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Study on the Epidemiological and Financial Impacts of Clinical Lumpy Skin Disease in Selected Districts of Tigray and Afar Regional States, North Eastern Ethiopia

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Abstract
Lumpy skin disease (LSD) is one of cattle diseases in small holder farmers and livestock industries. A study was carried out between October 2011 and February 2012 in selected districts of Afar and Tigray regional states to assess financial impacts of lumpy skin disease and benefits obtained from control interventions. Structured questionnaires were used to collect data on the epidemiological variables and production losses of the disease. Purposive sampling was used to select households who experienced the LSD during the last one year in their respective herds, and willingness of the livestock owners to participate in the study. Financial estimation was done in four study districts which consist of 15 kebeles where clinical LSD affected herds were reported. A total of 267 questionnaires were administered to the herd owners which owned totally 3442 animals and out of which 379 animals were affected by LSD. The cumulative incidence and mortality rate of LSD were found to be 11% (95% CI: 0.99-12) and 2 % (95% CI: 1.5-2.3), respectively. The percentage of production losses associated with the disease was estimated to be 3.26%, 2.52%, and 1.2% for milk loss, draft power loss and beef loss, respectively. The production losses per head of cattle were 11USD and the net benefit of the control through annual vaccination per head was 4USD. Thus, the herd owners should use annual vaccination against LSD in order to sustain and secure their production and productivity.
Keywords; Cattle, Lumpy skin disease**,** cumulative incidence, financial estimation, Ethiopia

1. Introduction

Lumpy skin disease (LSD) is among the most economically significant viral diseases caused by Neethling virus prototype strain classified in the genus *Capripoxvirus* of family *Poxviridae* (CFSPH, 2008; OIE, 2010). This strain is antigenically and serologically indistinguishable from strains causing sheep pox and goat pox but distinct at genetic level. The disease is acute to subacute infectious disease (CFSPH, 2008) and cattle strain of capripoxvirus do not infect and transmit between sheep and goats (OIE, 2010).

The disease occurs in different ecological and climatic zones and extends its boundaries to different areas (Davies, 1991). It is currently endemic in most African countries and expanded to Middle East region (Tuppurinen and Oura, 2012). The disease has high morbidity and low mortality rate and affects cattle of all age groups and breeds causing high economic losses as a result of reduced milk production, beef loss and draft power loss, abortion, infertility, loss of condition and damage to the hide (Green,1959; CFSPH, 2008). It becomes an important threat to beef and dairy industry (Kumar, 2011) and it is transboundary disease, causes international ban on the trade of livestock and their products (www.merckbooks.com).

Quantitative epidemiological investigations that compute prevalence and incidence of a particular disease is important to estimate magnitude of economic damage, work load, costs and required facilities to control diseases (Pfeiffer, 2002). Thus, knowledge on incidence of LSD and risk factors associated with disease are important for mitigations of outbreaks and associated economic loss. This enables optimum utilization of animals for farmers' and livestock industry owners (Gari *et al.*, 2011). The financial losses associated with occurrence of animal disease could exert high economic burden to households and to the nation. Such losses should be quantified to make decisions and apply control programs depending on the feasibility of the control programs (Morris, 1999).

In Ethiopia, few works have been reported in selected areas of the country on the financial impact of LSD (Gari *et al.*, 2011). Recently, a report on seroprevalence of disease indicated that the disease is widely distributed across the country and increases its impacts (Gari *et al.*, 2012). Though there were frequent outbreak reports of the disease in North Eastern part of Ethiopia, its epidemiology and financial loss were not determined. Therefore, the present study aims to provide baseline information on the epidemiological aspects, financial impacts of the diseases and financial benefits obtained from control of the diseases from livestock producers' perspectives in extensive farming system.

2. Materials and Methods

2.1. Description of the Study Areas

The study was conducted in Afar and Tigray regional states, north eastern Ethiopia. Afar is one of the pastoral areas in Ethiopia and has five administrative zones consisting of 32 districts (Piguet, 2001). It is located at 8°40˙ to 14°47˙ North latitude and 39° 51˙ to 42° 23˙ East longitude with altitude ranges from 150 meter below sea level to 1000 meter above sea level. Mean annual rainfall ranges 225.3 mm to 561 mm and disruptions of rainfall affects availability of pasture and water. Mean minimum and maximum annual temperature ranges between 18^0C and 35^0C (Piguet, 2001; CSA, 2008). Peoples' livelihood in the region mainly relies on pastoral (90%) and agro pastoral (10%) production system. Seasonal movements of the herds are routinely practiced in the region in search of pasture and water (Philpott *et al*., 2005). Two zones (Zone-1 and Zone-4) were included in the study with one district from each zone (Asiyta and Yallo) respectively (Philpott *et al*., 2005).

Tigray was the other study region located in the most northern part of Ethiopia. It extends from 120° 13' to 140° 54' N and 36° 27' to 40° 18' E. It has five Administrative Zones and the study was carried out in Southern zone of the region, located at 600 km north of Addis. The zone located at 12^o 15' to 13^o 41' North latitude and 38^o 59' to 39^o 54'East longitude, having an area of 9446km^2. It shares border with south eastern Tigray zone in the north, Amhara regional state from the south and west, Afar Regional state from the east. Five districts are available in the zone and two of them were included in study: Ofla and Alamata (Tigray livelihood report, 2005). These districts share similar farming system, practicing mixed crop livestock production system with varying agro ecology: Ofla is from the highland area and Alamata is in lowland. There is high livestock potential in the area and used for several purposes (Tigray livelihood report, 2005; CSA, 2007; REST, 2007). The two regions share many characters; having similar breed of cattle, camel and other livestock and keeping cattle for draught, milk supply, and meat and for consumption and cash source. They also share markets and there is uncontrolled movement of animals among these areas during the rainy season (Philpott *et al*., 2005). There is high risk of disease transmission from one place to another during these times when animals intermingle in grazing and watering areas. Major diseases frequently reported as economically important are pasteurellosis, blackleg, anthrax, foot and mouth disease (FMD), and LSD.

2.2. Study Population and Farming System

The target cattle population in the selected four districts was estimated to be 299,959 heads of cattle out of which Asiyta (80,130), Yallo (36,113), Alamata (110,102) and Ofla (73,614) were recorded for each district which were found in various agro climatic conditions. Generally these animals were with different vaccination history, physiological and production state, grazing under extensive production system; utilize communal grazing and watering points. Animals from pastoral areas in particular are subjected for seasonal mobility for search of pasture and water, but herds from the mixed farming system feed on crop residues during the dry season.

2.3. Study Design and Methodology

2.3.1. Study Design

A questionnaire survey was employed in cross sectional study between October 2011 and January 2012 to assess the financial impacts of lumpy skin disease at household level from farmers' perspective using structured questionnaire survey (Stevenson, 2005). The study approach was based on the symptomatic identification of the clinically observed LSD by herd owners that were asked to describe the clinical symptoms of the disease and cross checked for differential diagnosis with the other skin problems and these commonly occurred skin diseases in the study areas were taken in to consideration for the purpose of differential diagnosis from the epidemiological records of the district veterinary clinic and animals were taken as clinically affected animals as described in Radostits *et al*. (2006) from the herds considered in study of financial assessment. The study was conducted in four selected districts of Afar and Tigray regional states. The time horizon of the financial impact assessment was one year production cycle between December 2010 and November 2011 in the study districts. The benefit obtained from the control intervention of the disease by annual vaccination was calculated using partial budget analysis. Questionnaire was administered to the herd owners by face to face interview. The data obtained from the survey of the households were supported by the secondary data from the respective districts of the study areas, local markets and from CSA (2011) to compare the base line production parameters of the normal herd with the herds that were affected with LSD (Dohoo, 2003;CSA, 2011).

2.3.2. Sampling Technique and Field Data Collection

Hierarchal selection was done from region to district purposively based on livestock population, outbreak reports; inter-regional movement of animals for pasture, water search and trade activity, geographical location and access of transport as well as population with different farming systems. From selected districts, kebele and households and their respective herds were selected purposively based on the experience of the herd owners for the occurrence of the disease in their herd within one year production cycle. Here household was the final sampling units of the study and in this study, herd is defined as the collection of different age and sex groups of cattle owned by a single farmer or family members. From the selected districts, 12 kebeles from Asiyta, Alamata and Ofla, 4 kebeles from each district and 3 kebeles from Yallo, a total of 15 kebeles was selected with an average of 18 households or herds from each kebeles was collected with different herd size. However, herds that did not exposed to the disease and herd owners not voluntary to participate in the study were excluded from the study.

2.3.3. Data Collection

Collection of both primary and secondary data was carried out during the study period of the financial impacts of clinical LSD. Collection of primary data was undertaken using structured and pretested questionnaire. Data related to the beef, milk production and the average working days of the draft power were collected from the farmers and from the ministry of agriculture livestock development and local markets of respective districts. Accordingly, from the four purposively selected districts (Ofla, Alamata, Yallo and Asiyta) 15 kebeles with 267 total herds which consists of 379 clinically affected animals from the total 3442 heads were collected. These herds with these individual animals were the number of animals during the occurrence of the disease.

2.3.4. Questionnaire Survey

The questionnaire was designed based on literatures, published questionnaires and in consultation with experts on disease and previous knowledge of the study areas (Dohoo, 2003).

2.4.5. Lumpy Skin Disease Outbreak and Financial Loss Estimation at Household Level

Descriptive statistics was used to calculate cumulative incidence, mortality and case fatality rates of affected animals. This data was collected from surveyed households and these results were computed based on the formula set by Thrustfield (2007). Responses of herd owners about severity of the disease at herd level were ranked as mild, moderate and severe.This was done based on the number of animals affected and intensity of lesions. Confidence intervals of cumulative incidence, mortality rate, and case fatality were computed using the Excel spread sheet Microsoft, 2007.

Financial losses as a result of clinical LSD were assessed based on a one year production cycle and from livestock owners' perspectives. Model was developed to estimate costs of disease associated with morbidity, mortality and control expenditures that considers these costs as direct and indirect one (Rushton, 2009). Vaccine was given free of charge to farmers but it was considered in the model as the governmental offices bought it from privatized enterprises. The production parameters of local zebu cattle without LSD were obtained from CSA (2011) base line data. Farm outputs considered in the model were milk, beef production and draft working output. Epidemiological variables such as population at risk in the study group, total annual cumulative incidence, mortality rate and case fatality rate were used as the basis for financial loss estimation.

Considering production parameters and epidemiological variables obtained from the study, model was developed in a Microsoft Excel spread sheet 2007 which was mathematically represented as follows: $\mathbf{T_L = A + B_1 + B_2 + B_3 + C_1 + C_2}$. Where T_L=Total loss associated with the disease, A= Loss associated with mortality, B_1=Milk loss, B_2= Beef loss, B_3= Draft work output loss, C_1= treatment costs, C_2= opportunity labor cost. Mortality rate was calculated as; A=P*Qi*U where P=Population at risk, Qi=Proportion of mortality rate, U= Weighted average price of the animal. To compute the morbidity losses of milk, beef and draft work output lost; B=P*I*Q*U would be used where B= the total morbidity loss, I=cumulative incidence, Q=Quantity of disease losses and the rest were similar with above quantities. The costs incurred by the disease were calculated as C1 = P*It*Q*Utv; where C1= represents the total cost as to the disease, It= totals sick animals getting treated and Utv = cost of treatment and vaccination.

Percentage of the production loss of the beef, milk and draught output was computed annually as used by Getachew *et al.* (2011). This was a reduction in outputs attributable to the presence LSD as compared to its absence. The annual productions considered here were quantities of milk production per lactation, draft output in days, off-take rates of beefs. These production parameters in the presence of LSD were accounted as a numerator and in the absence of LSD as denominator.

$$Annualpercentageloss = \frac{AnnualproductionlossattributabletoLSD}{TotalannualproductioninabsenceofLSD} * 100$$

To calculate the percentage loss of milk production, lactating cows with LSD, annual cumulative incidence of LSD in female animals and lactating cows in the defined time period were taken from the questionnaire survey. The value of milk loss was estimated based on milk prices collected during the survey. Lactating cows died of during the course of the disease were not considered to avoid double consideration in financial analysis. Annual milk production loss and average lactation length subject to milk loss was estimated in the LSD sick and surviving lactating cows. The duration of the milk production loss in sick lactating cow varied with the severity and chronic nature of the disease as it remains 2-6 months to recover and average 50 days were taken in local zebu (Davies, 1991). The average milk-off take per lactation without LSD in the local zebu were also considered as 180 days and data of average milk off take per lactation were taken from CSA (2011).

$$Annualpercentagemilkloss = \frac{NumberofLSDcontractedlactatingcows * 50days}{Numberoftotallactatingcows * 180} * 100$$

When survey was carried out in the study areas, information was collected about effect of the LSD on the draught power oxen. Estimation of the draught loss of the oxen in the year was undertaken during seasons of high and low drafting activity of the year. Costs of draft power output service was calculated by taking the average number of days between the active and passive seasons of the year. The active season of the year in the study areas considered here was March to June. This is the cropping seasons at which workload of the draught oxen and their corresponding demand was high. The rest of the months were considered as seasons at which draught oxen were no more functional. The average annual work load for draught animals were taken as 60 days, considering religions of the society particularly the Orthodox Church (Tegegn, 1998). Draught service of oxen was high during the cropping season and relatively low during the other seasons. Weighted average prices of the service prices were taken during the survey. An average of fifteen days was taken as annual draught power loss of effects of LSD on the draft oxen. Percentage losses of draught power were calculated from the average number of work output losses annually as to LSD divided by the total expected annual output in the study population.

$$Annlpercentagelossofdraftworkoutput = \frac{No.ofdiseaseddraftoxen * 20days}{No.draftoxen * 60days} * 100$$

Beef off take rate were the proportion of animals' solid, consumed, slaughtered or used for other social purposes rather than as a result of impacts of the diseases in one year production cycle. Beef production loss as a result of LSD was estimated annually as the reduction in output of the percentage off-take rate in the study groups and the total incidence risk of the disease was taken in to account. Beef production without the disease was taken from the Ethiopian ministry of agriculture and rural development livestock development master plan of (2007) which is ranged 7-9 % an average of 8% was taken. The costs of the beef loss were computed from the weighted average prices of the cattle which were obtained from local market price data.

Financial losses associated with the mortality, treatment costs and labor opportunity costs were computed based on the collected weighted average prices. The losses associated with the cumulative mortality were estimated from the weighted average prices for each age group collected during the study period. In the present study mortality due to LSD was calculated based on the weighted average price of cattle for each category of age groups; calves, bull/heifer and adults animals that died of LSD. Treatment costs were costs incurred for prevention of further complication of the diseases for those who brought their animals to clinic. Opportunity labor cost computed here considers the herd owners who care their animals and brought to veterinary clinic to take the recommended prescriptions. The average weighted market prices of the various age and sex groups data was compared from the household's survey, local trader's questionnaire sample survey, and the prices observation taken by the district agricultural office on market day from the four primary markets of the four districts.

The weighted average prices collected were categorized in to three age groups as the price of calves, heifers and bulls and prices of adults. These three prices were summed up and averaged out to the minimum, average and maximum values for the use of beef production losses. The prices of the livestock products such as the price of milk per liter and meat per kg were obtained from the corresponding districts cafes and butchers and this was averaged out as maximum, minimum and average values as indicated in Table 1. Production losses and cost estimation were done using Excel spread sheet. Chi-square test was used to compute the probability value (p-value) and significance differences. Cost estimation model for loss due to disease was assessed using sensitivity analysis performed by regression coefficient in @Risk 5.7 (Palisade Corporation) implemented on the excel spread sheet by model assigning triangular distributions to the variables as minimum, the average value as most likely and maximum values.

Partial Budget Analysis: Financial Benefit of LSD Control

The partial budget analysis in livestock diseases compares economic cost of the diseases to benefits obtained from control interventions (Rushton, 2009). In this case, the econometric analytical method compares financial benefit of LSD control using vaccines to its cost at farm and household level in traditional farming system. Annual control projects to be advantageous, benefits obtained from control of the diseases must be greater than the costs of control intervention of the disease. In this study, partial budget analysis of control of LSD did not consider variable and fixed costs. Variables used financial loss assessment of the study groups were also applied to the partial budget analysis of target population. The prevalence obtained at individual animal level from previous study of risk factor assessment was 7.4% and this was considered as endemic disease hence inference to target population (Hailu *et al*., 2014). Cost estimation was based on the control of the disease to reduce the losses associated with the prevalence of disease. Target population of the study districts were shown in Table 2.

Vaccines given against LSD under extensive farming system was given to the farmers free of charge though vaccines were bought from private enterprise. The dose of the vaccine solid to private farmers was 0.4

cents/dose (0.0229USD). Opportunity labor costs that the herd owner would spend to vaccinate his or her animal was not taken into account because animals were vaccinated by campaign in the given kebele and this is cheap labor cost to bring animals to the nearby kebele. The benefit of LSD control was calculated as the sum of the production output that would be saved from being lost as result of the disease in target population and the treatment cost saved. Finally the farm output considered in the model were milk, beef production and the draft work output and the model was developed in excel spread sheet Microsoft2007. Cost break down involved in the partial budget analysis was estimated based on the following variables.

I. New (extra) cost= cost of LSD vaccine

Cost of vaccination= Population at risk of developing LSD*cost of LSD vaccine/head

II. New Revenue= (Prevented milk loss+ Prevented draught power loss + Prevented beef off take reduction+ Prevented mortality losses).

The parameters considered to estimate production increase in the target population as a result of disease control were calculated based on a previous data that showed LSD prevalence in the target population.

III) Saved cost of treatment= population at risk of developing LSD*Prevalence of LSD*%LSD treated cases* average treatment price/head (Gari *et al*., 2011).

Net Benefit= (III+II)-I

The benefit/cost ratio (BCR) is calculated by dividing the sum of the present value of benefits by the sum of the present value of costs.

BCR = $\dfrac{\sum_{t-1}^{n} \dfrac{B_t}{(1+i)^t}}{\sum_{t-1}^{n} \dfrac{C_t}{(1+i)^t}}$ which is equivalent to $\dfrac{B_t}{C_t}$. So, an intervention would be recommended or vaccination campaign would be beneficiary if the *BCR* is greater than 1(Putt *et al*., 1998; Rushton, 2009) and decision is made on the feasibility of disease control programme based on this ratio. Introduction of vaccination and its benefits could also be assessed using marginal rate of return (MRR) obtained from the change (Legesse *et at*., 2005). MRR measures the increase in net benefit (ΔNB) associated with each additional investment in a new technology. It is calculated as a net benefit (ΔNB) divided by the total cost that varies (ΔTCV) only by using the new technology. $MRR = \dfrac{\Delta NB}{\Delta TCV}$ This value is more or less similar to that of the benefit cost ratio.

3. Results

From surveyed households for LSD, 267 herd owners were participated in the study, 67 % of them declared that LSD affected their herd severely and the rest (33%) declared moderately affected based on the number of affected animals in the herd and severity of the lesion. About 50% of the herd owners were brought their animals to the nearby veterinary clinic for treatment. Out of the investigated 3442 heads of cattle in the study districts, 379 animals were affected with the clinical disease and 66 were died during the course of the disease. The production parameters of the study population in the absence LSD specific to selected study areas were obtained from CSA (2011) in Table 3.

About 67 % of the sex composition of the study herds were females and the rest 33% were males which might be as a result of farming system of pastoralists that mainly kept female animals for the purpose of reproduction and milk production but for the age category, the proportion of adult females (36%) and males (22 %) were dominating the herd composition followed by calves as shown in Table 3. Among the 379 affected animals from the four districts, 34% of them were male animals and the rest 66% were females. From the male animals, the adult draft animals were dominant (48%) followed by 32% bulls. Among the female animals 39% of them were lactating cows and the rest 27 % and 26 % were heifers and dry cows as indicated Table 4.

The annual cumulative incidence and cumulative mortality calculated for the study groups were 11% (95% CI: 10-12) and 2% (95% CI: 1-2) respectively but the annual cumulative incidences in males and females were similar but risk incidence in bulls and heifers were higher 15% (95% CI: 12-17) than adults 12% (95% CI: 10-13) and it was significantly different ($p<0.05$) as shown in Table 5. Mortality rate in age groups were significantly high in calves 3.4% (95% CI: 2-4) than in heifers and bulls. The total case fatality rate was 17% (95% CI: 13-22) and case fatality rate in the sex category was higher in males 26.4% (95% CI: 18-35) than in females 12.8% (95% CI: 8-17). Comparison among age groups show that the bulls and heifers 62.5% (95%CI: 48-77) were found to be significantly affected with the case fatality than the calves 20.5% (95% CI: 6-34) and adults 7.9 % (95% CI: 4-12) as shown in Table 5.

The average net milk production in the study group is 2 liter CSA (2011) and the annual cumulative incidence of the lactating cows was 11.7%. The average percentage loss of milk in all study districts was 3.26 % (95%CI: 3.16-3.35). The average days the cow felt sick and assumes loss of milk production was 50 days, and the cumulative incidence of LSD in the lactating animals was (11.7%). Thus, the average total milk loss in all the study districts was approximately 9173 liters with the weighted average costs of 5,752.85 USD.

The annual off take rate reduction of beef production was computed as the decreasing of the off take rate of the study population caused by the incidence of lumpy skin disease. The percentage annual beef production loss was estimated to be 1.2% (95% CI: 0-6) which was reduction in off take rate for the local breeds. This beef loss was estimated by the multiplication of 0.08 with the total study groups and cumulative incidence of the study group (11%). Finally using the weighted average prices, average financial loss was 7,948.04 USD. The number of died animals were deducted to avoid double counting.

The average duration of draft power output loss was estimated to be 20 days per year for draft ox that had been sick by LSD and the estimated percentage loss was 2.56% (95 CI:2.4-2.7). The average loss of the draught power in sedentary areas was 4,102.21 USD and this was because the farmers in these areas keep livestock primarily for the purpose of draught power for crop production. The draft power output loss either for self service or rent was accounted for the average 5,743.10 USD. Died draught oxen were deducted while estimating draft power loss for avoiding double considerations.

An average weighted price of died animals were 16,502.86 USD. The expenditure incurred for the treatment of the sick animals as well as the opportunity costs for the labor were calculated based on the information obtained from the district veterinary officer but vaccination was provided free of charge for the households. Opportunity Labor cost was estimated from the percentage of farmers who brought their sick animals to the clinic. From the questionnaire 20% of the pastoralists and 80% of the sedentary farmers from mixed farming system were brought their animals to the nearby veterinary clinic. This, the average percentage of the animals brought to clinic in these study areas were 50% and an average of three days were assumed for nursing the sick animals during the course of treatment. Hence, 190 patient animals were treated by 50 % of the herd owners. The casual labor cost of 2.01USD per day for three days was calculated for 134 herd owners. Average cost of 807.18USD for the opportunity labor cost and 599.51USD for the treatment cost with sum total of 1406.69 USD was incurred. The overall production losses from all parameters were 38051.23 USD. The most important losses were due to the morbidity of the disease (53%) followed by the mortality (44%) loss and the treatment and the opportunity labor costs were less than others.

Sensitivity analysis

The sensitivity analysis of the model parameters showed that, the beef off take reduction is highly subjected to uncertainty due to the crude estimation of the existing sensitive market price changes having significantly wide range between the minimum and maximum prices. Treatment cost contributes almost insignificant variation to the overall estimation. Opportunity labor cost was not included in the model, because its value contains only the most likely estimate without lower and max limits.

Financial Benefit of LSD Control by Vaccination

Production parameters involved in the model was milk production, draught power and beef off take and the average annual milk production increase in the herd computed as a net benefit was 3.7% in all farming systems. The percentage of the financial net benefit of draught power and beef off take was 1.23% and 1.60% respectively. The control intervention was expected to save costs from treatment of clinical LSD and was calculated as 70142.52USD. Though vaccines was given free of charge to farmers, the farmers were still beneficiary if they were expected to cover the costs of the vaccine. Vaccination cost considered here was to show that farmers were benefited even if they paid the charges for the vaccine. The marginal rate of return (MRR) gained from the control intervention was 174 and the net benefit per head was 4 USD (Table 7).

4. Discussion

Lumpy skin disease is one of the severe diseases that could exert economic burden in the poor farming communities and gross domestic production (GDP) of the nation. As reported from Egypt by Ali *et al.* (1990), the disease is threat of food security for the livelihood of the poor farmers. In the study population at risk of developing the disease and sick animals, the proportion of females were higher and this might be due to the purpose of keeping female cattle for various purposes particularly in areas of the pastoral and agro pastoral farming systems, the cattle keepers were highly dependent on milk and milk products but farmers from the mixed crop livestock production system, the primary purpose for keeping of cattle was for the draught purpose.

The cumulative incidence among the sex category indicated that there was no significant difference between males and females groups and this indicated that both sexes are equally susceptible to the disease but comparison between different age groups of cattle showed that there was high cumulative incidence in heifers and bulls and this might be due to management problems as more attention was given to lactating animals and the same is true for the mixed farming system care for the draft oxen was given rather than the biological consequence of the disease. The reason why calves didn't become more infected might be due to the maternal protection of the dams that protect them (Barnard *et al*., 1994).

The mortality in age category, calves were with high proportion and this might be due to the severity of the disease in calves but in case fatality rate, heifers and bulls still in high proportion which might be with a similar reasons. Mortality also higher in males than the females that might be due to more work load than the females in particular emphasis during the cropping season where there was no ample food and to the contrary more working and became highly stressed and this corresponds with Gari *et al.* (2011).

The production losses due to LSD were varying in different parameters depending on the purpose of cattle population kept. LSD is disease of lactating cows which cause a sharp reduction in milk yield up to 50% in infected herds (Woods, 1988) and this might be due to secondary complication of mastitis and generalized malaise (Tuppurainen and Oura, 2012). Other report by Kumar (2011) said that the disease result in milk production drop of 40-65 % and is very important economically particularly in those cattle keepers whose mainstay is on milk and milk products. Similar reports from Ethiopia by Gari *et al*. (2011) showed that milk production was higher in crossbreeds than the local zebu. The present study compares the variation in farming system in different districts and high milk loss was observed in the pastoral and agro pastoral and the main reason for this was due to high prevalence of the disease and keeping of large proportion of cows for milking and their products.

The estimation of the losses of the beef off take rate due to the interference of lumpy skin disease was considered in the study (Thomas, 2002). The incidence of LSD had a great impact on herd dynamics beef farms as the disease causes emaciation and long convalescent period which take several months to recover. This might cause loss of market opportunity or reduction in the surplus production of the households (Tuppurainen and Oura, 2012). The disease also has a long term debilitating effect and long disposal time and might also cause mortality in different age groups (CFSPH, 2008).

LSD is one of the draft animal diseases which interfere with the livelihood of the farmers during the cultivation of land during the cropping season of the year (Thomas, 2002). LSD sick draft oxen were unable to work properly because of lameness, generalized fever, loss of appetite and stressing factors of the disease. During these seasons, farmers suffer from lack of power beyond the estimated costs as the fluctuating rainfall affects them. If they don't cultivate and sowing crops timely, they would suffer hunger as the crops they produce were their annual feeds (CFSPH, 2008). The farmers were also unable to pay for the hired draught animals during these seasons. So, the disease is a question of the food security in the poor households.

The average total losses of the diseases was summed to be 38051.23 USD from the diseased animals and on break down to individual household, they loss an average of 142.50 USD from an average herd consisting of 11 heads annually and 11 USD from the average animal level holdings and this result was higher than the report by Gari *et al*. (2010) by 6.09 USD and this might be due to the exponentially increased prices of livestock and livestock products, and wide spread of disease across the country. Among the major constraints of the livestock production systems, disease and consequent mortality was one of responsible factor to aggravate the household economy (CFSPH, 2008). As indicated from study 53 % of the total losses were due the morbidity of the disease; productivity losses due to milk, beef and draught power were comparable to the losses by mortality was found 44 % of the total losses. Out of the total loss, 97 % losses were due to mortality and morbidity and the remaining 3% derived from the costs for treatment. From the costs of the treatment considered here 50 % were used for treatment costs of prevention of secondary complication and the rest 50 % were the opportunity costs of the labor.

From these results, benefit obtained from control LSD is economically feasible that LSD can be controlled by mass vaccination of the herds before the coming of rainy season. As Preeze (2006) reported that animals can develop a solid immunity after recovery from infection and in endemic areas cattle should vaccinate every year to prevent and to keep under control the severe loss of the disease and consequent disturbance of the food security. The net benefit obtained to herd owners is beyond this as there are several benefits obtained from the control of the disease more than the present study considered three parameters of milk, beef and draught power. The disease was highly prevalent in the developing world where most of the people heavily dependent directly and indirectly on the livestock and their products particularly in Africa and Middle East and needs a joint venture to control with the feasible control costs (Rushton, 2009).

4. Conclusion and Recommendations

The average cumulative incidence of the study group is 11% and financial losses associated with the occurrence of the disease were estimated 11.07USD annually from a single head of cattle. The net financial benefit obtained from the control of the disease was 4 USD from each head of cattle. Based on these conclusions, the following recommendations are forwarded.

Awareness should be created among the herd owners to understand the financial impact as well as the total economic value of the disease on their herds.

Prophylaxis and control measures should be expanded at these areas as the disease causes significant production losses on milk, beef, and draft power, permanent damage to hide skin and other losses and to get benefits from controlling it.

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Conflicts of interest statements
None of the authors has any financial or personal relationships that could inappropriately influence the contents of the paper.

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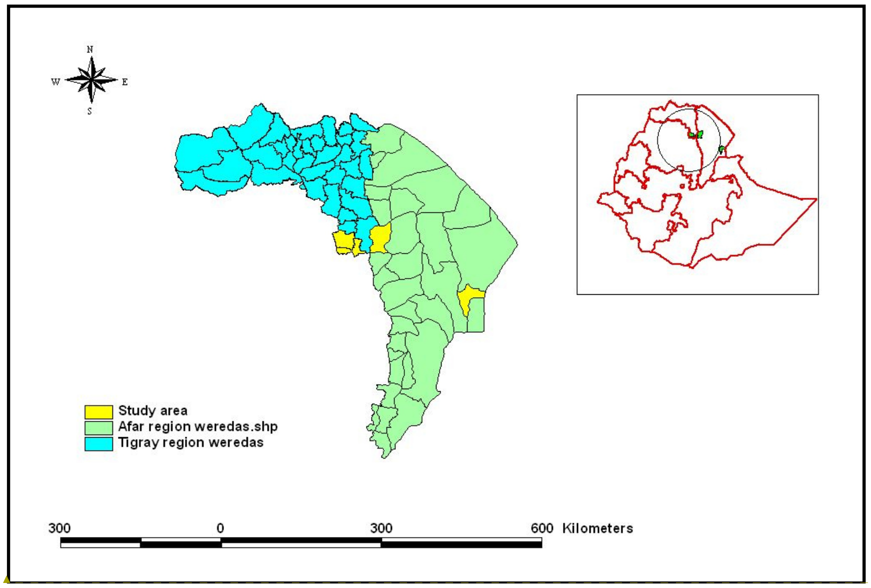

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Table 1.Weighted Average Prices of the Cattle and their Product from Districts local market Survey reports in USD

R.No	Cattle and their products	Prices		
		Maximum	Average value	Minimum
1.	Weighted average price of cattle	470.42	281.10	91.79
2.	Weighted average price of calf	149.16	120.48	91.79
3.	Weighted average price heifer/bull	372.89	283.98	195.05
4.	Weighted average price adult	470.42	392.98	315.53
5.	Price of Milk per liter	0.68	0.63	0.57
6.	Beef meat per kg	5.16	4.88	4.59
7.	Draught power service per ox per day	7.74	5.16	4.59
8.	Average Treatment cost	3.44	3.16	2.86

Table 2.Target Cattle Population in the Study districts of Afar and Tigray Regions

District	lactating	Dry cow	Heifer	Draft oxen	Bull	Calves	Total
Alamata	21045	18131	10,453	30320	9113	21040	110,102
Ofla	13520	10750	11720	28670	8954	13516	73614
Yallo	12563	8821	6370	0	8359	12557	36113
Asiyta	24721	11370	9587	2500	7231	24721	80130
Total	**71849**	**49072**	**38,130**	**61490**	**33657**	**71834**	**299,959**

Table 3. Cattle population by sex &age groups from questionnaire survey results in study districts.

Role number	Description	Sum	Percent
a.	Male cattle	1145	33
b.	Female cattle	2297	67
c.	Calves	727	21
d.	Bulls	290	8
e.	Heifers	458	13
f.	Lactating cows	790	23
g.	Dry cow	437	13
h.	Draught oxen	740	21

Table 4. Description of cattle population affected with LSD by sex and age category

Sex, age category	District				Total
	Ofla	Alamata	Yallo	Asiyta	
Male calves	3	5	9	15	32
Bulls	4	9	7	9	29
Adult male	24	28	7	9	68
Female calves	3	8	3	6	18
heifers	17	24	6	22	68
Dry female	16	16	12	21	66
lactating	15	24	13	44	98
Total	**82**	**114**	**57**	**126**	**379**

Table 5.Cumulative incidence and mortality of different Sex and Age groups

Age and Sex category	Total category	Diseased	95% CI	P-Value
Sex category				
Male	1145	129 (11)	9-13.2	0.388
Female	2297	250(10)	10-12.2	
Total	344	379(11)	10-12	
Age category				0.000
Calf	727	50(6.9)	5-8.8	
Bull/heifer	748	97(12.96)	12-17	
Adult	1967	232(11.7)	10-13	
Cul.Mortality				0.002
Sex category				
Male	1145	34(2.96)	2-3	
Female	2297	32(1.39)	1-2	
Age category				0.000
Calf	727	25(3.4)	2-4	
Bull/heifers	748	23(3.1)	2-4	
Adult	1967	18(0.915)	0.5-1.3	
Total	3442	66	1-2	
Case fatality	379	66(17)	13-22	
Sex				0.002
male	129	34(26.4)	18-35	
Female	250	32(12.8)	8-17	
Age				0.000
Calf	50	25(50)	30.4-69.5	
Bull/heifer	97	23(23.7)	48-77	
Adult	232	18(7.75)	4-12	

Table 6. Average production Losses and Costs Estimated in USD

Financial loss			Percentage loss (%)	Average production loss	Max	Average	Min
Milk loss	Pastoral and agro pastoral		3.26	7622Lts	5247.20	4809.94	4372.67
	Mixed crop livestock			2269Lts	1562.05	1431.87	1301.70
	Total			9891Lts	6809.25	6241.81	5674.37
Total work output loss	Pastoral and agro pastoral		2.52	320 days	1835.81	1652.23	1468.65
	Mixed crop livestock			800 days	4589.52	4130.57	3671.62
	Total			1120	6425.33	5782.80	5140.27
Annual beef off take reduction			1.2	30	12908.04	8002.98	3097.92
Annual mortality loss total	calf	25			3728.98	3011.86	2294.76
	Bull/heifer	23			8576.67	6531.46	4486.26
	Adult	18			8467.67	7073.60	5679.54
	Total	66			20773.33	16616.95	12460.56
Total treatment costs					654.01	599.51	545.01
Opportunity labor cost					860.54	807.18	774.48
Overall Total costs					48377.14	38051.23	25143.71

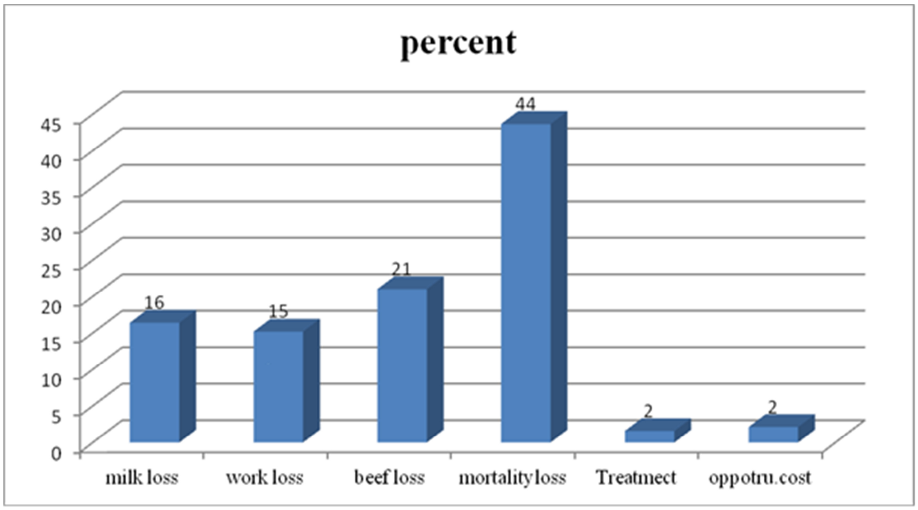

Figure 2. Financial loss of LSD attributed to different parameters

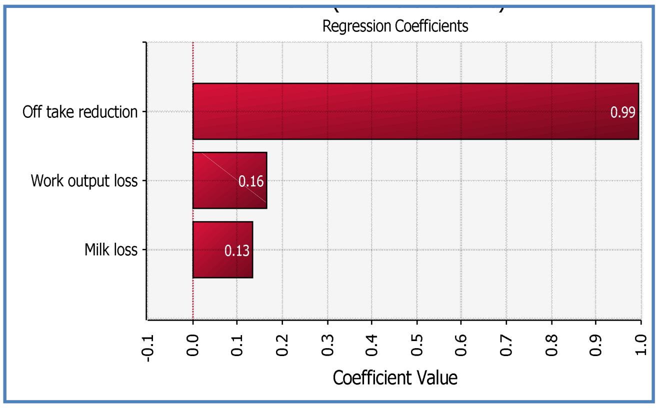

Table 7.Financial benefit of LSD control through vaccination in four districts(in pastoral, agro pastoral and mixed farming) using partial budget analysis in USD

Parameters	Value in USD
I. New cost	
Vaccination cost	
II. Revenue forgone	6883.37
Opportunity labor cost	0
II. New Revenue	
1.Draught power increase	469,879.41
2. Milk losses saved	167,761.71
3. Beef production increase	499,180.23
III. Cost saved	
Treatment cost	70142.52
IV. Subtotal benefit (II +III)	1,206,963.87
Net benefit= IV-I	1,200,080.50
MRR= Net benefit/I	17400%
Net benefit per head(USD/head)	4.00/head

Benefit to cost ratio=Bt/Ct=1,199,831.50/6883.37=174