Academic Journal of Animal Diseases 5(1): 01-15, 2016
ISSN 2079-200X

DOI: 10.5829/idosi.ajad.2016.01.15

Review on Contagious Bovine Pleuropneumonia and its Economic Impacts

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Abstract: Contagious bovine pleuropneumonia (CBPP) is a bacterial disease of respiratory system which is caused by *Mycoplasma mycoides subspecies mycoides* SC variant (MmmSC) and characterized by pneumonia and serofibrinous pleurisy. This review was aimed to elucidate the epidemiology, control measures and economic significance of CBPP, to address the economic loss of the country and to state effective control and prevention method of the disease. CBPP also epidemiologically characterized by its ability to transmit through direct contact, long incubation period, possibility of early excretion of mycoplasmas (up to 20 days) before apparition of clinical sings during the course of the disease and after recovery in "lungers" up to two years. Closeness of contact, intensity of infection and the number of susceptible animals determine the rate of spread of the disease. The clinical manifestations and lesions are typical and are no different in Africa from those seen in other countries. The post mortem lesions of CBPP include thickening and inflammation of lung tissues. Diagnosis requires the isolation of the etiological agent. In carrying out CBPP diagnosis it is necessary to differentiate this disease from other diseases that may present similar clinical signs or lesions. Treatment is recommended only in endemic areas because the organisms may not be eliminated and carriers may develop. The main problems for control or eradication are the frequent occurrence of sub acute or subclinical infections, the persistence of chronic carriers after the clinical phase and the lack of extensive vaccine coverage. Generally, CBPP is one of the major threats to cattle health and production in most African countries including Ethiopia. Relevant control measures should be implemented to minimize the incidence of CBPP zonal and national levels.

Key words: *Cattle · CBPP · Economic loss · Epidemiology · Prevention · Risk factors · Transmission*

INTRODUCTION

In addition to their direct role in generating food and income [1, 2], livestock are a valuable asset, serving as a store of wealth, collateral for credit and an essential safety net during times of crisis throughout the developing world [3-6] and generally generate a livelihood for 1.0 billion poor people in the world [7].

The livestock sector accounts for about 30% of the agricultural GDP in sub-Saharan Africa (SSA) and nearly 60% of the value of edible livestock products is generated by cattle [8]. However, Ethiopia has high livestock population which provides draught power, milk, meat, fibber, fuel and fertilizer and foreign currency from hide and skin, our country is not using from her livestock as much expected due to many animal disease circulating in animal population [9, 2].

Contagious bovine pleuropneumonia (CBPP), one of these animal diseases which cause threat to our livestock, is a highly infectious respiratory disease in cattle causing lung and occasionally joint disease [10- 12]. It is caused by *Mycoplasma mycoides subspecies mycoides* SC variant (MmmSC) [13- 12]. It is difficult to see the organism even with a light microscope but growth of the organism can be seen when infectious material is cultured in the laboratory [15]. CBPP is an economically important

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disease of cattle that affects domestic ruminants of the genus *Bos*, mainly *Bos taurus* and *Bos indicus* and is an important disease in many of the principal pastoral areas of Africa [14, 16].

Many researchers and the Pan African program for the Control of Epizootics (PACE) has identified CBPP as the second most important trans-boundary disease in Africa next to render pest and thus, CBPP is now a major focus of activity for the program [14].

In recent years, it has been found in countries like Botswana from where it was previously eradicated [17]. It is characterized by a morbidity rate of 75% - 90%, a mortality rate from 50% to 90% and a case-fatality rate of 50% [18]. Additionally, different authors were reported as it is a respiratory illness characterized by the presence of sero-fibrinous, interstitial pneumonia, interlobular edema and hepatization giving a marbled appearance of the lung and capsulated lesions termed as sequestra in the lungs of affected cattle. Contagious bovine pleuropneumonia is a highly infectious acute, sub-acute, or chronic disease, primarily of cattle, affecting the lungs and occasionally the joints [19, 16].

There is growing evidence to indicate that the incidence of the disease is increasing in endemic areas [20]. These recent increases can be attributed to uncontrolled movement of cattle, poor disease control strategies and application of sub-standard vaccines [21, 22]. There is sufficient consensus that efficacious vaccines could contribute substantially to an integrated control program for CBPP [23]. This would involve improvement of existing and development of a new generation of vaccines [24]. So, it has become a serious obstacle to livestock development in sub-Saharan Africa and Asia.

The occurrence of sub acute, symptom less infections and chronic carriers after the clinical phase of the disease are the major problems in the control of this disease. It affects cattle production through mortality and reduced productivity [10, 20, 22]. It also retards genetic improvement and limits the ability of cattle to work [22]. Unlike some parasitic animal diseases whose impacts are confined to a single farm, the impact of CBPP is often felt at and beyond a single farm. The outbreak of CBPP in one herd poses a threat to neighboring herds especially in a production system where there is poor control of cattle movements. The economic impact of CBPP should therefore be seen beyond the farm level.

According to the report of most sub-Saharan African countries, a total of 2,612 outbreaks of CBPP between 1995 and 2002 were observed and this value represented 96% of the total number of outbreaks reported by all the countries in West, Central and East Africa and thus, found to be one of the major threats to cattle production and the lives of millions of cattle owners. An outbreak of contagious bovine pleuropneumonia (CBPP) was reported in the Somali National Regional State, Eastern Ethiopia and confirmed by detailed physical clinical examination, autopsy and bacteriological examinations to be CBPP [25]. The traditional management system and cattle movement played vital role in the spread of the diseases [4]. When the disease spreads for the first time within a sensitive cattle population, it generally causes high mortality. In countries such as Ethiopia where CBPP was reported to be prevalent, the knowledge of the diseases and factors associated to such important disease is crucial. Therefore, the objectives of this paper are to review the epidemiology, control measures and economic significance of Contagious Bovine Pleuropneumonia (CBPP) and to find the least cost method to restore health and productivity.

Contagious Bovine Pleuropneumonia (CBPP)

The Disease: Contagious bovine pleuropneumonia (CBPP) is an insidious pneumonic disease of cattle sometimes referred to as lung sickness [12, 11, 26]. There is considerable variation in severity of signs observed in cattle affected by CBPP, ranging from hyper acute through acute to chronic and subclinical [27]. CBPP has been known to occur in Europe since the 16th century but it gained a world-wide distribution only during the second half of the 19th century because of increased international trade in live cattle [26, 10].

It was eradicated from many countries by the beginning of the 20th century through stamping-out policies. However, the disease persists in many parts of Africa, with minor outbreaks occurring in the Middle East. The situation in Asia is unclear. There have been no reported outbreaks in Europe since 1999. In natural conditions, MmmSC affects only the ruminants of the *Bos* genus, i.e. mainly bovine and zebu cattle. MmmSC (bovine biotype) has been isolated from buffaloes in Italy (Bubalus bubalus) [26, 28] and from sheep and goats in Africa and more recently in Portugal and in India [29, 30].

Among wild animals, one single case has been reported in American buffaloes (Bison bison) and none in African buffaloes (Syncerus caffer) or other wild ruminants. Wild animals do not play a role in the epidemiology of the disease. CBPP is manifested by anorexia, fever and respiratory signs, such as dyspnea, polypnoea, cough and nasal discharges. In the case of

acute outbreaks under experimental conditions, the mortality rate may be as high as 50% in the absence of antibiotic treatment. When an outbreak first occurs in an area, the mortality will be high but is often lower in the field following the primary outbreak [10, 26].

Causative Agent: The bacterial agent of contagious bovine pleuropneumonia is *Mycoplasma mycoides* [29]. *Mycoplasma* belongs to the order *Mycoplasmatales* and class Mollicutes (soft skin). *Mycoplasmas* are unique in microbiology because of their extremely small size and their growth on complex but cell-free media. Members of the *M. mycoides* group, *M. capricolum* group and Leach's group 7 form the so-called *M. mycoides* cluster, which consists of six Mycoplasmaspecies, subspecies or groups of strains, originating from bovines and goats [31].

In natural conditions, two types of Mm are recognized: large colony (LC) and small colony (SC) [29, 31, 32]. They cannot be differentiated serologically but are different morphologically, culturally and in their pathogenicity and can be distinguished through mouse protection tests. *Mycoplasma mycoides subspecies mycoides* Small Colony type (MmSC) affects only the ruminants of the *Bos* genus (mainly bovine) [10, 29]. *Mycoplasma mycoides subspecies mycoides is* the cause of CBPP in cattle [29, 31, 32]. Large colony types occur almost exclusively in goats, rarely in sheep while SC types cause CBPP in cattle [31]. *M. mycoides mycoides* large colony (LC) type does not result in disease in cattle, but causes septicemia, polyarthritis, mastitis, encephalitis, conjunctivitis, hepatitis and occasionally pneumonia in sheep and goats [33, 10].

Epidemiology: *Mycoplasma mycoides* subspecies mycoides SC type, the etiological agent of contagious bovine pleuropneumonia (CBPP) [29, 31, 33]. It can be grouped into two major, epidemiologically distinct, clusters. One cluster contains strains isolated from different European countries since 1980 and a second cluster contains African and Australian strains collected over the last 50 years [33, 35].

Hosts: Bovine, both *Bos taurus* and *Bos indicus*, are the main species that are susceptible to CBPP. Infections have also been reported from Asian buffalo (*Bubalus bubalis*), captive bison (*Bison bison*) and yak (*Poephagus grunnien,* formerly *Bos grunnien*). Sheep and goats can also be naturally infected, but with no clear associated pathology. Wild bovids and camels seem to be resistant and, so far, do not appear to be important in the transmission of CBPP [36, 10, 16]. The African water buffalo (*Syncerus caffer*) is refractory to CBPP. CBPP prevalence with respect to age was assessed and cattle over two years were found highly affected as compared to the younger animals with significant variation [37].

Incubation Period: Incubation period of the disease is usually 1-4 months, but can be longer. After experimental inoculation into the trachea, clinical signs may appear in 2-3 weeks [10, 26, 38].

Transmission: Contagious bovine pleuropneumonia is epidemiologically characterized by its ability to transmit through direct contact, long incubation period, possibility of early excretion of *mycoplasmas* (up to 20 days) before apparition of clinical sings during the course of the disease and after recovery in "lungers" up to two years [32, 34, 39]. The organism is also present in saliva, urine, fetal membranes and uterine discharges [40].

Closeness of contact, intensity of infection and the number of susceptible animals determine the rate of spread of the disease. It is spread mainly by inhalation of droplets from infected coughing animals, especially if they are in the acute phase of the disease. Because of large numbers of MmmSC are present in bronchial secretions, nasal discharges and exhaled air, it is transmitted to susceptible animals in close contact by droplets emanating from either cattle with clinical disease or subclinical carriers that are actively excreting the organism [10, 16, 26].

Closely stabled or trucked animals are therefore most prone to infection. However, aerosols containing infected droplets may spread the disease over distances of 20 m or more [41]. Close proximity is necessary for transmission, which occurs primarily through the inhalation of infected droplets from a coughing animal [40].

Cattle are the only species affected; there is no reservoir host in wild animals and cattle movements play a very important role in the maintenance and extension of the disease [42]. Airborne spread up to 200meters is thought to be possible. Conditions under which cattle are herded closely together favour rapid spread of the disease. Apart from shedding of MmmSC by clinically ill animals, there are other sources of infection [43].

Outbreaks and Distribution: Contagious bovine pleuropneumonia was introduced in the Cape Province of South Africa in 1853 through cattle imports from the Netherlands. Following the first outbreak, CBPP quickly spread to neighboring countries and is now present in

many parts of Africa. In 1904, it was eradicated from Zimbabwe followed by South Africa in 1924 and Botswana in 1939. It is generally accepted that after its arrival in South Africa from Europe, CBPP spread into East Africa by Boer settlers who trekked their cattle to the Kenyan highlands around the turn of the 20th century. Others believe it may have been present in pre-colonial times and cite Thompsonäs description of a cattle disease resembling CBPP in Maasai cattle in the1880s in Eastern Africa [44].

Today, CBPP is present in Central, East, West and parts of Southern Africa but is absent in North Africa. After examination of the number of countries reporting the disease, a more accurate estimate of distribution was provided [22]. According to OIE reports, there are about 27 sub-Saharan African countries with cases of CBPP [45]. The epidemiology of CBPP in Africa is dominated by different factors [46]. During the Pan African Rinderpest Campaign (PARC), which started in 1986, fewer countries experienced outbreaks of CBPP, due in part, to the combined vaccination against render pest and CBPP [47].

Epidemiological and clinical observations indicate that the European outbreaks of CBPP are less virulent than the disease encountered in Africa. Furthermore, CBPP in Europe seems to be far more insidious, as it is usually chronic and affected cattle show few distinctive clinical signs and rarely die [34].

An alternative or additional route of infection into Africa was the introduction of CBPP into Ethiopia and Sudan with infected Indian cattle belonging to the British Expeditionary Force in the late 19th Century [48-49]. Today, CBPP is endemic in much of sub-Saharan Africa and its incidence is increasing. The disease would then have spread into Eastern and possibly Western Africa via well established trade routes [43, 13, 32, 26].

Morbidity of CBPP: Morbidity refers to the proportion of animals affected in a given population. It includes prevalence and incidence, both of which measure the risk that a susceptible animal in a population has of contracting a disease [50]. CBPP morbidity rates vary significantly between herds. A CBPP CFT seropositive rate of 8.1% was reported by [51] in Sudan. Using the standard procedure of the Kenya Veterinary Laboratory and an antigen from the Muguga (Kenya) Veterinary Research Laboratory to test sera, [52] reported a morbidity rate of 8.3% among cattle in Sudan. Other report surveys reveal rates above 25% in Chad, Ethiopia, Guinea and Tanzania [53, 54, 55, 56]. Morbidity rates below 5% have been reported in Burkina Faso and Uganda [57, 53].

Prevalence and Incidence: The prevalence and incidence of CBPP vary according to the cattle production system concerned. Prevalence rates tend to be higher in extensive cattle production systems compared to more intensive dairy and beef production systems where animals are confined. In Chad, [55] estimated a CBPP prevalence rate of 1.6% for cattle on transhumance and a rate of 1.2% for cattle rose in agro-pastoral production systems. In Nigeria, an estimated prevalence rate of 0.29% from post mortem examinations of lesions in 81 national abattoirs [58]. [59] also estimated a prevalence rate of 0.51% in Nigeria while [53] reported rates of 2.9% for Burkina Faso, 5.4% for Mauritania and 10.5% for Mali. [60-61] reported prevalence rates of 2.8% and 4.0% in Kenya and Ethiopia respectively.

Mortality: CBPP outbreaks have been associated with various levels of mortality. Due to the debilitating nature of the disease, mortality rates have been relatively low, particularly in endemic situations. Higher mortality rates are however not uncommon. In its acute form, the mortality rate can reach 50% [15]. Mortality rates above 10% have been reported in Guinea [53] and Ethiopia [54]. Rates between 5 and 10% have been reported in Chad and Cote d'Ivoire [53] while rates below 5% have been reported in Tanzania, Uganda, Burkina Faso, Ghana and Mali [57, 56, 62, 53].

Pathogenesis: Many authors were reported that CBPP is typical example of multi-factorial diseases, where factors such as inter-current infections, crowding, inclement climatic conditions, age, genetic constitution and stress from transportation, handling and experimentation are important determinants of the final outcome of infection. An essential part of the pathogenesis of the disease is thrombosis in the pulmonary vessels, probably prior to the development of pneumonic lesions [63, 26].

Natural infection is by inhalation and results in Bronchitis, alveolitis, bronchiolitis with predominantly neutrophils and mononuclear cellular response constitute the very early inflammation in *Mycoplasma* pneumonia [64-65]. It is lobar variety of pneumonia in which the inter-lobular septa are dilated and prominent due to a great out pouring of plasma and fibrin in to them and it this dilated septa that give the "marbling" effect to the lung in these areas [46]. CBPP is characterized by substantial unilateral pulmonary necrosis, sometimes sequestration and marked serosanguinous fluid accumulation in interstitial and pleura [64]. Vasculitis appears to be an important component of the pathological changes in this disease,

explaining the marked exudation and pleurisy. Thrombosis can explain ischemic necrosis and infarcts of the lung. Death results from anoxia and presumably from toxemia [66].

The pathogenic determinants of *M. mycoides subsp. Mycoides* SC types have not yet been elucidated completely, so the pathogenesis of CBPP is still unclear. Subcutaneous inoculation of virulent cultures into susceptible cattle causes extensive oedema, the so-called Willems' reaction, but never the natural disease. The only way to induce genuine pleuropneumonia lesions is by endobronchial inoculation of a virulent culture or, preferably, of ground lesions taken from a cow with naturally obtained CBPP. A toxin has not yet been definitively demonstrated. The galactan may be of pathogenic significance. This mycoplasmal antigen seems to contribute to the severity of the lesions by its inflammatory action as well as by its thrombotic effect on capillaries [67]. It probably also stimulates the development of connective tissue around sequestra [68].

The antigenic relationship between the mycoplasma galactan and lung tissue galactan could cause autoimmunity, with precipitation of immune complexes and damage of the pulmonary cells [67]. The lesions develop first in the lymphatic system. Thrombi that develop in the lymphatics cause coagulation of lymph, distension of interlobular septa and focal perivascular round cell infiltration. The formation o cuffs of round cells around the arterioles is the only histological pathognomonic characteristic of CBPP. The secondary lesion is characterized by alveolar involvement due to the accumulation of exudate from the foregoing changes. Necrotic foci surrounded by a band of polymorpho nuclear granulocytes often develop. These foci may develop into sequestra in chronic cases [69].

Clinical Signs: There is considerable variation in severity of signs observed in cattle affected by CBPP, ranging from hyperacute through acute to chronic and sub-clinical forms [70] and summarized as follows.

Hyper Acute Forms: The clinical signs observed in the hyperacute form are much accelerated. Affected animals may die within a week exhibiting classical respiratory signs [36, 46, 43].

Acute Forms: The early stages of CBPP are indistinguishable from any severe pneumonia with pleurisy. After an incubation period of 3-6 weeks, animals show dullness, anorexia, a fall in milk, yield irregular

Fig. 1: Source: [13]

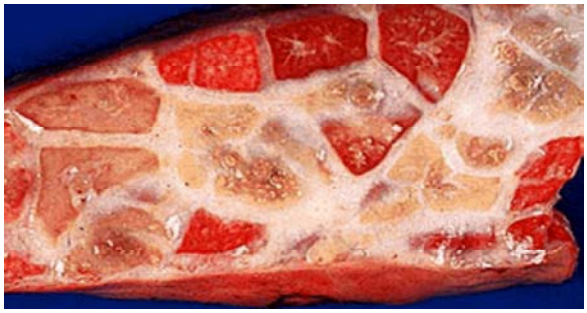

Fig. 1: Early CBPP: Marbled lung
Source: [13]

rumination with moderate fever and may show signs of respiratory disease [46, 27]. Coughing is usually persistent and is slight or dry. Sometimes fever goes up to 40-42 °C and the animal prostrates with difficulty of movement. As the typical lung lesions develop, the signs become more pronounced with increased frequency of coughing and the animal becomes prostrate or stands with the back arched, head extended and elbows abducted. While classical respiratory signs may be evident in calves, articular localization of the causative agent with attendant arthritis usually predominates [71, 27].

Sub Acute Forms: Signs may be limited to a slight cough only noticeable when the animal is exercised [72, 32]. Cattle that recover naturally are extremely weak and emaciated. Many infected animals develop chronic or milder forms of the disease, which may be either symptomless or associated with only a slight temporary rise in body temperature and some loss of condition [22, 73]. In infected herds mortality was around 2-3% [74].

Necropsy Findings: The post mortem lesions of CBPP include thickening and inflammation of lung tissues. Large amounts of straw-colored fluid may be present in

the chest cavity. A characteristic marbled appearance of the affected lungs is caused by the presence of both acute and chronic lesions in the connective tissues. Fluid accumulation in the lungs progresses to excess tissue formation (fi brosis). Encapsulated areas of diseased tissue can be found even in recovered animals [13].

Abnormalities (lesions) are generally confined to the chest cavity except in young calves, where inflammation of the limb joints (usually the carpal and tarsal joints), with increased fluid, is sometimes seen. A most striking feature of the acute disease is the very large volume of yellow fluid (up to 30 litres) containing clots, which can accumulate in the chest. The lungs (almost always one) and pleura are affected. In most cases, only the diaphragmatic lobe is involved; it is firm and fleshy, resembling liver rather than healthy pink lung. It does not collapse when the chest is opened. In acute forms, the yellowish fluid in the chest cavity may solidify and cover the lining of the chest and surface of the lung (the pleura) with a yellow or yellowish grey coating resembling a fibrin [13].

Lymph nodes in the chest may be enlarged and wet (edematous), with small necrotic foci and pinpoint hemorrhages, the difference between cortex and medulla may be indistinguishable. In the kidney cortex, white spots of dead tissue of variable size, called infarcts, can sometimes be seen. Because the lesions are so characteristic, slaughterhouse monitoring is a powerful tool to use in detecting introduction and spread of the disease although in the Ethiopian context slaughtering is achieved in almost all small butchery at backyard slaughtering [46].

Diagnosis: Contagious bovine pleuropneumonia is difficult to diagnose based on clinical signs alone as there can be many causes of severe pneumonia in cattle. But, we can diagnosis CBPP based on a history of contact with infected animals, clinical findings, immuno-diagnosis tests, necropsy findings and cultural examination. CBPP frequently results in disease in only one lung as compared with other types of pneumonia in which both lungs are affected. In a herd with signs of pneumonia in adults and polyarthritis in calves, CBPP should be considered. Post mortem lesions may be more useful in the diagnosis [40]. Confirmatory diagnosis is based on the isolation of *Mccp* from clinical samples of lung [65].

Differential Diagnosis: In carrying out CBPP diagnosis it is necessary to differentiate this disease from other diseases that may present similar clinical signs or lesions. Some sources of confusion are: Rinderpest, Foot-and-mouth disease (FMD), Haemorrhagic septicaemia (HS), Bacterial or viral broncho-pneumonia, Theileriosis (East Coast Fever), Tuberculosis, Actinobacillosis and Echinococcal (hydatid) cysts [13]. Differentials for acute infections include acute bovine pasteurellosis and bronchopneumonia and pleuropneumonia resulting from mixed infections [40].

Treatment: Under practical field conditions, when the disease breaks out in a new area, treatment is not applicable and not recommended because of reasons of disease prevention []. Treatment is recommended only in endemic areas because the organisms may not be eliminated and carriers may develop, Tylosin (10 mg/kg, IM, bid, for six injections) and danofloxacin 2.5% (2.5 mg/kg/day for 3 consecutive days) have been reported to be effective [46], but in practice farmers are treating their animals when they have no other alternative. Although the *Mycoplasmas* are susceptible to a number of antibiotics *invitro*, treatment failures are common [66].

The use of antimicrobials is controversial because of fears that it could result in more carriers, but cattle owners nevertheless do use antimicrobials to cure clinical disease and save the lives of their cattle. Oxytetracyclines (OTC) are the antimicrobials most widely used in Africa to treat CBPP. In spite of widespread and probably sub-optimal use over a long period of time resistance has not been detected, but a number of other products have been investigated [75].

Control and Prevention: The old maxim that prevention is better than cure is very relevant to dealing with CBPP. Quarantine is the first line of defense against these diseases and all countries should devote an appropriate level of resources to ensure that they implement effective border and import quarantine policies and programmes to prevent the introduction of serious livestock diseases. Eradication of CBPP has been achieved in North America, Europe, Australia and apparently in Asia, with only sub-Saharan African continent remaining significantly infected [76].

Methods used have generally involved movement control and stamping out of infected herds, although eradication in China, in which infection was widespread, was finally achieved by the use of an attenuated vaccine

involving numerous passages in rabbits that was apparently effective, although it took more than 30 years to achieve eradication [75]. The most important resource in the prevention of CBPP (or any other livestock disease) is the informed animal owner or manager. Cattle owners at all levels of production must be able to recognize CBPP and know what to do when they suspect it. This can only be achieved by intensive farmer training, using media that are easily understood, highly visual and that will serve as a constant reminder of the disease and its importance [21].

CBPP control is achieved by eliminating the whole cattle herd population, i.e. stamping out, wherever the disease is detected. However, this may not prove realistic and quarantine coupled with vaccination is the most frequently used CBPP control measure [43]. Lack of the necessary resources as well as resistance by cattle-owning populations preclude the use of massive culling as a control measure for CBPP in most countries and vaccination is usually regarded as the only alternative. Tylosin is quite effective for prophylactic treatment for controlling CBPP but the cost per head of cattle is much more expensive than the cost of vaccination. Hence vaccination is a more affordable alternative for farmers [41].

Vaccination: It is widely agreed that vaccination will play a central role in reducing the impact of CBPP in Africa and that it may be necessary to combine vaccination with therapy using approved antimicrobials. For this approach to succeed, a more effective vaccine than those currently available would be a great advantage [77].

The only commercial vaccines available are live attenuated vaccines using the T1/44 and T1sr strains. The former is more widely used, as it provides coverage for a year, while the duration of immunity of the T1sr vaccine is shorter. The latter has the advantage of inducing fewer adverse reactions and being unlikely to cause clinical disease, as sometimes occurs with T1/44, where especially first time vaccination may induce a Willems reaction that is sufficiently severe to require treatment [65].

Vaccination programmes as components of a CBPP eradication campaign must be comprehensively and consistently applied until there is evidence from disease surveillance that the disease has either apparently disappeared or at least the incidence has fallen to an extremely low level. The target areas for vaccination should include all but proven CBPP-free zones. In endemic regions, countrywide programmes are usually needed [21].

Live, attenuated CBPP vaccines are used. These may involve some compromise between inocuity and immunogenicity. Vaccine strains that are currently in use are T1-44 and T1-SR. T1-44 is currently the preferred vaccine in most countries. However, it has been criticized in some countries for causing excessive local reactions in vaccinated animals [76].

Status of Cbpp in Ethiopia: The irregularity and low rate of vaccinations since 1993 seem to contribute to the increased incidence of the disease and its further spread [78]. The usual blanket coverage was around 50% and never reached the desired 80-100% level. According to eleven years (1992-2002 G.C.) disease outbreak reports by Federal Ministry of Agriculture, several CBPP epidemics have been recorded from the south, south-west, west, north-west and north-east regions of the country (Table 2). The passive disease outbreak reports from 1992-2002 shows 587 outbreaks, 16,806 cases and 3,262 deaths. The highest record was in 1998 when 187 outbreaks with 5,652 cases and 1071 deaths were reported [79].

However, this data cannot be used to determine, the level and geographic feature of the disease, determine the importance of the disease, set priorities for the use of resources for disease control activities, plan, implement and monitor diseases control program, or demonstrate disease status to trading activities. Due to the insidious nature of the disease, such official data do not necessarily convey the extent of the problem caused by CBPP in Ethiopia [32].

The recent change in administrative structure and new management services at district level urges one to optimize local interventions (like vaccination). Therefore, prevalence and incidence studies are still required at such scale. However, the choice between appropriate interventions (preventive versus curative) guided by prevalence and incidence of the disease, should be compared in terms of the relative cost effectiveness of both the technologies [80].

Recent studies conducted in Western Ethiopia [81-82], Northwest Ethiopia [25], Southern Ethiopia [83] and different regions of the country [84] revealed that CBPP is posing a major threat to cattle in many parts of the country thereby causing considerable economic losses through morbidity and mortality and warranting for serious attention [85]. The cattle population at risk of CBPP and livestock production systems in CBPP endemic and epidemic zones of Ethiopia is estimated to be a total

Table 2: Prevalence of CBPP in some areas of Ethiopia

Area		Number of examined animals	Prevalence	Average prevalence	Sources
Western Ethiopia	West Wellega	651	48%	32.5%	[37]
	East Wellega and Illubabor	105	17%		
North Omo	Konso	240	35%	56%	[87]
	Derashe	263	78%		
Southern Ethiopia	Shashemene	955	6.07%	6.14%	[88]
	Arbaminch	595	6.21%		
North West Ethiopia	Awi	2073	27.3%	19.1%	[89]
	Western Gojjam	67	12%		
Borena	Liben	1014	6.8%	9.4%	[90]
	Dire	787	12%		
	Didatuyure	246	9.4%		
Western Wellega	Bodji	506	28%	28%	[61]
Somali	Shinille and Jijiga	793	39%	39%	[32]

Source: [91]

of 13,325,700 heads of cattle. All of them are considered to be at risk of CBPP, of which 5,510,700 are in endemic zones and 7,815,000 are in epidemic zones. Generally, based on the available information, the epidemiological situation of CBPP in various parts of Ethiopia can be summarized as follows [85]:

Western Ethiopia including Western Wollega and Assosa Zones: (and possible a part of Gambella Region) are considered endemic and epidemic Southern Ethiopia: (Southern Nation, Nationalities and People region, SNNPR). Borena Zone as a whole (Oromia Region), infected since long time, is an endemic area and characterized by pastoralism; South Omo, Konso Derashe and Amaro Zones (SNNP Region) are considered as endemic, with recent outbreaks in the neighboring Zones such as Bench Maji and North Omo Zones,

Gondar and Gojam Areas: Have declared numerous outbreaks since 1993 and South Gondar and West Gojam are categorized as epiendemic areas. West Gojam zone comprises of seven districts, namely Burie-Wonberma, Denbecha, Jabitenan, Dega-Damot, Quarit, Sekela and Achefer, of which the first two districts are considered CBPP endemic and the last four districts are considered CBPP free.

The highlands of North Shewa: Were considered as CBPP free, however, [86] reported sero-prevalence rate of 54% using CFT.

Southern Tigray: seems to be recently infected with sero-revealence rate of 50% reported in 1996 [86] and this can be categorized as epiendemic.

Agew Awi Zone: Comprises of four districts, namey Dangela, Ankesha-guagusa, Gungua and Banja-shikudad, of which the first three are considered as CBPP endemic and the last is with sporadic occurrence. Here mixed crop-livestock production system is practiced and the dominant livestock species are cattle (Table 1) [25].

North Eastern Ethiopia: Afar Region as a whole and Northern Somali Region may be considered as endemic, with recent outbreaks encroaching on the edge of endemic are in Southern Tigray, North Wello, North Shewa, East Shewa, (Amhara Region) and Arsi Zone (Oromia Region).

Eastern Ethiopia: In Somali Region except one zone, Shinille, which is considered to be CBPP epidemic zone, the status of the disease in all the other zones is unknown. Once introduced to a new area, initial losses in pastoral communities can be very high and its eradication is very difficult requiring major expenditure for control.

Economic Impact of CBPP: In the affected countries, enormous losses are experienced each year from the death of animals and the loss of production during convalescence. The highly fatal nature of the disease, the ease of spread and the difficulty of detecting carrier also

Table 3: Estimated losses in cattle and cattle products caused by CBPP

	Losses			
Country	Cattle death (no)	Beef (metric tones)	Milk (metric tones)	Drought power
B.Faso	1606	216	1312	365
Chad	3335	299	1927	506
Cote d'Ivior	930	83	537	141
Ethiopia	10112	1350	8500	1645
Ghana	474	64	387	108
Guinea	1395	188	1140	317
Kenya	3033	373	2316	494
Mali	2606	350	2129	593
Mauritania	556	75	476	126
Niger	785	106	672	179
Tanzania	4499	526	3527	641
Uganda	1542	180	1208	220
Total	30873	3810	24132	5335

Sources: [41]

mean that close restriction must be placed on the movement of animals from enzootic areas. The economic impact of CBPP is enormous resulting in heavy losses in cattle populations [92]. Over 100,000 cattle died within two years of the introduction of CBPP in to South Africa [19]. In the Netherlands nearly 65,000 cattle died of CBPP between 1833-1850 [48]. In the early 1860s when the disease spread rapidly throughout Australia, it behaved as a virulent epidemic with losses of up to 75% of animals in an affected herd amounting to 1.4 million head.

Consideration of the true costs of control and eradication of CBPP in central and southern Africa have been detailed recently [93]. Estimates provided by indicate that animal diseases cause losses of up to 30% of the annual livestock output in developing countries [94]. CBPP is considered as a disease of economic significance because of its ability to compromise food security through loss of protein and draft power, reduce output, increase production costs due to costs of disease control, disrupt livestock/product trade, inhibit sustained investment in livestock production and cause pain and suffering to animals [21, 95].

Mortality and Morbidity Losses: Mortality losses were estimated by applying the CBPP specific mortality rate to each class of cattle at risk. Cattle production in each of the countries considered involves large pastoral communities and the effective contact rate for pastoral transhumant production systems in East Africa was estimated [41]. Morbidity losses were considered as reductions in the productivity of milk, beef and draft power. The loss in milk was estimated from two components: reductions due to dead cows that no longer produce milk and reductions due to diseased milk cows that do not produce the same quantity of milk as before [96]. Based on expert opinion, infected milk cows were assumed to lose 90% of their milk during the entire lactation period.

[98] estimated the annual losses directly or indirectly attributable to CBPP to be around US$ 2 billion. For some countries, the losses can disrupt the entire livestock sub-sector and other economic sectors that depend on it. In Botswana, [98] estimated that a generalized outbreak of CBPP would result in a closure of its access to the European Union (EU) market and that the economy-wide effects of such closure would be a 60% decline in beef and other export products. In Nigeria, [99] reported economic losses due to CBPP of US$3.6 million. In the northern part of Nigeria, [100] estimated the direct economic cost of CBPP to be US$1.5 million of its economic cost.

Production Losses: In cattle and cattle products can be lowered by this disease. The total number of dead cattle in all twelve countries was estimated at about 30,873 head, giving an average of 2,573 head per country (range from 474 in Ghana to 10,112 in Ethiopia). The estimated total loss in beef and milk was 3,810 (318 MT per country) and 24,132 (2,011 MT per country) respectively. The former was obtained by multiplying the proportion of oxen in the herd by the number of oxen with clinical disease [41].

The loss in draft power was estimated at 445,000 workdays per country. The loss in draft power was estimated as the product of the number of infected oxen and the number of workdays per year. All physical losses in cattle, beef, milk and draft power were valued using market prices (FAO, 2004). Beef production loss by infected animals was used as a proxy for the absence of weight gain since diseased animals are assumed to not

Table 4: Estimated value of losses in cattle and cattle products caused by CBPP

	Value of losses (1000 Euros)				
Country	Cattle death	Beef	Milk	Animal power	Total
B.Faso	397	432	656	117	1601
Chad	824	598	164	162	2547
Coted' Ivoir	230	167	296	45	710
Ethiopia	2521	2700	4250	823	10294
Ghana	124	128	194	35	480
Guinea	344	375	570	102	1391
Kenya	867	933	1390	247	3437
Mali	643	701	1064	190	2598
Mauritania	137	149	238	40	565
Niger	194	211	336	57	798
Tanzania	1121	1051	1764	320	4258
Uganda	384	360	604	110	1454
Total	7786	7805	12299	2248	30136
Average	649	650	1025	1875	2511

Sources: [101-104]

gain weight. The loss in beef production was estimated from the number of infected cattle and not from the number of dead cattle [96, 54].

The total value of output loss incurred by all twelve countries was estimated at 30.1 million Euros, giving an average of 2.5 million Euros per country (Table 4). The value of output loss ranged from 0.5 million Euros for Ghana to 10.3 million Euros for Ethiopia. The losses due to morbidity (productivity reductions in beef, milk and draft power) accounted for 74% of the total value of loss while mortality losses accounted for 26%.

Economic Costs: Many governments in Africa were found to use public funds to carry out vaccination campaigns against CBPP [20]. The cost of CBPP control by vaccination in ten (10) African countries during the PARC period and found unit costs to vary from 0.27 Euros in Ethiopia to 0.71 Euros in Cote d'Ivoire with an average of 0.42 Euros was estimated [105]. And also [106] has stated that the cost of controlling CBPP using a regional mass vaccination program in countries of Central, Eastern and Western Africa to be quite high (Euros 300 million).

Conclusion and Recommendations: Contagious bovine pleuropneumonia (CBPP) is an insidious pneumonic disease of cattle sometimes referred to as lung sickness. It was identified as the second most important trans-boundary disease in Africa next to render pest which needs a major focus. CBPP is a disease that causes high morbidity and mortality losses to cattle. The major risk factors those responsible for the occurrence of the disease are host factors, pathogen factors and the type of husbandry or management system. The financial implications of these losses are of great significance to both cattle owners and to the nation. Moreover, CBPP has potential to be spread in to new areas that have been considered previously as free areas. Control of CBPP is therefore important as a way to salvage the losses and increase the incomes of cattle owners. CBPP constitutes a major disease problem, which justifies a specific internationally coordinated regional control programme at least for Africa. For these facts, the following recommendations were forwarded:

- A regular programme of mass vaccination and a proven treatment regime would have a major impact on prevalence, morbidity and mortality losses.
- Abattoir surveillance for CBPP lesions is a useful technique for the detection of CBPP
- Pertinent control measures to minimize the incidence of CBPP zonal and national levels are recommended.
- Comparison of serological tests, improvement of the national veterinary infrastructure and education of livestock owners should be carried out.
- Further study on the prevalence and distribution of the disease in the country are needed.

ACKNOWLEDGEMENTS

The authors are very much grateful to the inhabitants of all staff members of School of Veterinary Medicine, College of Medical and Health Science, Wollega University for provision of materials and necessary supports during our work. Next to that, our sincere appreciation is extended for all individuals that voluntarism to provide us with sufficient information to do our research.

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