Contagious Bovine Pleuropneumonia (CBPP) Post-Vaccinal Complication in Ethiopia

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ABSTRACT

In Ethiopia, immunization of cattle against contagious bovine pleuropneumonia (CBPP) has been practiced for the last 4 decades using vaccines prepared from streptomycin-resistant vaccine seed strain. Recently, a vaccine strain denominated T1/44 has been introduced to Ethiopia to prepare vaccine for filed use. A total of 296,248 cattle were vaccinated with vaccine produced from this seed strain in 3 different zones of Ethiopia. Post-vaccinal reaction affected the vaccinated animals with an overall attack rate of 1.02% (95% confidence interval, 1.0192–1.024) while the mortality and case-fatality rates were found to be 0.17% and 16.5%, respectively. The occurrence of the reaction was found to be significantly higher in Western Wellega zone ($P < 0.001$) than in the other 2 zones. Site of inoculation was shown to be the main predisposing factor in all 3 zones considered. The post-vaccinal reaction caused substantial economic loss and moral demotion to the resource-poor, livestock-owning community. Strict adherence to precautions and guidelines needs to be adopted in order to reduce the likely loss following mass vaccination.

INTRODUCTION

Contagious bovine pleuropneumonia (CBPP) is a contagious respiratory disease of cattle caused by *Mycoplasma mycoides* subsp. *mycoides* small-colony strain bovine biotype (Mmm-sc) of the class *Mollicutes*.[1] Under natural conditions, it affects only domestic ruminants of the genus *Bos* (ie, mainly *Bos indicus*). This respiratory disease is characterized by morbidity rates that could be as high as 75% to 90%. The mortality rate seems to vary from 50% to 90% while the case-fatality rate was found to be 50%.[2] In endemic areas, it assumes the following pattern: 13% of the animals develop the hyperacute form, 20% the acute form, and 4% the sub-acute form; approximately 21% of the animals are resistant.[3] This situation has also been realized in epizootic cases.[4]

Contagious bovine pleuropneumonia is an endemic disease in most African (and a few European) countries.[5] Even thought sufficient information is lacking on the epizootiology of CBPP in Ethiopia, it was thought to be a problem of lowland pastoral areas with incursion to the adjacent highland. However, the recent outbreaks in Addis Ababa and North Shewa (belonging to the Addis Ababa dairy shed)[6] obviates the risk it carries into the dairy sector in the near future. Thus, the economic impact that CBPP poses on the agricultural sector and national economy of the country is subtle.

For instance, Laval[6] reported that CBPP incurs a cost of more than ETB 205.6 million per annum in Ethiopia.

Contagious bovine pleuropneumonia had been eradicated from the U.S.A, Australia, and most European countries through implementation of policy of restriction of animal movement. It remains endemic in African countries where effective vaccination policy seems the only realistic method of choice for control of CBPP.

In Ethiopia, vaccination against CBPP has been carried out since 1964. Initially, broth culture-based vaccine prepared from KH3-J vaccine strain of Mmm-sc was used extensively during the years 1964–1968. In the later years (since 1969), a more stable freeze-dried vaccine prepared from the same strain was used. A need arose during the 1970's PARC (Pan African Rinderpest Campaign) program to combine CBPP and rinderpest vaccines in an attempt to eradicate rinderpest and possibly control CBPP. Hence, a streptomycin-resistant variant of KH3-J, KH3 J-SR, came into use until 1988 when it was replaced by T1-SR, that is, streptomycin-resistant vaccine strain T1 of the causative mycoplasma. In 1996, a streptomycin sensitive but more immunogenic variant of the vaccine strain T1 (denominated T1/44) was recommended by the Food and Agriculture Organization as the only vaccine strain of choice; T1-SR was constrained by lower potency and efficacy.[7] No CBPP vaccination campaign had been followed by post-vaccinal reaction in Ethiopia before introduction of T1/44 as the seed strain. However, immunization of animals with vaccine prepared from T1/44 has caused post-vaccinal complication in different regions. The objective of this paper was, therefore, to investigate the reaction and its impact on the livestock owners.

MATERIALS AND METHODS

Study Areas

The study was undertaken in 3 zones where vaccination with T1/44 has been carried out, namely Borana, South Omo and Western Wellega. In Borana zone, the vaccination was given in 4 districts. The mean annual temperature varies from 19° C to 25° C with moderate seasonal variation. The mean annual rainfall ranges from 250–700 mm with bimodal distribution. Pastoral livestock production is the main means of livestock for hundreds of thousands of individuals in Borana.

In Western Wellega zone, the vaccination was given in 2 districts. The area is characterized by humid and tropical climate with average annual rainfall of 2200 mm. The altitude range of the zone is 1000–2000 m above sea level with mean annual temperature ranging from 12° C to 28° C. Sedentary mixed crop-livestock farming is the dominant economic activity encountered across the zone.

In South Omo zone, the campaign covered 5 districts.The area is characterized by dry to sub-humid climate with mixed farming dominated by pastoral livestock production.

Study Animals

A total of 296,248 cattle vaccinated with CBPP vaccine derived from T1/44 during the campaign were the subject of the study. The cattle type reared in the Borana zone was the Borana breed (type). The dominant cattle breed (type) in Western Wellega zone was the Horro cattle. The cattle breed or type vaccinated in South Omo zone was the Muris cattle. All of the cattle breeds (types) included in the study belong to the African Zebu (*Bos indicus*) species.[8]

Vaccines and Their Management

Live attenuated CBPP vaccines in lyophilized form strain T1/44 were used during the campaigns. The vaccines were produced from a pan-African Veterinary vaccines center (PANVAC)-EMVT CBPP reference seed strain denominated T1/44/2 (batch pan 002) prepared at PANVAC, Debrezeit, Ethiopia, in June 1996 from original strain T1/44 (16/11/70, Kevevapi, Muguga, Kenya) with 2 passages in liquid medium.[7] A working seed lot denominated was prepared from the T1/44/2 (batch pan 002) in liquid medium and stored in lyophilized form. All batches of inoculants (production seed) and final products were prepared from this working seed with 2 additional passages in liquid medium. The batches of vaccines used during the campaign were PL2/97 in Borana, PL3/99 in Western Wellega, and PL8/99 in South Omo zones.

Data Collection and Analysis

Data concerning the post-vaccinal complications were obtained from preliminary filed observation and official source. The filed observation provided figures on attack rates, mortality and case-fatality rates, and costs of treatment of the affected animals, etc. The animals were inspected visually, and physical examination of the affected animals was undertaken. The diameter of swelling was measured using a ruler. Clinical findings encountered were recorded. The official sources of data were record books, case reports, and veterinary personnel. The confidence interval for attack rate, mortality and case-fatality rates, and chi-square values were calculated using standard epidemiological methods,[9] while cost analysis assisted with the post-vaccinal reaction was estimated based on the average local price of each class of animals and average cost of treatment offered to affected animals.

RESULTS

Clinical Findings

The preponderant clinical findings were circumscribe swelling at the site of inoculation (swelling at site was thick and painful) that became firm and necrotic after sloughing of the skin or led to abscess due to secondary bacterial infection. In some animals, the swelling was extensive, covering the whole neck area and extending down to the fore limbs and dewlaps, and followed by death. The severely affected animals were febrile (40° C to 41° C).

Their visible mucous membranes were hyperemic. Inappetence and loss of body weight were common sequelae. The mean time for the development of the swelling was 3–21 days post-inoculation in both Borana and South Omo zones. In affected areas of Western Wellega zone, the reaction developed within 10–12 days post-immunization even though few animals developed lesions 3 months later. The average size of the circumscribed swelling was 5–20 cm in diameter. Bigger swellings, which were as large as 40 cm in diameter, however, were seen in animals from South Omo zone. Treatment with antibiotics (especially oxytetracyclins) resulted in recovery in most of timely treated cases. The complication took about 14 days to abate unless it culminated in death or exacerbated with secondary bacterial infection.

Occurrence of the Reaction

A total of 296,248 cattle (176,750, 81,788, and 37,710 in Borana, South Omo, and Western Wellega, respectively) were vaccinated. Among those vaccinated, a total of 3,010 cattle (413, 1120, and 1477 cattle in Borana, South Omo, and Western Wellega, respectively) developed post-vaccinal reaction (Table 1). The overall attack rate was 1.02% (95% confidence interval [CI], 1.0192–1.024) while the mortality and case-fatality rate were 0.17% and 16.5%, respectively. The post-vaccinal reaction attack rate was 0.23%, 1.37%, and 3.91% in Borana, South Omo, and Western Wellega zones, respectively. The highest case-fatality rate (19.2% with 95% CI of 19.196–19.204) was observed in West Wellega zone (Table 1) while the lowest rate was recorded in Borana zone.

The attack rate and the mortality and case-fatality rates were significantly higher ($P < 0.001$) in West Wellega zone than the 2 remaining zones. Within each zone, the occurrence of the reaction with associated mortality and case-fatality rates varied greatly among different districts (Table 2).

The highest case-fatality rate (35.8% with 95% CI of 35.812–35.828) was recorded in Kuraz district of South Omo zone.

Table 1. Attack Rates and Mortality and Case-Fatality Rates Due to Post-Vaccinal Reaction in the Zones Investigated.

	Areas Studied				
	Western Borana	South Wellega	Omo	Total	
Vaccinated population	176,750	37,710	81,788	296,248	
Number affected	413	1477	1120	3010	
Number died	41	283	173	497	
Attack rate (%)	0.23	3.91	1.37	1.02	χ^2 = 4331.47
Mortality rate (%)	0.023	0.75	0.21	0.17	χ^2 = 994.256
Case-fatality rate (%)	9.9	19.2	15.4	16.5	χ^2 = 21.43

Table 2. The Attack Rate and Mortality and Case-Fatality Rates Due to Post-Vaccinal Reaction in Victimized Districts.

Zone	District	No. Vaccinated	No. Affected	No. Died	Attack Rate (%)	Mortality (%)	Case-Fatality
South Omo	Bona Tsemai	31,681	266	41	0.84	0.13	15.4
	Sala Mago	10,000	383	57	3.83	0.57	14.9
	Bako Ghazar	12,000	40	2	0.33	0.017	5.00
	Kuraz	15,600	201	72	1.9	0.46	35.82
	Hamar	12,507	231	1	1.84	0.008	0.43
Borana	Dirre	30,720	66	14	0.21	0.045	21.2
	Yabello	41,850	133	4	0.32	0.0096	3
	Teltele	27,200	68	7	0.25	0.025	10.3
	Arero	76,980	146	16	0.19	0.02	11
Western Wellega	Manasibu	26,360	887	135	3.4	0.51	15.2
	Laloasabi	11,350	590	148	5.2	1.3	25.1

Similar higher rates were encountered in Dirre and Laloasbi districts of Borana and West Wellega zones, respectively.

Associated Economic Loss

A total of 3,010 cattle have succumbed to illness due to post-vaccinal complication. Among these diseased cattle, 497 have died. The price of each age group and sex group of cattle affected was not available from Borana and South Omo zones for indicated periods. Taking the average price of cattle from West Wellaga zone, one can estimate the loss due to direct mortality. On top of direct economic loss arising from cattle death and cost of treatment, there had been a significant depression of production (mainly milk production), traction power, manure out, body weight, etc. A direct economic loss amounting to ETB 318,151.48 (Table 3) has resulted.

DISCUSSION

The clinical findings encountered in affected animals were typical features of CBPP post-vaccinal reaction and inconsistent with results of other studies.[2,10,11] Contagious bovine pleuropneumonia post-vaccinal reaction (termed Willem's reaction) has been well documented since the mid-19th century.[11] Therefore, the complication encountered during the vaccination campaigns was the classical Willem's reactions.

The attack rate and mortality and case-fatality rates were significantly ($P < 0.001$) higher in Western Wellega zone. This difference was due to the difference in breeds

Table 3. Direct Economic Loss Due to CBPP Post-Vaccinal Reaction in the Affected Zones.

No.	Types of Cost	Data Used for Calculation	Western Wellega	South Omo	Borana
1	Mortality	• Price of cattle per age/sex at Mendi and Inango markets • Mortality rate in vaccinated animals per age/sex	ETB 145,030	ETB 89,288.76	ETB 21,160.92
2	Treatment costs	• The population of affected cattle • Average cost per treated animal (16.7 birr per animal)	ETB 24,665.90	ETB 18,704	ETB 6,897.10
3	Other costs	• Fuels & lubricants per diem	ETB 12 354.80	Not available	Not available
4	Total		**ETB 318,151.48**		

of cattle in the respective areas. That is, the Horro breeds of Western Wellega zone were found to be more susceptible than the other 2 breeds of cattle. The variation in sensitivity between different breeds of cattle to the CBPP post-vaccinal reaction has been described previously.[10,11] The highest case-fatality rate (19.2% with 95% CI of 19.196–19.204) observed in West Wellega zone showed that the breeds of cattle reared in this area are more sensitive to the complication than the other breeds. They are more likely to die from the attack of the complication. This difference could be confounded by the inferior body condition resulting from malnutrition. In Western Wellega zone, particularly in the affected districts, there was extensive and severe termite infestation and degradation of rangeland. As a result, animals in the area were undernourished due to range biomass reduction and almost all were highly emaciated and debilitated. The lower mortality rate in Borana also could be due to the timely treatment of the affected animals with antibiotics; 93% of the affected cattle were recovered after receiving antibiotic treatment.

Despite the use of vaccines of the same batch derived from the same seed strain, the incidence of the reaction with associated mortality and case-fatality rates varied greatly among different districts within the zone where the cattle population was more or less homogenous (the same breed). This variation was due to difference in sensitivity to the complication among herds and individuals of the same breed. Such individual and within-herd variations will be a hindrance to a vaccination campaign because of possible unpredictable reactions and consequent mortalities. Within-herd difference in susceptibility to CBPP post-vaccinal reaction has been documented.[7,10]

In eastern and southern African countries where T1/44 has been used for the last 3 decades as vaccine seed strain, post-vaccinal reaction of 1/10,000 (0.0001%) was recorded. In Namibia, where strict subcutaneous route was used over the 11th rib, mortality due to post-vaccinal complication was found to be 6 out 500,000, which is equivalent to 0.0012%.[12] The occurrence of the complication in fewer woredas of South Omo and Borana zones were closer to this figure, though the incidences of the reaction as well as the mortality and case-fatality rates recorded in this observation seem higher than the previous reports. One factor, which could contribute to this variation, is the site and route of administration of the vaccine. Vaccines for CBPP (prepared from T1/44) should be administrated strictly into subcutaneous tissues. Infiltration and injection into intramuscular tissues will increase the probability of occurrence of Willem's reaction and result in death. This case was seen in South Omo zone where post-mortem examination of dead cattle revealed intramuscular inflammatory infiltration and swelling, which indicates that the vaccine was inoculated intramuscularly. In all 3 zones, the most common site of inoculation was the cervical tissue (one of the forbidden sites for CBPP vaccine administration).[10] Cervical tissues have greater sensitivity to T1/44 vaccines and are not a recommended area for delivery. On top of their sensitivity, the close existence of the skin and muscular tissues of the neck region allows easy infiltration into the intramuscular tissues. For practicality, subcutaneous tissue behind the shoulder blade over the 11th rib is a recommended site for field use. Besides reducing the possibility of mortality following post-vaccinal reaction, inoculation at this site has no negative impact on the future use of draft oxen. Tissues over the neck area become necrotized, dry, and friable as a result of which draft oxen fail to pull implements for farmland preparation.

Strict adherence to the use of sharp needles with indicated gauge size and length is important to minimize the incidence of the reaction. It is crucial to switch the needles after inoculations of every 10–20 cattle, and the used needles should be washed, sterilized in boiling water, and dipped in ethyl alcohol (as ethyl alcohol has no effect on Mmm-sc).[11] Only freshly opened, sterile, disposable needles should be used to withdraw vaccine from bottle. This needle should not be used to inoculate cattle. Failure to respect these procedures can cause contamination of the vaccine and inoculation of contaminants into animals. In all the investigated areas, these procedures were not respected. Hence abscesses due to secondary bacterial complication aggravated the situation of the reaction. In the absence of these precautions, T1/44 strains caused post-vaccinal reactions, which could affect 2% to 3% of the vaccinated animals.[10]

Under normal conditions, CBPP vaccines need to be delivered to healthy animals. This situation, however, is difficult to attain at the field level leading to only partial vaccination in heavily contaminated herds. Normally, some group of animals become carriers, while certain proportions could be incubating the disease[4]; in both cases, the post-vaccinal reaction is expected to be severe. All 3 areas considered in this investigation are CBPP endemic areas where both carriers and incubating animals were likely to be vaccinated. Moreover, both South Omo and Western Wellega zones are endemic areas for precarious diseases like trypanosomosis and piroplasmosis, which could exacerbate the situation of post-vaccinal reaction.

As a result of the occurrence of post-vaccinal reactions, the planned vaccination campaign has been discontinued. Hence, of the stipulated 1,000,000 Borna cattle, only 549,068 (55%) were vaccinated. Similarly, only 3% and 19.8% of cattle were immunized before interruption of the campaign in Western Wellega and South Omo zones, respectively. This led to continuance of outbreaks of CBPP that attacked thousands of animals. This is particularity true in Western Wellega zone where active outbreaks are seen in different districts. Since the complication was strange for the livestock owners, they became suspicious and reluctant to get their animals vaccinated against other endemic and epidemic diseases. In addition to losing their confidence on the veterinary services, the farmers refused to have their children immunized against different human diseases. Generally, the attitudes of the livestock owners towards the veterinary services and other extension or development interventions have been negatively affected. There are even a few farmers who have become completely destitute, owing to the death of all their cattle.

Even though data are lacking on the estimate of the price of each category of animals that died in Borana and South Omo zones, the loss entailed due to the post-vaccinal complication was desperate. It caused food insecurity at the household level though its impact at the zonal or national level seems insignificant relative to the impact of the outbreaks.

Due to unavailability of certain data like age and sex and price of each age group and sex group of cattle during the period when the complication arose, one must be aware that the result of economic loss in this investigation lacks precision. Therefore, the same average cattle price obtained from Western Wellega zone was considered for all 3 zones. Certain production losses were difficult to express in monetary value because of the lack of methods to do so. These included traction power (the major production loss in the agro-pastoral areas of South Omo zone and Western Wellega zone) and others like abortion and body weight loss. Owing to these constraints, the economic impact that the post-vaccinal complication posed on the livestock owners was underestimated.

The relative efficacy of vaccine produced from T1/44 made it the seed strain of choice to continue to use in combating this rampant disease. Thus, adherence to all precautions during manufacture and field use is highly recommended.

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