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Micro-economic analysis of the potential impact of contagious bovine pleuropneumonia and its control by vaccination in Narok district of Kenya

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ABSTRACT

There is inadequate herd and community level information on the impact of CBPP and its control by vaccination to allow adequate allocation of resources for CBPP control in affected ecosystems. A study was designed in Narok district of Kenya provide this crucial information for the Maasai ecosystem. Data were collected through a cross-sectional survey involving 232 households, a longitudinal survey involving 39 herds, 32 outbreak investigations and a project vaccination follow up involving 203 households. Data were also collected from secondary sources and from current and past vaccination programs. Deterministic spreadsheet models estimated the cost of vaccination at KSh 34.6 (USD 0.49) to KSh 72.2 (USD 1.03): 1USD=KSh 70 per animal depending on the vaccination program. The value of annual production losses due to CBPP in the district were estimated at KSh 113.1 million (USD 1.62 million). The estimate of annual losses associated with response to outbreaks amounted to KSh 12.8 million (USD 0.18 million). Disease reporting and treatment of the sick accounted for 34.7% and 48.4% of the estimated value of annual losses associated with response to outbreaks respectively. Annual household CBPP losses were estimated at KSh 275.3 thousand (USD 3933), over twice the average annual household net income of KSh 118.8 thousand (USD 1697) from cattle. At community level, the estimated annual cost of preventive CBPP vaccination through a Wellcome Trust project was KSh 8.53 million (USD 0.12 million), 35.2% of which was due to indirect costs following adverse reactions to vaccination. A benefit-cost analysis demonstrated the annual net benefits to be KSh 67.8 million (USD 0.97 million) and BCR to be 9.60. Herd level BCR was 12.81 while annual net benefits were KSh 35.5 thousand (USD 507.81). Sensitivity analysis showed that vaccination was economically beneficial even when costs of vaccination nearly doubled in biannual vaccination. A break even analysis showed that the threshold herd incidence below which vaccination ceases to be economically worthwhile was 1.1% and 2.3% in annual and biannual vaccination respectively. In conclusion, a CBPP outbreak could cause the loss of a household's entire income from cattle keeping. The highest proportion of costs associated with response to outbreaks was in reporting and treatment of the sick. Early reaction to CBPP reports and eventual eradication of CBPP in the community is therefore urgent to safeguard livelihoods. Annual and biannual CBPP vaccination by any of the programs studied would be beneficial even if the incidence of the disease were as low as 2.2% and 3.9% respectively. However, losses due to adverse post-vaccination reactions need to be monitored and adequately managed. Macroeconomic analysis of the impact of CBPP and its control along the value chain is recommended for better decision making regarding CBPP control at national level.

1. Introduction

Contagious bovine pleuropneumonia (CBPP) is a highly contagious trans-boundary disease of cattle and water buffalo caused by *Mycoplasma mycoides mycoides* Small Colony (*Mmm*SC) (Masiga et al., 1996). It occurs in the hyperacute, acute, sub-acute, or chronic form, affecting the lungs and occasionally the joints particularly in calves. Clinically it manifests as fast, difficult or noisy breathing, discharges from the nose and/or mouth, and a painful cough which becomes worse on exercise. In the chronic stage, there is weight loss. Death may be sudden in the hyperacute stage or after prolonged illness in the chronic form (Masiga et al., 1996; FAO, 2002). Clinical disease

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persists for a period of 4–12 months, with an average of 6 months (Mariner et al., 2006). At post-mortem, CBPP is characterized by fibrinous interstitial pneumonia, pericarditis and pleurisy and hepatization giving a marbled appearance to the lung in acute to sub-acute cases with formation of sequestra in the chronic form. It is these typical pathological lesions that make the disease easy to recognize at post mortem (Santini, 1998). The disease is economically important because of its effects on food security, production costs and trade in cattle and their products (Paskin, 2003; Tambi et al., 2006). The livelihoods of nearly 24.4 million people in 19 African countries are at risk from these effects (Thomson, 2005; AU-IBAR, 2013). In an endemic situation, the disease is insidious and its impact underestimated (Thomson, 2005). However, in an endemic situation, CBPP may occasionally occur as isolated episodes of explosive epidemics (outbreaks) particularly during stressful conditions such as drought (Wanyoike, 1999) as is typical of an endemic disease (Thrusfield, 2007), making it easier to appreciate the impact of the disease.

In Kenya, CBPP is important in pastoral and agro-pastoral systems in the arid and semiarid lands where livestock keeping is a major source of livelihood. The disease affects about 1.3 million people in over one hundred thousand households (Thomson, 2005; Wanyoike, 2009; Onono et al., 2014). The prevalence of CBPP is reported to be 2.8% and 12.7% in endemic and epidemic situations respectively and incidences of up to 47% can occur in sporadic outbreaks (Wanyoike, 1999).

Direct production losses due to CBPP include mortality and morbidity losses, loss of weight and working ability, reduced milk yield and reduced fertility as well as low birth weights, poor growth rates and poor carcass quality (Wesonga, 1994; Tambi et al., 2006). Indirect losses include costs of prevention and control, costs of and response to outbreaks (treatment, vaccination, slaughter of clinical cases, surveillance activities), trade barriers and inadequate exploitation of genetic material due to a reluctance to use improved breeds in an endemic environment (Rushton et al., 1999). The consequences of CBPP can be complex and generally go well beyond the immediate effects on affected producers. These other effects can be classified as ripple, spillover, long-term, or remote. Ripple effects are those which affect the industry's upstream and downstream activities such as industry input and genetic resource suppliers as well as other activities such as slaughtering, processing and marketing therefore affecting jobs, and income and market access. Spillover effects affect other sectors while long- term and remote effects include reduced confidence in the veterinary service and increase in price of the commodity in locations different from the production area due to imposed trade embargos. These effects and the impact of their control can be estimated in a macro-economic analysis (McLeod and Leslie, 2000; Le Gall, 2009; Rich and Wanyoike, 2010). The total annual economic costs of CBPP in Kenya due to cattle deaths, beef, milk and draught power losses were estimated at 4.8 million Euros (Tambi et al., 2006) while Onono et al. (2014) estimated the impact of CBPP to the nation due to mortalities, reduced milk yield, reduced weight gain and reduced fertility rate at US$ 7.6 million per year. In Uganda, in a completely susceptible population, the net loss per animal due to CBPP was US$ 20.14 (Twinamasiko, 2002).

CBPP control involves livestock movement control, quarantine, test and slaughter policy and vaccination with T1 vaccines. Movement control is difficult and often impractical in pastoral production systems because of need for transhumance, trade and socio-cultural practices. It is also difficult where there is civil strife and cattle rustling (Masiga et al., 1998). Stamping out is difficult with far reaching socio-economic effects (Mullins et al., 2000; Le Gall, 2009). The less stringent method of test and slaughter fails in most African countries because of the reluctance of farmers to slaughter their animals and of governments to pay compensation (Thomson, 2005). Antibiotic treatment against CBPP is still officially discouraged in the absence of favourable results (FAO, 2007). In Kenya, as with most sub-Saharan African countries, vaccination continues to be the preferred strategy against CBPP (Amanfu, 2009; Kairu-Wanyoike et al., 2014b). An analysis of the various strategies applied in CBPP control either individually or in combination has shown that annual preventive vaccination involving 75% of animals with a vaccine that protects for at least 18 months combined with test and slaughter of 75% of positive reactors every six months is the optimal strategy (Wanyoike et al., 2004; Onono et al., 2014; Ssematimba et al., 2015).

Although the goal of most vaccination campaigns is wide-scale adoption at national level (Heffernan et al., 2008), perception of benefits at community and household level and among policy makers form the base of such adoption. However, vaccination coverage is low (Wanyoike, 1999; Kebkibah, 2004) due to problems with adverse post vaccination reactions (Thiaucourt et al., 2000; Teshale, 2005) and low government funding due to inadequate information on disease and control impact (Masiga et al., 1996; Wanyoike, 1999).

Formally, disease impact and benefit cost analysis (BCA) for a disease intervention provides information for policy advice (Putt et al., 1988; Boardman et al., 2001). In Senegal, Ly et al. (1998) demonstrated that private vaccination without profit cost more than that by government veterinarians. Twinamasiko (2002) and Tambi et al. (2006) demonstrated the average cost of vaccination against CBPP per head to be US$ 0.44 and between US$0.27 and US$ 1.71 respectively. Usually, vaccination is seen as being only beneficial. However, up to 5% of animals (Thiaucourt et al., 2003) can react adversely to vaccination. In mass vaccinations the total number of animals reacting adversely to vaccine can be high (Teshale, 2005; Kairu-Wanyoike et al., 2014b). The reactions range from mild muscular involvement to paralysis and death. A drop in production and weight as well as abortions may be added effects. Only the study by Teshale (2005) in a mass vaccination of cattle in Ethiopia has made an economic estimation of this effect. In a mass vaccination of cattle with T1/44 vaccine adverse reaction rates of 0.23–3.91% were observed with up to 35.8% case fatality rate. The resulting total economic loss from adverse post vaccination reactions was Ethiopian Birr (ETB) 318,151 (USD 45,450) for the 3010 animals affected.

According to Tambi et al. (2006), in Kenya the annual incremental benefits of controlling CBPP by vaccination and treatment combined were estimated at 3.4 million Euros and the BCR was 2.56. However, this study used country level data which may be an underestimate in a community where CBPP is a major problem. Officially, Kenya practices public funded vaccination and no treatment against CBPP (Wanyoike, 1999), hence the need to demonstrate the benefits of vaccination alone different from the study by Tambi et al. (2006). However, farmers treat animals with antimicrobials due to lack of proper diagnosis and delayed vaccination, the costs of which can be considered as losses if the control strategy is vaccination alone. There have been few studies on the impact of CBPP and its control by vaccination at herd, community and national level that are based on empirical findings.

The objective of this study was to evaluate the impact of CBPP on productivity and livelihoods and the benefits of vaccination at household and community level in Narok South district where the disease is most prevalent. This was in order to aid policy decisions in control of CBPP in the district. The study also demonstrated the threshold incidence below which it is unprofitable to vaccinate against CBPP. The study was part of a larger CBPP project (Wanyoike, 2009).[1]

[1] The project's objectives included the evaluation of diagnostic tests for the determination of prevalence of CBPP, evaluation of the immunological responses to infection, and development of a modified vaccine with increased efficacy and reduced adverse reactions and the assessment of the socio-economic impact of CBPP and this modified vaccine.