like CBPP.

6.0 STUDY LIMITATIONS

Notwithstanding the findings reported in the current study around the associated drivers of the CBPP outbreak reported in Chisamba District and the level of knowledge among the livestock owners about CBPP as an economic disease of cattle, the small sample size of the participants coupled with the low level of cooperation received may pose as a limitation in interpreting and over generalising the findings of this study. The lack of corroborating evidence owing to the nature of retrospective studies presents another limitation. It is, therefore, recommended that an adequate sample size of participants willing to volunteer all the necessary information to unravel the factors associated with an outbreak of a notifiable disease of economic importance be employed. Moreover, the presence of recorded corroborating evidence linked to an outbreak would further strengthen the linkage between a disease outbreak and the precipitating factors.

7.0 CONCLUSION AND RECOMMENDATIONS

The identified risk factor that was associated with the occurrence of CBPP in Chisamba district was cattle trading ($p = 0.039$). Generally, 13.8% of the participants knew what CBPP was, including the various aspects of the disease such as aetiological agent, mode of transmission, signs and symptoms, and impact of the disease. The knowledge assessment of the study shows that there were low knowledge levels of CBPP among the study participants as a relatively small proportion of the study participants demonstrated knowledge of the disease.

From the findings of the study, most farmers sought veterinary services only when they saw a clear indication of a sick cow. The study therefore recommends that farmers should have herd health plans where veterinarians can regularly check on their animals.

Since cattle trading was identified as the cause of the occurrence of CBPP in the Chisamba district, the study therefore recommends that before cattle that has been bought can be integrated with the other animals in a farm, the cows must be thoroughly checked and quarantined to prevent introducing diseases into farms. The study further recommends a concerted one-health approach from multiple disciplines in ensuring safety of animals. Through the one health approach, the council and police have a critical role to play in ensuring that all animals that are being traded and transported from one region to another have valid permits, certified by veterinarians, showing that the transported animals are healthy and disease-free.

Based on the low knowledge levels of the participants, the study also recommends that veterinarians should regularly engage community livestock farmers to teach them on various diseases of economic importance such as CBPP. Educating the farmers would raise awareness on diseases of economic importance. If cattle farmers know various aspects of diseases such as the mode of transmission, signs and symptoms, and impact of diseases, the information can help prevent the spread of diseases of cattle.

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9.0 APPENDICES

Appendix 1: Ethical approval



Plot No. 272, Cnr Olive Tree Meanwood Road,
Meanwood Ibex
Lusaka - Zambia
Tel: +260 955 155 633
+260 955 155 634
Cell: +260 977 493 220
Email: eresconverge@yahoo.co.uk

I.R.B. No. 00005948
F.W.A. No. 00011697

21st March, 2024.

Ref. No. 2024-Feb-008

The Principal Investigator
Mr. Oscar Kamasongo
The University of Zambia
School of Veterinary Medicine
Lusaka, Zambia

Dear Mr. Kamasongo

**RE: ASSOCIATED RISK FACTORS OF CONTAGIOUS BOVINE
PLEUROPNEUMONIA IN CATTLE FOLLOWING AN OUTBREAK IN
CHISAMBA DISTRICT.**

Reference is made to your protocol submission. The IRB resolved to approve this study and your participation as Principal Investigator for a period of one year.

Review Type	Ordinary	Approval No. 2024-Feb-008
Approval and Expiry Date	Approval Date: 21 st March, 2024	Expiry Date: 20 th March, 2025
Protocol Version and Date	Version - Nil.	20 th March, 2025
Information Sheet, Consent Forms and Dates	• English.	20 th March, 2025
Consent form ID and Date	Version - Nil	20 th March, 2025
Recruitment Materials	Nil	20 th March, 2025
Other Study Documents	Questionnaires	20 th March, 2025
Number of participants approved for study		20 th March, 2025

Where Research Ethics and Science Converge

Specific conditions will apply to this approval. As Principal Investigator it is your responsibility to ensure that the contents of this letter are adhered to. If these are not adhered to, the approval may be suspended. Should the study be suspended, study sponsors and other regulatory authorities will be informed.

Conditions of Approval

- No participant may be involved in any study procedure prior to the study approval or after the expiration date.
- All unanticipated or Serious Adverse Events (SAEs) must be reported to the IRB within 5 days.
- All protocol modifications must be IRB approved prior to implementation unless they are intended to reduce risk (but must still be reported for approval). Modifications will include any change of investigator/s or site address.
- All protocol deviations must be reported to the IRB within 5 working days.
- All recruitment materials must be approved by the IRB prior to being used.
- Principal investigators are responsible for initiating Continuing Review proceedings. Documents must be received by the IRB at least 30 days before the expiry date. This is for the purpose of facilitating the review process. Any documents received less than 30 days before expiry will be labelled "late submissions" and will incur a penalty.
- Every 6 (six) months a progress report form supplied by ERES IRB must be filled in and submitted to us.
- A reprint of this letter shall be done at a fee.

Should you have any questions regarding anything indicated in this letter, please do not hesitate to get in touch with us at the above indicated address.

On behalf of ERES Converge IRB, we would like to wish you all the success as you carry out your study.

Yours faithfully,
ERES CONVERGE IRB



Dr. Jason Mwanza
Dip. Clin. Med. Sc., BA., M.Sc., PhD
CHAIRPERSON

Appendix 2: Information sheet

INTRODUCTION

My name is Oscar Kamasongo, a student from The University of Zambia, pursuing a Master's of Science in Tropical Infectious Diseases and Zoonosis. I am undertaking a study: **Risk Factors Associated with the Outbreak of Contagious Bovine Pleuropneumonia in Chisamba District, Zambia.**

AIM OF THE STUDY

The aim of this study is to identifying the risk factors that led to the outbreak of CBPP in Chisamba district, and also assess the knowledge of cattle farmers of the disease CBPP. This will help in preventing any future disease outbreaks as well as put in the necessary preventive measures.

PROCEDURES

If you agree to take part in this study, you will be asked questions about your education, farm management practices such as feeding, and general knowledge on CBPP.

RISKS AND BENEFITS

This study is purely questionnaire based hence you will not be subjected to any pain. The information that you will provide in this study will be strictly kept confidential and at no point will it be disclosed to anyone.

There are a number of benefits of participating in this study of which the two key benefits are: it will enhance your understanding of how CBPP is acquired and transmitted, and also it will provide you with knowledge of how you can prevent your cattle from possible future outbreaks.

VOLUNTARISM

It is your choice to get involved in this study. If you agree to participate in this study, your answers will be confidential and kept private to the extent that the law allows. As you will be asked questions during the study, you can decide not to answer some questions, it is up to you. If you decide not to take part, your decision will be respected.

Thank you for your time.

Appendix 3: Consent form

You are invited to participate in this study. If you agree to take part, your answers will be confidential and kept private. It is entirely up to you to decide when to discontinue your participation and to decide whether to answer some questions or not. For any questions or clarifications to be made, you are free to ask at whatever time.

Would you like to take part in this study?

Consent from Participant

By signing my name below, I confirm the following:

- I have read the Information Sheet for this study and have had details of the study explained to me.
- My questions about the study have been answered to my satisfaction and I understand that I may ask further questions at any point.
- I understand that I am free to withdraw from the study within the time limits outlined in the Information Sheet, without giving a reason for my withdrawal or to decline to answer any particular questions in the study without any consequences to my future treatment by the researcher.
- I can either give out my name or choose to be anonymous.
- I volunteer to participate in the study and agree to follow the study procedure as directed.

Participant's Name: _____ **Date:** _____

Participant's Signature: _____

Witness of participant (Signature): _____

Researcher's details

Researcher's Name: _____

Researcher's Signature: _____

Date: _____

**Thumbprint of
Participant**

Appendix 4: Questionnaire

Risk Factors Associated with the Outbreak of Contagious Bovine Pleuropneumonia in Chisamba District, Zambia.

INFORMED CONSENT

Introduction and Aim of the study

Hello. My name is Oscar Kamasongo, a student from The University of Zambia, pursuing a Master's of Science in Tropical Infectious Diseases and Zoonosis. I am undertaking a study: **Risk Factors Associated with the Outbreak of Contagious Bovine Pleuropneumonia in Chisamba District, Zambia.** At the end of this study, recommendations on how to prevent any future outbreak of CBPP in the community will be made. I would like to ask you questions about your education, farm management practices such as feeding, and general knowledge on CBPP. I will greatly appreciate your participation in this study. No one else will know that it was you who provided the answers as this interview is strictly confidential. Do you have any questions?

Participation in this study is voluntary and you can choose not to answer any individual question or questions.

Your details will be treated as highly confidential and anonymous.

Are you willing to participate? May I begin the interview now?

Signature of the interviewer

____/____/____

Date

Start time:_____

End time:_____

A. DEMOGRAPHIC INFORMATION

No	Questions	Responses
1	Gender of respondent	Male.....1 Female.....2 []
2	What is your age as at last birth day?	1. Years 2. Refused to disclose []
3	What is your marital status?	Single.....1 Married.....2 Divorced.....3 Widowed.....4 Separated.....5 [] Others (Specify).....
4	What is your level of education?	Never went to school.....1 Primary.....2 Junior secondary.....3 Senior Secondary.....4 Tertiary.....5 [] Other; Specify.....
5	What is your occupation?	Farmer.....1 Unemployed.....2 Home maker.....3 Business person.....4 Fishing5 [] Others Specify.....
6	Do you have any people living with you in this household?	Yes1 No.2 []

7	If yes in (6) above, how many?	
8	Do you keep other animals apart from cattle	Yes1 No2 []
9	If yes in (8) above, what other type(s) of animals do you keep?	Cats1 Dogs.....2 Goats3 Pigs.....4 Cattle5 Sheep6 All of the above7 [] Others; specify.....

B. CATTLE MANAGEMENT PRACTICES

No	Questions	Responses
10	How many cows do you have?	
11	Of the total number of cattle you have, how many are males and how many are females?	Male..... Female.....
12	What are the age groups of your cattle?	0 ≤ 1 years1 1 – 3 years2 ≥ 3 years3 []
13	Do you have any housing facility for your cattle?	Yes1 No2 []
14	If yes in (13), do you clean the housing facility?	Yes1 No.....2 []
15	How are the cows fed?	Food is provided within the facility.....1 They go grazing outside the facility.....2 All of the above3 []
16	If 2 or 3 is part of your response in 15, who is primarily responsible for taking care of the cattle when they are grazing?	Yourself.....1 Children.....2 Workers.....3 All the above.....4

		None.....5 []
17	Do your animals mix with other animals from neighbouring farms during grazing?	Yes.....1 No.....2 []
18	What is the source of water for the cattle?	Stream.....1 Borehole.....2 Well.....3 [] Others; specify.....
19	Do all your animals have the same source of drinking water?	Yes.....1 No.....2 [] Other; specify.....
20	Do you experience any health-related problems (e.g., coughing, eye and nasal discharges, bloody diarrhoea, hair loss, laboured breathing on your farm?	Yes.....1 No.....2 [] Other; specify.....
21	If yes in (20) above, which sex of animals experience most health-related problems on the farm?	Males.....1 Females.....2 []
22	Do you seek veterinary services regularly?	Yes.....1 No.....2 [] Other; specify.....
23	If yes in (22) above, who are the providers for the animal health care?	Vet.....1 Community livestock auxiliary.....2 NGO.....3 [] Others.....
24	Do you buy cattle from other farmers?	Yes.....1 No.....2 [] Other; specify.....
25	Do you sell cattle to other farmers?	Yes.....1 No.....2 [] Other; specify.....
26	Do you take your cattle to abattoirs or any slaughter slabs?	Yes.....1 No.....2 [] Other; specify.....
27	If the cows are not slaughtered that day, are they returned to mix with others that remained behind?	Yes.....1 No.....2 [] Other; specify.....

C. CBPP KNOWLEDGE

No	Questions	Responses
28	Have you ever heard of the disease called CBPP?	Yes.....1 No.....2 []
29	If yes in 28 above, what causes the disease?	
30	If yes in 28, above how is it transmitted?	
31	If yes in 28 above, what are some of the signs/ symptoms?	
32	Do you have any idea of the impact of the disease?	Yes.....1 No.....2 []
33	If yes in 32 above, what are some of the impacts that you know?	
34	In the recent CBPP outbreak, was any of your cow slaughtered?	Yes.....1 No.....2 []
35	Did any of your cows die due to CBPP?	Yes.....1 No.....2 []
36	If yes in 34 above, how many of your cows were slaughtered?	
37	If yes in 35 above, how many of your cows died?	
38	If yes in 34 above, how many males and females were slaughtered?	Male..... Females.....
39	If yes in 35 above, how many males and females died?	Male..... Females.....
40	Did any of your animals survive the CBPP outbreak?	Yes.....1 No.....2 []
41	If yes in 40 above, was any veterinary service sought for the animals that survived CBPP?	Yes.....1 No.....2 []
42	If yes in 41 above, what veterinary services were sought?	

