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Willingness to pay for contagious bovine pleuropneumonia vaccination in Narok South District of Kenya

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ABSTRACT

Contagious bovine pleuropneumonia (CBPP) is an economically important trans-boundary cattle disease which affects food security and livelihoods. A conjoint analysis–contingent valuation was carried out on 190 households in Narok South District of Kenya to measure willingness to pay (WTP) and demand for CBPP vaccine and vaccination as well as factors affecting WTP. The mean WTP was calculated at Kenya Shillings (KSh) 212.48 (USD 3.03) for vaccination using a vaccine with the characteristics that were preferred by the farmers (preferred vaccine and vaccination) and KSh −71.45 (USD −1.02) for the currently used vaccine and vaccination. The proportion of farmers willing to pay an amount greater than zero was 66.7% and 34.4% for the preferred and current vaccine and vaccination respectively. About one third (33.3%) of farmers would need to be compensated an average amount of KSh 1162.62 (USD 13.68) per animal to allow their cattle to be vaccinated against CBPP using the preferred vaccine and vaccination. About two-thirds (65.6%) of farmers would need to be compensated an average amount of KSh 853.72 (USD 12.20) per animal to allow their cattle to be vaccinated against CBPP using the current vaccine and vaccination. The total amount of compensation would be KSh 61.39 million (USD 0.88 million) for the preferred vaccine and vaccination and KSh 90.15 million (USD 1.29 million) for the current vaccine and vaccination. Demand curves drawn from individual WTP demonstrated that only 59% and 27% of cattle owners with a WTP greater than zero were willing to pay a benchmark cost of KSh 34.60 for the preferred and current vaccine respectively. WTP was negatively influenced by the attitude about household economic situation ($p = 0.0078$), presence of cross breeds in the herd ($p < 0.0001$) and years since CBPP had been experienced in the herd ($p = 0.0375$). It was positively influenced by education ($p = 0.0251$) and the practice of treating against CBPP ($p = 0.0432$). The benefit cost ratio (BCR) for CBPP vaccination was 2.9–6.1 depending on the vaccination programme. In conclusion, although a proportion of farmers was willing to pay, participation levels may be lower than those required to interrupt transmission of CBPP. Households with characteristics that influence WTP negatively need persuasion to participate in CBPP vaccination. It is economically worthwhile to vaccinate

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against CBPP. A benefit cost analysis (BCA) using aggregated WTP as benefits can be used as an alternative method to the traditional BCA which uses avoided production losses (new revenue) and costs saved as benefits.

1. Introduction

Contagious bovine pleuropneumonia (CBPP) in Africa is an important trans-boundary animal disease due to the high mortalities and productivity losses its causes as well as its threat to food security and access to markets (Paskin, 2003). Its annual economic costs in 12 sub-Saharan African countries have been estimated at 44.8 million Euros (Tambi et al., 2006). About 24.4 million people in 19 sub-Saharan African countries, including 1.3 million in Kenya, are at risk of livestock losses caused by CBPP and 30–50% of these people are living below poverty levels (Thomson, 2005).

The existing sub-Saharan policy on CBPP control is based on the strategy proposed following observations recorded in the Mara in Kenya and Tanzania. It recommends movement control, quarantine, test and slaughter policy and vaccination with T1 vaccines. Complete (100%) and regular vaccination for at least five consecutive years with repeat (biannual) vaccination was recommended by the post Pan-African rinderpest campaign (PARC) report (OAU-IBAR, 1999) and re-affirmed at successive regional CBPP workshops (AU/IBAR, 2004). The recommendation by OAU-IBAR (1999) aimed at eradication of CBPP. However, due to socio-economic and socio-cultural reasons, control of impact of the disease needs to be the immediate objective rather than eradication, although eradication at zonal or country level as a long term goal must be kept in sight (AU-IBAR, 2004).

Cattle movement control is difficult to implement in pastoral production systems because of transhumance and socio-cultural practices. It is also difficult where there is civil strife and cattle rustling (Masiga et al., 1998). Test and slaughter fails in most African countries because of the reluctance of owners to slaughter their animals and of governments to pay compensation (Thomson, 2005). Antimicrobial treatment against CBPP is still officially discouraged (FAO, 2007) although it is under research. Stamping out is difficult to implement and has far reaching socio-economic effects (Mullins et al., 2000). Cognizant of the aforementioned shortcomings associated with other control methods, vaccination remains the most preferred control method in the African region. However, vaccinations throughout the region are irregular and coverage is low (Wanyoike, 1999). This is probably due to the fact that national mass vaccination campaigns against CBPP are expensive and often beyond the budget of most African countries (Thomson, 2005). A minimum coverage of 80% twice a year is required in order for herd immunity to reach 80% and this must be maintained at above 80% in order to interrupt disease transmission (Mariner and Catley, 2004). This requires a good vaccine, adequate funds and appropriate policies and practices in delivery of the vaccine as well as cooperation by the farmers (McLeod and Rushton, 2007). It is suggested that in countries where CBPP vaccination is conducted by the government, vaccination should be elective and can be sub-contracted to the private sector with the government facilitating the supply of the vaccine and enacting enabling legislation in order to reach the appropriate vaccination coverage (Mariner et al., 2006).

Although T1 vaccine is the recommended vaccine against CBPP, its stability after reconstitution in a thermolabile environment is only up to 2 h and there is no way of visually assessing its viability (March, 2004). Further, although adverse reactions are less than with the earlier vaccines, T1 vaccine continues to elicit adverse reactions in 1–5% of vaccinated cattle (Thiaucourt et al., 2004). The vaccine also elicits poor efficacy of only 65% in a single vaccination although it can increase to 95.5% in revaccination after 6 months. It also confers immunity for 6–12 months (Wesonga and Thiaucourt, 2000; Nkando et al., 2011).

In some countries, vaccination costs have been partially recovered from cattle owners (Twinamasiko, 2002). However, introduction of full scale cost recovery or privatization of vaccination against CBPP may lead to further reductions in vaccination coverage especially if the vaccine has shortcomings and in the absence of outbreaks (McLeod and Wilsmore, 2002). In Kenya, although cost recovery has been introduced for some vaccinations, CBPP vaccination remains government controlled and is free of charge particularly in pastoralist areas (Kajume, 1999) although commercial farms may purchase the vaccine and vaccinate under supervision. Privatization of services is hard to implement in pastoral areas yet this is where CBPP is more prevalent (Woodford, 2004; Wanyoike, 2009). McLeod and Wilsmore (2002) observe that there may be market failure and subsequent low adoption if service delivery of a public good is performed by the private sector unless there is subsidization.

In spite of the fact that participation in CBPP vaccination can be pegged to farmers' willingness to pay (WTP) (Thomson, 2005), no study has been carried out to investigate this. The purpose of this study seeks to close this information gap, and to provide a monetary estimate of what livestock farmers in Narok district of Kenya are willing to pay to participate in a CBPP vaccination programme. This study was part of a project aimed at comparing the safety and efficacy of the currently used CBPP vaccine and one improved in stability by including a buffer in the mycoplasma growth medium (March, 2004) and is an extension of a study on farmer preferences for CBPP vaccine and vaccination (Kairu-Wanyoike et al., 2013).

Willingness to pay for a good or service or both can be quantified using contingent valuation method (CVM) either directly using revealed preference formats or indirectly using stated preference formats (Brown, 2005). Conjoint analysis (CJA) is a stated preference format which requires the good and/or service to be first split into its various components (attributes). Different levels of attributes of the good or service are combined to form profiles. The profiles can also incorporate some hypothetical but realistic attributes which are required to be included in a good or service under development (Mitchell and Carson, 1989). The consumer then values a reduced number of profiles by ranking or rating with the latter giving more power during statistical analysis (Sayadi et al., 2005). A regression model is then applied to obtain attribute parameter estimates (β coefficients) and therefore preference levels for each attribute. If price is included as one of the attributes, the utility estimates can then be used to calculate WTP first for the other attributes as $-\beta_j/\beta_p$ where j is an attribute and p is price and then for the profile by adding up the WTPs for the individual attributes (Sayadi et al., 2009). When used this way, the technique is termed conjoint analysis–contingent valuation method (CJA–CVM) and can be used to obtain first preferences and then WTP for a good or service.

This paper reports on the findings of a study designed to measure WTP or compensation for CBPP vaccine and vaccination as well as factors affecting WTP in 190 households in Narok South District of Kenya.

2. Materials and methods

2.1. Selection study area

The study was carried out in the Mara and Loita divisions of Narok district of Kenya (Fig. 1). These divisions were selected because of the high incidence of reported outbreaks of CBPP. Indeed 11 out of the 16 (68.8%) confirmed outbreaks reported countrywide in the last 5 years prior to the study were from this part of the district (Wanyoike, 2009). In addition, livestock farmers in these divisions are familiar with the disease and its control methods and vaccination in particular (Wanyoike, 1999). Further, there is need for cooperation between Kenya and Tanzania in CBPP control as the disease exists in the cattle belonging to the *Maasai* communities residing on both sides of the Kenya–Tanzania border. Mara and Loita divisions are in Southern Kenya, bordering the area in Tanzania where CBPP exists and were therefore suitable areas for the study.

2.2. Description of the study area

Narok South District is part of the Arid and Semi-Arid Lands (ASALs) of Kenya. While Mara division is characterized by lowland grasslands, there are a few highland areas in Loita division. The district is inhabited mainly by Maasai pastoralists. The traditional Maasai homestead or *boma* belongs to one or more families. The main cattle production systems are pastoralism and agro-pastoralism, the main cattle breed kept being Zebu. Other economic activities are tourism and wildlife related activities principally in Mara division (Thompson and Homewood, 2002). CBPP is endemic in both divisions due to communal grazing and watering of cattle as well as congregation of animals at night in a central cattle holding area. Livestock cross the Kenya–Tanzania border in search of pastures and for trade leading to cross-border disease spread (Lamprey and Reid, 2004).

In the 1970s and 1980s, the incidence of CBPP in Narok district was largely reduced by test and slaughter and mass vaccination. Following the re-emergence of CBPP in Narok district in 1989/90, mass vaccinations reduced the disease incidence but vaccination coverage remained low due to fear of adverse post-vaccination reactions, contributing to the persistence of the disease to date (Wanyoike, 1999, 2009).

2.3. Description and selection of vaccine and vaccination attributes to be valued

The choice of vaccine and vaccination attributes was guided by preferences expressed by farmers in a Participatory Rural Appraisal (PRA) carried out in a larger study (Wanyoike, 2009). The farmers showed differing preferences for vaccine administration, nature and frequency of vaccination. They were familiar with the aspect of declining stability after reconstitution of the vaccine. They also indicated the fear of adverse post-vaccination reactions in animals and revealed that the vaccinators charged an unofficial fee per animal. In addition, various researchers have recommended a safer vaccine, private and elective vaccination as well as cost shared vaccination (Thiaucourt et al., 2004; Thomson, 2005; Mariner et al., 2006). It has also been suggested that the vaccine be modified by inclusion of a pH buffer in the mycoplasma growth medium and a pH indicator in the final product in order to increase the stability of the vaccine and introduce end user assessment of viability of the vaccine (March, 2004).

Costs of vaccination have also been determined in various vaccinations for CBPP alone or in combination with other vaccinations. The vaccine attributes that were considered for valuation were stability, inclusion of a pH indicator, safety and frequency of administration. The vaccination attributes that were considered were administration of the vaccine and nature of vaccination. Price was included in the profiles to allow for eventual calculation of WTP.

Stability of a vaccine is the time after reconstitution for which the vaccine can be used. It is up to 2 h for the current vaccine but may be greater than 2 h when the vaccine is buffered as in the modified vaccine. The levels of stability included were therefore 2 h and greater than 2 h. Safety of the vaccine relates to the proportion of animals that do not elicit adverse reactions to the vaccine. The current CBPP vaccine may elicit post-vaccination reactions in 1-5% of vaccinated animals (Thiaucourt et al., 2004). An ideal vaccine should exhibit 100% safety. The levels of safety included were therefore 95% and 100%. In the CBPP vaccine, it is increasing acidity that leads to death of the mycoplasma. This leads to the ineffectiveness of the vaccine. The pH indicator is a dye that is placed in the vaccine so that when the acidity rises, it is indicated by colour change over a pH range. The current vaccine does not have a pH indicator. The levels included were therefore inclusion and non-inclusion of the pH indicator. Frequency refers to the number of times an animal will be vaccinated per year. If a vaccine protects for a year then there is need to vaccinate

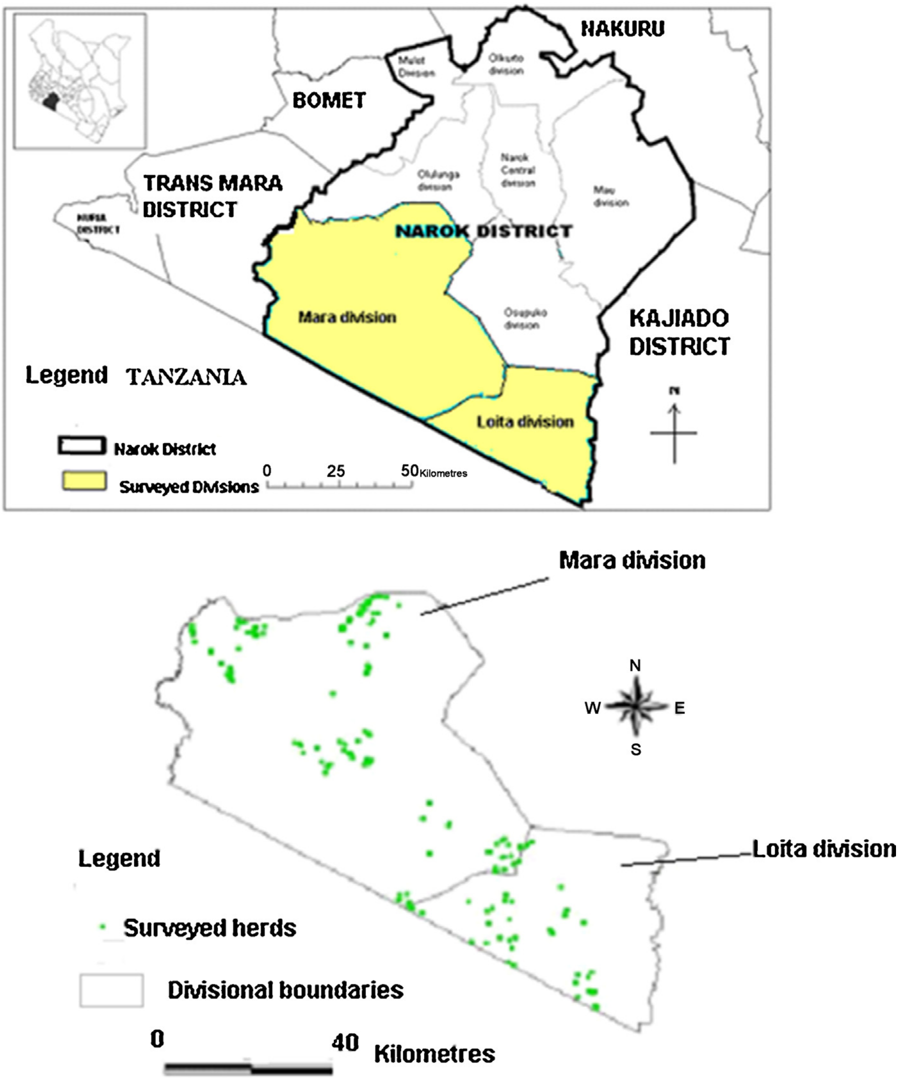

Fig. 1. Map of the herds and households surveyed in the study divisions, Narok South District, Kenya, 2006.

only once a year but if it protects for less than a year there is need to vaccinate at least twice a year. It has also been observed that revaccination after 6 months raises vaccine efficacy from 65% to 95.5% (Wesonga and Thiaucourt, 2000). Currently CBPP vaccination in Kenya is once a year. The levels included were once and twice a year vaccination.

Administration refers to who conducts the vaccination. The Kenya Government has always administered CBPP vaccine in the study area. The Government can choose to continue with this practice or allow private veterinarians to vaccinate while it (the Government) continues with its regulatory role. Therefore, the levels of administration included were government and private vaccination. The nature of vaccination refers to whether the farmer can make decisions on vaccination. CBPP vaccination in Kenya is compulsory but it can also be elective in which the farmer decides whether and when to vaccinate. The levels of nature of vaccination therefore included compulsory and elective vaccination.

The price was the amount of money to be paid to vaccinate each animal during vaccination at the vaccination site and in cash. In Kenya, CBPP vaccination is offered free by the government. However, due to financial constraints, an unofficial fee of KSh 10 is charged to facilitate vaccine distribution (Wanyoike, 2009). The cost of vaccinating one animal under a pastoralist setting is USD 0.44 (Kenya Shillings (KSh) 30 to USD 1.71 (KSh 120) (Twinamasiko, 2002; Tambi et al., 2004).[3] The price levels were drawn from these reports and considered the budgets provided by government and private veterinarians in Kenya in the larger study (Wanyoike, 2009). The cost of vaccinating one animal by the government veterinarian was KSh 34.60. A profit margin of KSh 20–40 per animal was quoted in the budgets of private veterinarians. The price levels included

[3] US$ = Kenya Shillings 70 at the time that these studies were carried out.

were therefore KSh 10, KSh 30, KSh 50 and KSh 70 (rounding down to the nearest 10). The high price of KSh 120 was not considered as it may have elicited protest answers as the price of vaccinations against cattle diseases in the area do not normally rise above KSh 70.

2.4. Sample size calculation and data collection

The sample size was calculated using a formula for determining sample sizes for contingent valuation. The formula gave a sample size of 192 households. The sample size was increased to 232 to cater for a possible 20% non-response rate (Mitchell and Carson, 1989, p. 364).

There were 14 and nine sub-locations in Mara and Loita divisions respectively (CBS, 2001). The sub-locations were characterized first on the basis of vaccination, disease history and sources of livelihood and then one or two contrasting sub-locations were selected from each location in each division. The sampling frame was a list of households from all the villages in the selected sub-locations which was obtained from existing lists maintained by local organizations involved in various community-based activities in the area. Households to be visited were selected randomly from the lists. Each household visited was geo-referenced using Geographic Positioning System in order to view the distribution of the households and for future traceability (Fig. 1).

Six attributes were presented at two levels each and a seventh, price, was presented at four levels, amounting to $2^6 \times 4 = 256$ different product profiles. These would have been too many for effective valuation by the farmers. To reduce the number of profiles that respondents needed to rate, an orthogonal design was applied in SPSS Conjoint 8.0 (Casey, 2009) which selected 16 profiles (Table 4) which was the least number of profiles possible which were needed for rating given the number of attributes and their levels. The profiles were presented in pictorial form on 16 cards. Data to determine preferences for vaccine and vaccination attributes were collected using these cards. The rating method which applied a five-point Likert scale (1 = highly undesirable and 5 = highly desirable) was used (Likert, 1932). Data on farmer demographics, socio-economic characteristics, attitudes towards CBPP and its control as well as herd CBPP risk factors were collected using pretested semi-structured questionnaires administered in person by trained enumerators. All the vaccine and vaccination attributes as well as the valuation procedure were described to the farmers in detail before valuation while avoiding 'information overload' and other biases that are associated with this methodology (Mitchell and Carson, 1989). Information on the study was supplied to the farmers verbally and also through an information sheet. The research tools had been approved by the Research Ethics Committee of the University of Reading.

2.5. Analytical methods

By applying a random utility function (Adamowicz et al., 1994), the utility of the *i*th livestock farmer selecting the *j*th vaccine and vaccination profile can be presented in the following form:

$$U_{ij} = V_j + \omega_{ij}, \tag{1}$$

where *U* is a stochastic utility function, *V* is the deterministic component of utility (standard regression function) and is determined by attributes of the vaccine and vaccination profile, and ω_{ij} is a stochastic error term which accounts for the inherent shortcomings in observing respondent preferences. It was assumed that livestock farmers will be able to rate product *j* higher than product *l* based on the underlying utility, if $U_{ij} < U_{il}$. Conceptually, the term V_j was thus presented as:

$$\begin{aligned} V_j = {} & \beta_0 + \beta_1\,\text{Stability} + \beta_2\,\text{Safety} + \beta_3\,\text{Indicator} \\ & + \beta_4\,\text{Administration} + \beta_5\,\text{Frequency} \\ & + \beta_6\,\text{Nature} + \beta_7\,\text{Price} \end{aligned} \tag{2}$$

where V_j represents the ordered response (with 1 = highly undesirable and 5 = highly desirable) with respect to a set of vaccine and vaccination attributes (Table 1). Based on the ordering of the response and the assumption of normality in ω_{ij}, an ordered probit model (OPM) was estimated. The OPM accounts for the ordinal nature of the response (dependent) variable (Greene, 2011). The β values are marginal utilities arising from a change in the levels of the respective vaccination attributes.

Vaccine and vaccination attributes were the independent variables and were coded as dummy variables while price was treated as a continuous variable to allow only one price coefficient to be used in the WTP calculation. The database consisted of 3040 data profiles resulting from 190 fully completed questionnaires and 16 profiles for each household. The dependent variables were the ratings of each of the profiles. Data were analyzed using Statistical Analysis Software (SAS) Version 9.1.3 (SAS Institute Inc., Cary, NC, USA). Data analyses were carried out in several stages.

In the first stage, an additive composition model in which the coefficients are added together rather than multiplied (multiplicative model) was applied to estimate an overall WTP model (Ehmke et al., 2008; Sayadi et al., 2009). From the coefficients obtained for preferences of vaccine and vaccination attributes, the WTP for each attribute j was calculated as in Eq. (3).

$$-\beta_j/\beta_{\text{price}} \tag{3}$$

The overall WTP for vaccine and vaccination was calculated by aggregating the WTPs for all vaccine and vaccination attributes. As the coefficients were those of the vaccine and vaccination attributes that the farmers preferred, the model was thereafter referred to as 'preferred vaccine and vaccination'. In CJA–CVM, WTP can be calculated for any profile, presented for valuation or otherwise so long as the attributes are known (Newman et al., 2006). WTP was also calculated for all the sixteen profiles presented to the farmer and for the current vaccine. The profiles were then ranked according to WTP for them. Further, the additional WTP resulting from the interaction between attributes and household characteristics

Table 1
Description of the farmer demographic and household characteristic variables used in the regression models, Narok South District, Kenya, 2006.

Variable code	Variable description
EDUC	Number of years of education of the household head
INC	Household income
CROSS	Number of cross-bred cattle in a herd
FAMSIZE	Number of members in a household who are dependent on the household head
HRDSIZE	Household cattle herd size
TIMES	Number of times a herd had suffered CBPP since 1991[a]
YEARS	Number of years since the last incidence of CBPP in the herd
HHNO	Number of other households in the homestead
GENDER	Sex of household head
AGE	Age of the household head
DIV	Administrative unit in which the household was situated
PRIOR	Priority given to CBPP with respect to control
LIKE	Likelihood of CBPP occurring in the herd
HHSITU	Household head's perception of the household economic situation
SALT	Practice of mixing cattle at salt licks
TREAT	Practice of treating CBPP cases
OCC	Occupation of the household head
GROUP	Membership of any household member to an organized group
LEAD	Any leadership position of the household head in the community
CLAN	Sub-clan of the household head
REAC	Adverse post-vaccination reactions to previous CBPP vaccination in the herd
KNOW	Household head's knowledge of CBPP

[a] The year that CBPP returned in the study area.

were added to the WTP from the overall model to ascertain the influence of household characteristics on WTP for attributes (Makokha, 2005) as in Eq. (4).

$$\frac{-(\beta_{\text{attribute}} + \beta_{\text{interaction}})}{\beta_{\text{price}}} \tag{4}$$

In the second stage, individual farmer willingness to pay was obtained by first running individual models for each farmer similar to the first overall OPM but using only the 16 observations unique to each farmer (Sayadi et al., 2009). This was done for all the 190 individual farmer sets of profiles. The marginal WTP for each attribute and the total WTP for the preferred and current vaccine and vaccination attributes for each farmer were obtained in a similar fashion to that for the overall model. The proportions of farmers willing to pay an amount greater than zero and those willing to pay a negative amount were calculated. A negative WTP emanates from the fact that the WTP was indirectly estimated by calculation as the method used in the study was a stated preferences method, rather than revealed preferences method, which may lead to zero, some positive values and some negative values. Negative WTP means the farmers would require compensation before they can allow vaccination of their animals. The average amount of compensation required per animal was calculated as average negative WTP for both the preferred and the current vaccine. The total amount of compensation was calculated as in Eq. (5).

$$\text{Total compensation} = N \times \text{proportion of respondents with negative WTP} \times \text{compensation per animal} \tag{5}$$

where N was the total population to be vaccinated.

In the third stage, a backward fitting ordinary least squares (OLS) model was fitted on WTP data in order to demonstrate the household characteristics conditioning WTP (Serneels et al., 2007). The empirical model was specified in Eq. (6). The dependent variable WTP_i was the estimated willingness to pay for CBPP vaccine and vaccination for the ith household at the time of the survey.

$$\begin{aligned}\text{WTP}_i = {} & \beta_0 + \beta_1\,\text{EDUC} + \beta_2\,\text{INC} + \beta_3\,\text{CROSS} + \beta_4\,\text{FAMSIZE} \\ & + \beta_5\,\text{HRDSIZE} + \beta_6\,\text{TIMES} + \beta_7\,\text{YEARS} + \beta_8\,\text{HHNO} \\ & + \beta_9\,\text{GENDER} + \beta_{10}\,\text{AGE} + \beta_{11}\,\text{DIV} + \beta_{12}\,\text{PRIOR} \\ & + \beta_{13}\,\text{LIKE} + \beta_{14}\,\text{HHSITU} + \beta_{15}\,\text{SALT} + \beta_{16}\,\text{TREAT} \\ & + \beta_{17}\,\text{OCC} + \beta_{18}\,\text{GROUP} + \beta_{19}\,\text{LEAD} + \beta_{20}\,\text{CLAN} \\ & + \beta_{21}\,\text{REAC} + \beta_{22}\,\text{KNOW} + \varepsilon\end{aligned} \tag{6}$$

A description of the independent variables is in Table 1. β_0 was the y intercept, β were the coefficient estimates while ε was the error term.

Multicollinearity was tested by checking that the Pearson correlation coefficients between any pair of regressors were less than 0.8 (Kennedy, 1985) and that the confidence intervals of the parameter coefficient estimates were not too wide (Table 2). The White's test (White, 1980) showed that heteroscedasticity was absent ($\chi^2 = 40.67$, df = 40, $p = 0.4407$). A natural logarithmic transformation was carried out to normalize the WTP and income distributions and residual plots of the ensuing data carried out to ascertain normality prior to regression (Kennedy, 1985). There was high correlation for the disease risk factors of mixing at grazing, watering and saltlicks. Mixing at saltlicks was considered to be the more important risk factor according to the farmers and was retained to represent the three in the OLS model. The measurement of parameter estimates used SAS statistical software which fixed the independent variables in a repeated sample model to avoid errors in variable assignment as either dependent or independent and autoregression.

In the fourth stage, assuming a control strategy of annual vaccination, total social benefits were calculated as aggregated WTP which was the product of mean WTP and the cattle population to be vaccinated (200,000 cattle). The cost of vaccinating one animal was KSh 34.60 (USD 0.49) in the Food and Agriculture Organization of the United Nations and Government of Kenya (FAO/GOK) and Wellcome Trust programmes, KSh 45.8 (USD 0.65) for the Pan African Rinderpest Campaign (PARC) programme and KSh 72.2 (USD 1.0) in the proposed private programme (Wanyoike, 2009). The benefits were assumed similar across all programmes and were applied in a benefit cost analysis (Saengsupavanich et al., 2008). The benefit cost ratio was obtained as in Eq. (7). The analyses were for control rather than eradication and for only one year since the short lived potency of CBPP vaccine may not allow benefits to be experienced beyond one year hence discounting was not considered. CBPP eradication given the current shortcomings in movement control and other control processes required in the eradication process is not feasible. The partial budget model (Dijkhuizen et al., 1995) was applied. The aggregated WTP was assumed to have considered total costs saved as avoided outbreak control costs and total new revenue as avoided production costs as well as total additional costs of managing adverse post vaccination reactions.

$$\mathrm{BCR} = \frac{\text{Mean WTP}}{\text{Cost of vaccinating one animal}} \tag{7}$$

Taking the proportion of respondents expressing WTP for the vaccine and vaccination at the amount indicated and above as a proxy of the quantity of vaccines ‘purchased’ at the indicated price (WTP), pseudo-demand curves for the preferred and current vaccines and vaccination were developed (Mitchell and Carson, 1989; Ngugi, 2002). Demand was described as the proportion of farmers willing to pay an amount greater than zero for the vaccine and vaccination. From the demand curves, the proportion of farmers willing to pay the calculated cost of vaccinating one animal against CBPP alone under joint government programmes was derived for both the preferred and the current vaccine.

3. Results

In the surveyed population of 190 farmers, the median number of years of education of the household head was zero with a range of 0–14. The median annual household income was KSh 335 (range 36–2080 thousand). There were 0–110 cross-bred cattle in each household with a median number of zero. Each household had a median number of 7 (range 1–45) family members. The median number of other households in a homestead was 3 (range 0–46) and cattle per household was 75 (range 4–600). The number of times CBPP had been experienced in the herd since 1991 was zero (range 0–4) while the median number of years since CBPP had been experienced in the herd was 0 (range 0–47).

Male respondents and young (18–40 years old) respondents contributed 73.7% and 35.3% of total respondents respectively. Respondents from Mara division formed 66.3% of the total respondents. A proportion of 32.1% of household heads had an alternative occupation to livestock keeping but only 33.2% believed their household economic situation was acceptable. Nearly 70.0% of households mixed their animals at watering, grazing and salt licks. The proportion of respondents who had some knowledge of CBPP was 87.4%. While 61.6% of the respondents gave CBPP priority with regard to control and 70.0% saw a high likelihood of their cattle suffering CBPP, early 38.9% households treated their animals against CBPP with antimicrobials and 53.7% of households had experienced adverse CBPP post-vaccination reactions in their herds. Membership to an organized group by any of the household members was observed in 55.3% of households and 37.4% of household heads were community leaders.

Coefficient estimates of the ordered probit model are presented in Table 2. It is apparent that overall, the respondents’ preference regarding vaccine and vaccination was 100% vaccine safety, inclusion of a pH indicator in the vaccine and administration of the vaccine by the government ($p < 0.0001$). From the positive β coefficients of the other attributes, overall the respondents also preferred stability of the vaccine beyond 2 h after reconstitution, annual and elective vaccination although this was not statistically significant ($p > 0.05$).

Table 3 presents the willingness to pay (WTP) for each attribute level and vaccine profile preferred by the study

Table 2
Regression coefficient estimates for the preferred vaccine and vaccination attributes, Narok South District, Kenya, 2006.

Attribute	Coefficient estimate	95% CI of coefficient estimates	*p*
Intercept	1.5249	1.3963 to 1.6535	<0.0001
Greater than 2 h stability	0.0567	−0.0198 to 0.1332	0.1469
100% safety	0.8256	0.7469 to 0.9043	<0.0001
Inclusion of pH indicator in vaccine	0.9507	0.8709 to 1.0305	<0.0001
Government administration of vaccine	0.2315	0.1549 to 0.3081	<0.0001
Annual vaccination	0.0514	−0.0251 to 0.1279	0.1879
Elective vaccination	0.0542	−0.0223 to 0.1307	0.1653
Price (linear)	−0.0102	−0.0119 to −0.0085	<0.0001

The coefficient estimate for the alternate attribute (e.g. less than 2 h stability) was the negative of that presented in this table. Price was given linearity to allow the use of one price coefficient estimate for calculation of WTP for each attribute as $-\beta_j/\beta_p$ where β_j is the coefficient estimate for a vaccine of vaccination attribute and β_p is the coefficient estimate for price.

Table 3
Mean willingness to pay (WTP) for preferred vaccine and vaccination attributes, Narok South District, Kenya, 2006.

Attribute	WTP KSh (USD)	95% CI of WTP KSh (USD)	% of total WTP
Inclusion of pH indicator	95.12 (1.36)	6.92 to 183.32 (0.10 to 2.62)	44.8
100% vaccine safety	79.20 (1.13)	−16.84 to 175.24 (−0.24 to 2.50)	37.3
Government administration of vaccine	21.45 (0.31)	11.65 to 31.25 (0.17 to 0.45)	10.1
Greater than 2 h vaccine Stability	6.83 (0.10)	−14.73 to 28.39 (−0.21 to 0.41)	3.2
Compulsory vaccination	5.05 (0.07)	−24.35 to 34.45 (−0.35 to 0.49)	2.4
Annual vaccination	4.82 (0.07)	−22.62 to 32.26 (−0.32 to 0.46)	2.3
Total	212.48 (3.04)	40.00 to 384.96 (0.57 to 5.50)	100.0

KSh is Kenya Shillings: 1 USD = KSh 70.

population (preferred vaccine and vaccination). Thus while the inclusion of a pH indicator contributed the most (44.8%) to the overall WTP, frequency of once a year vaccination contributed the least (2.3%) to overall WTP for the preferred vaccine and vaccination. The mean farmers' WTP calculated from the overall model was KSh 212.48 (USD 3.03); 95% CI: KSh 40.00 (USD 0.57)–384.96 (USD 5.50).

The proportion of farmers willing to pay an amount greater than zero for the preferred vaccine was 66.7% (95% CI: 59.6–73.4) while 33.3% (95% CI: 26.6–40.4) were not willing to pay (zero and negative amount). Therefore, if WTP was used as a proxy to measure the expected participation in vaccination, the average participation expected was 66.7%. On average, 33.3% of the farmers would need to be compensated an amount of KSh 1162.62 (USD 13.68); 95% CI: KSh 166.63 (USD 2.38)–KSh 2158.61 (USD 30.84) per head of cattle. The rate of compensation that would be required would be KSh 500 per head of cattle vaccinated (Fig. 2) for the majority of those to be compensated (71.4%; 95% CI: 58.5–81.8%). With a vaccination target of 160,000 cattle and an average 108 cattle per herd (in the pastoral system), the total amount of compensation in the study area would be KSh 61.39 million (USD 0.88 million).

Table 4 presents the willingness to pay for the 16 vaccine and vaccination profiles presented to the farmer and additionally the current and preferred vaccine and vaccination profiles. For the current vaccine and vaccination, the farmers were willing to pay on average KSh −71.45 (USD −1.02); 95% CI: KSh −320.53 (USD −4.58)–177.64 (USD 2.54). Only 34.4% (95% CI: 27.6–41.5) of farmers were willing to pay an amount greater than zero for the current vaccine and vaccination. The remaining 65.6% (95% CI: 58.5–72.4) were not willing to pay (zero and negative amount) and would need compensation to vaccinate their cattle against CBPP using the current vaccine. As with the preferred vaccine, KSh 500 per head of cattle vaccinated would be required to compensate the majority (78.4%; 95% CI: 70.0–85.1) of those not willing to pay (Figure 2). The average amount of compensation would be KSh 853.72 (USD 12.20); 95% CI: KSh 492.75 (USD 7.04)–KSh 1214.69 (USD 17.35). The total amount of compensation in the study area would be KSh 90.15 million (USD 1.29 million).

Various household characteristics influenced the attribute coefficients by a value equivalent to the interaction coefficient as observed in the interaction ordered probit regression model (Kairu-Wanyoike et al., 2013; Wanyoike, 2009). Willingness to pay for vaccine and vaccination attributes was in turn influenced by these interactions (Table 5). For instance those with higher incomes would pay above the average amount for 100%

Table 4
Willingness to pay (WTP) and rank for profiles of CBPP vaccine and vaccination, Narok South District, Kenya, 2006.

Vaccine and vaccination profile	Stability (h)	Safety (%)	Indicator included	Administration of vaccine	Frequency of vaccination	Nature of vaccination	Price KSh (USD)	WTP KSh (USD)	Rank
Preferred	>2	100	Yes	GOK	Once	Elective	–	212.48 (3.03)	1
Current	2	95	No	GOK	Once	Compulsory	–	−71.45 (−1.01)	14
1	>2	95	No	Private	Once	Elective	50 (0.71)	−186.36 (−2.66)	17
2	>2	95	Yes	GOK	Twice	Compulsory	70 (1.00)	35.12 (0.50)	6
3	2	95	Yes	Private	Twice	Elective	50 (0.71)	−21.35 (−0.30)	11
4	2	100	Yes	GOK	Once	Compulsory	50 (0.71)	196.24 (2.80)	3
5	>2	100	Yes	GOK	Twice	Elective	30 (0.43)	197.19 (2.81)	2
6	2	100	No	Private	Twice	Elective	70 (1.00)	−45.21 (−0.64)	13
7	2	95	Yes	GOK	Once	Elective	10 (0.14)	34.43 (0.49)	7
8	2	95	No	Private	Twice	Compulsory	30 (0.43)	−207.11 (−2.96)	18
9	2	100	No	GOK	Once	Elective	30 (0.43)	10.22(0.14)	9
10	2	100	Yes	Private	Twice	Compulsory	10 (0.14)	140.31 (2.00)	5
11	>2	100	No	Private	Once	Compulsory	10 (0.14)	−24.27 (−0.34)	12
12	>2	100	Yes	Private	Once	Elective	70 (1.00)	162.33 (2.31)	4
13	>2	95	No	GOK	Twice	Elective	10 (0.14)	−150.21 (−2.14)	15
14	>2	100	No	GOK	Twice	Compulsory	50 (0.71)	1.041 (0.16)	8
15	2	95	No	GOK	Once	Compulsory	70 (1.00)	−151.09 (−2.16)	16
16	>2	95	Yes	Private	Once	Compulsory	30 (0.43)	0.11 (0.00)	10

In the price column, – means no price given as the profiles were not presented to the farmers since they were not selected by the orthogonal design. However WTP was calculated from the individual attribute WTPs since the attributes of the profiles were known. KSh is Kenya Shillings and 1 USD = KSh 70. Frequency of vaccination was per animal per year. GOK is Government of Kenya. Rank was for the vaccine and vaccination profile according to the amount of money the farmers were willing to pay.

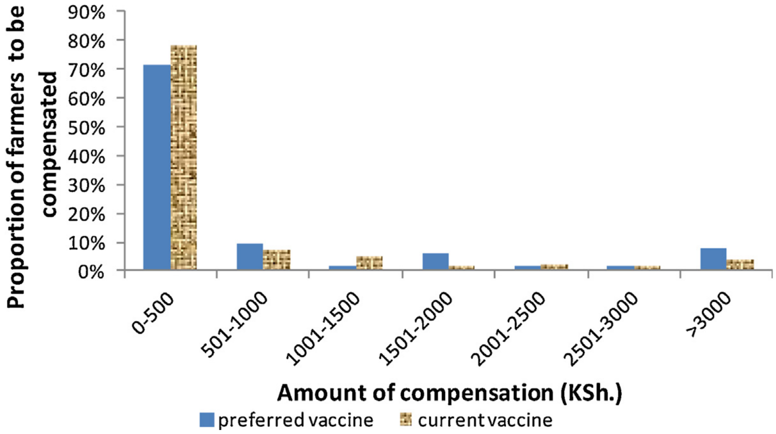

Fig. 2. Proportion of farmers to be compensated to allow use of current and preferred CBPP vaccine and vaccination, Narok South District, Kenya, 2006.

vaccine safety, inclusion of a pH indicator in the vaccine and government vaccination. Also male heads of households, respondents from Mara division, those who had experienced CBPP in their herds many times or saw a high likelihood of CBPP occurring in their herds were willing to pay a higher than average amount for 100% vaccine safety.

The most parsimonious model resulting from a backward fitting OLS on WTP, farmer demographics and household characteristics data is presented in Table 6. WTP for vaccine and vaccination profiles was significantly influenced by the attitude about household economic situation ($p = 0.0078$), presence of cross-breds in the herd ($p < 0.0001$), practice of treating animals against CBPP ($p = 0.0432$), education ($p = 0.0251$) and the number of years since clinical CBPP had been experienced in the herd ($p = 0.0375$). Although the influence of income was not significant ($p = 0.5761$), it was positively correlated to WTP. Those who treated against CBPP and the educated were willing to pay for vaccination (positive β estimates). Unexpectedly, those who perceived their household situation to be acceptable and those with crosses in their herds were less willing to pay for vaccination (negative β estimates). As expected, those who had experienced CBPP many years ago (not recently) were less willing to pay for CBPP vaccination.

Table 5
Willingness to pay (WTP) resulting from the interaction model, in Narok South District, Kenya, 2006.

Interaction	WTP (KSh)	WTP (USD)	*p*
Income*100% safety of the vaccine	93.75	1.34	<0.001
Income*inclusion of a pH indicator in the vaccine	100.61	1.44	0.005
Male gender*100% safety of the vaccine	143.97	2.06	<0.001
Age*inclusion of a pH indicator in the vaccine	139.69	2.00	0.006
Likelihood of CBPP in herd*100% safety of the vaccine	118.57	1.69	0.013
Mixing of cattle at salt lick*100% safety of the vaccine	169.18	2.42	0.001
Treat against CBPP*inclusion of a pH indicator in the vaccine	134.32	1.92	0.030
Mara division*100% safety of the vaccine	109.87	1.57	0.008
Years ago since CBPP was experienced*100% safety of the vaccine	83.39	1.19	0.044
Number of times CBPP experienced*100% safety of the vaccine	103.81	1.48	0.007
Herd size*Government administration of the vaccine	22.52	0.32	0.030

In the interaction column, * means interaction. Interaction is the influence of one attribute on another. Interaction effect exists when differences in one factor depend on the level of another.

Table 6
Effect of household characteristics on willingness to pay (WTP) for vaccination Narok South District, Kenya, 2006.

Variable	Coefficient estimate	95% CI of coefficient estimate	*p*
Intercept	7.7375	6.81–8.67	<0.0001
Gender	0.1196	−0.02 to 0.26	0.0947
Household situation	−0.1765	−0.30 to −0.05	0.0078
Crosses	−0.0203	−0.03 to −0.01	<0.0001
Treat	0.1356	0.01 to 0.27	0.0432
Education	0.0164	0.00 to 0.03	0.0251
Group	0.0499	−0.07 to 0.17	0.4292
Years	−0.0118	−0.02 to 0.00	0.0375
Income	0.0208	−0.05 to 0.09	0.5761

The factors influencing WTP were determined through a backward fitting ordinary least squares (OLS) regression model. From 22 factors assumed to be important, only those that significantly influenced WTP were included in this output (most parsimonious model) except for the case of gender and group which were retained for the purpose of discussion.

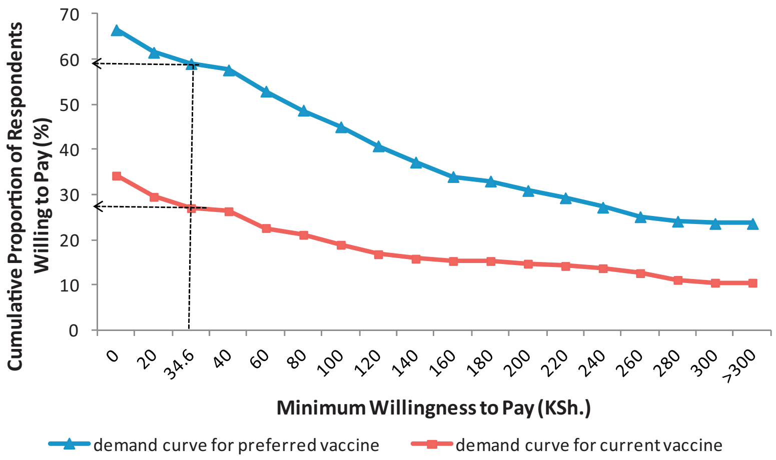

Fig. 3. Cumulative proportion of respondents willing to pay for current and preferred CBPP vaccine and vaccination, Narok South District, Kenya, 2006.

A demand curve can be constructed for only those with WTP equal to zero and above. A pseudo-demand curve was constructed for these respondents. The pseudo demand curve represented the share of households that were willing to pay the amount indicated and above up to the next amount (Fig. 3). The proportion of those with WTP above zero who were willing to pay the calculated cost of vaccination of KSh 34.60 was 59% for the preferred vaccine and vaccination and 27% for the current vaccine and vaccination.

Table 7 shows the social benefit to cost ratios of the various vaccination programmes. The BCRs using aggregated WTP as benefits ranged from 2.9 to 6.1 depending on vaccination programme indicating that vaccination against CBPP was economically worthwhile for all programmes.

4. Discussion

The mean farmers' willingness to pay for the preferred vaccine and vaccination was KSh 212.48. When compared with the calculated cost of vaccination of KSh 34.6 by the government and KSh 72.2 by the private sector, this mean WTP can be considered a high price especially because this community is generally poor (Wanyoike, 2009). However, the wide confidence interval indicates a high level of uncertainty and further studies are needed. It nevertheless demonstrates the desire by the community for a better vaccine. Similar scenarios of high WTP premiums for goods or services have been noted in other WTP studies involving developing African countries (Frick et al., 2003; Rheingans et al., 2004; Ehmke et al., 2008). The negative WTP of an average KSh −71.45 for the currently used vaccine and vaccination shows that on average, farmers were not willing to pay for the current vaccine and vaccination.

A WTP above zero by 66.7% of farmers is similar to the actual observation that in past studies in the study area, CBPP vaccination coverage using the current vaccine reached a maximum of 60% (Wanyoike, 1999). Ultimately, even if the vaccine and vaccination were free and had the desired attributes vaccination coverage may not rise above 66.7% which might not be sufficient to interrupt transmission of CBPP in a herd. This means that including all the preferred vaccine and vaccination attributes may not necessarily lead to optimal participation in CBPP vaccination. Farmers may also have other reasons for rejecting vaccination other than undesirable vaccine and vaccination attributes. Possible reasons are inadequate knowledge of how vaccines work and their full benefits in spite of having knowledge on the disease, inappropriate attitudes and perceptions about CBPP and its control as well as wrong timing of vaccination (Wanyoike, 2009). Heffernan et al. (2008) in their study on livestock vaccine adoption among poor farmers in Bolivia demonstrated that membership of a farmer to an organized group in the community and knowledge transfer through social networks can increase vaccine uptake.

Nearly one-third and two-thirds of farmers required compensation to accept the preferred and current vaccine and vaccination respectively. Other studies have also elicited need for compensation to use a good or service

Table 7
Social benefit to cost of vaccination under various programme costs, in Narok South District, Kenya, 2006.

	Wellcome Trust Project	PARC	FAO/GOK	Private without profit	Private with profit
Cost of vaccinating one animal (KSh)	34.6	45.8	34.6	61.0	72.2
Total cost of vaccination (Million KSh)	6.9	9.2	6.9	12.2	14.4
Total social benefits (Million KSh)	42.5	42.5	42.5	42.5	42.5
Net benefits (Million KSh)	35.6	33.3	35.6	30.3	28.1
Social benefit cost ratio	6.1	4.6	6.1	3.5	2.9

PARC, Pan African Rinderpest Campaign; FAO, Food and Agriculture Organization of the United Nations; GOK, Government of Kenya; KSh, Kenya Shillings (1 USD = KSh 70).

(Ngugi, 2002; Frick et al., 2003; Rheingans et al., 2004). The implication is that even if vaccine and vaccination were offered free of charge, these farmers would not vaccinate their animals unless they are compensated. However, as the WTP was calculated rather than given directly by the farmers, it was not possible to query the respondents on it. The total amounts of compensation required for both the preferred and the current vaccine and vaccination were high and compensation may not be feasible especially if vaccination is carried out more than once a year. Awareness creation in farmers on impact of CBPP and its control by vaccination as well as how CBPP vaccine works, coupled with dialogue with farmers to persuade them to vaccinate, would probably increase vaccination coverage.

One CBPP infected herd in an area can lead to infection of other herds (high negative externalities associated with CBPP). In addition, CBPP control in several herds in an area can lead to control even for those who do not vaccinate (high positive externalities associated with its control) (Rushton and Leonard, 2008). Due to these phenomena, the current vaccine limitations and the fact that private veterinary practitioners in Kenya are not willing to operate in pastoralist areas as well as the limited WTP demonstrated in this study (Wesonga and Thiaucourt, 2000; Thiaucourt et al., 2004; Woodford, 2004), CBPP remains essentially a disease whose control requires public funds. Consequently, market failure is likely to be encountered in delivering the CBPP vaccine by the private sector (McLeod and Wilsmore, 2002). A proportion of farmers were willing to pay for vaccination using either the preferred or the current vaccine at the calculated cost of KSh 34.60 for publicly administered vaccine. The proportion would be lower for private vaccination. A farmer may be unwilling to pay because their incomes are low or their expenditures in other areas are high. The current scenario in vaccination against CBPP in Kenya is that it is compulsory, administered by the government and fully subsidized (Kajume, 1999). This obviously has not ensured optimal CBPP vaccination. This study has demonstrated that while some farmers are willing to pay, some are not. In addition, some farmers may prefer private to government vaccination (Kairu-Wanyoike et al., 2013). Elective vaccination can be allowed with the farmer meeting part or full cost of vaccination for the proportion that would like to pay but compulsory, fully subsidized vaccination retained for those not willing to pay. It has already been stated that CBPP is essentially a public good disease. Therefore, if the private sector were to vaccinate against CBPP, subsidization is important to achieve the required coverage and to avoid market failure. The government would need to synchronize and regulate vaccination in all scenarios (elective and compulsory) and to change policy on CBPP vaccination to accommodate elective and privatized vaccination in order to achieve the optimal vaccination coverage.

Farmers with higher incomes would pay more to have a better vaccine and for government administration of vaccine probably in the hope of getting better returns on their investment. The young would pay more for inclusion of an indicator in the vaccine probably because they would more readily try something new. Farmers who saw a higher likelihood of their animals contracting CBPP, those who had experienced CBPP many times as well as those from Mara division would pay more for a safer vaccine probably due to their experiences with adverse post vaccination reactions. As expected, WTP was positively influenced by education as was also observed in other studies (Ngugi, 2002; Frick et al., 2003; Rheingans et al., 2004) and those who had experienced CBPP many years ago (not recently) were less willing to pay probably because of perceived low risk of the disease. However, Wanyoike (2009) has demonstrated that it is beneficial to vaccinate against CBPP even if the incidence were as low as 1.1% and so these farmers should be encouraged to vaccinate. It is possible that participation in vaccination can be sustained by taking advantage of the cooperation of those with characteristics which positively influenced WTP and persuading those with characteristics which negatively influenced WTP to vaccinate.

The unexpected observations that households which perceived their household situation to be acceptable and that those with cross-bred cattle in their herds were less willing to pay is likely to be because of a type I error due to the stepwise automated fitting approach although this was controlled by checking that there were no large variations in the coefficient estimates and p values during addition and removal of parameters to the model. Alternatively, households which perceived their household situation to be acceptable may not have considered cattle keeping as very important in their livelihoods. Likewise, it is possible respondents may have considered cross-breds to be more resistant to CBPP.

About half (53.7%) of farmers had experienced adverse post-vaccination reactions in at least one animal in their herds (Wanyoike, 2009). Usually this may be unacceptable to some farmers who may own only a few animals. In some cases, it may the best producer in the herd whose production has been reduced even if temporarily (Wanyoike, 1999, 2009). In addition, in the overall preference model, farmers had a strong preference for 100% safety of the vaccine (Kairu-Wanyoike et al., 2013). However, the experience of post-vaccination reactions in their herds did not significantly influence their willingness to pay for vaccine and vaccination. This was consistent with the attitude in some farmers that in spite of the reactions, their animals were protected anyway (Wanyoike, 2009). Though membership to an organized group influenced the WTP positively, this was not significant. Indeed, information offered by such groups did not include information on CBPP and its control (Wanyoike, 2009). The possibility of offering information about CBPP and its control through organized groups can be explored.

The calculated BCRs showed that it is economically beneficial to vaccinate against CBPP. The BCRs were lower than but comparable to those observed in the same study area as this current study (5.64–9.60) which used avoided production losses and costs saved as benefits in traditional benefit cost analysis (Wanyoike, 2009). Thus there was some agreement in results while using two different study methodologies. This justifies the use of aggregated WTP in a benefit cost analysis particularly because measuring avoided losses in an animal population in pastoral communities can be difficult, time consuming and expensive. It is generally assumed that in valuing benefits using aggregated WTP, the farmer may consider benefits which are not normally quantified in traditional BCA (intangible social benefits) and that revenue forgone such as that due to adverse reactions to ring vaccinations after outbreaks will be avoided. Consequently, if the farmers fully understand the impact of CBPP and the value of vaccination in control, benefits valued this way should be higher than when avoided losses and costs saved are used (Rheingans et al., 2004). However in this case they were lower probably because while widespread vaccination provides indirect benefits through herd immunity effects, this may not be captured by the WTP of individual farmers who do not consider the benefits experienced by other farmers. Compensation for farmers not willing to vaccinate against CBPP was way above the calculated benefits of vaccination and may cause vaccination to be uneconomical.

To the best of our knowledge, this is the first study to measure WTP for CBPP vaccine and vaccination. It is also the first study that has used CJA–CVM in the field of veterinary medicine although the method has been used in other fields (Ehmke et al., 2008; Sayadi et al., 2009). Other formats that can be used to elicit WTP are revealed preference methods such as open ended, payment cards, bidding games and dichotomous choice methods (Brown, 2005).

The major shortcoming of revealed preference is that it puts the respondent through the difficult task of formulating a price and can lead to protest or strategic answers where the farmer refuses to give a price or gives unrealistic answers (Mitchell and Carson, 1989). Stated preference methods such as CJA–CVM minimize these problems. On the other hand the stated preference method requires the calculation of WTP given the responses which makes it difficult to query the farmers about the calculated WTP and can also result in outlier and negative WTPs. However, it gives a clear indication of the level of demand for the vaccine. In both stated and revealed preference methods, the farmers may not pay what they indicate they will pay. If an affordable benchmark price is needed, then the incomes and expenditures of the farmers need to be examined to determine ability to pay.

In this study, stated preference was used because the farmers were not familiar with formulating prices for vaccine and vaccination since currently the vaccine is offered free of charge. In addition, the study objective was to measure preferences and WTP in a single step to reduce costs which is best done using CJA–CVM. A shortcoming of this study was that the ability to pay by the respondents was not quantified due to data limitations and can be considered in further research.

Narok South district was chosen because it was assumed that the high and long presence of the disease made the farmers aware of the disease and would respond to the study better than farmers who are not familiar with the disease. It is possible that in an area of low CBPP incidence, the preferred vaccine and vaccination attributes as well as WTP may have been different. Although the results may be limited to Narok South District, the study provides useful information on preferences and WTP and provides a model for CBPP WTP studies in other districts in Kenya and other countries experiencing CBPP as well as for other diseases.

5. Conclusions

The WTP for preferred vaccine and vaccination was high but since there was high level of uncertainty, further WTP studies are needed. About two-thirds and one-third of farmers were willing to pay for the preferred vaccine and vaccination and the current vaccine and vaccination respectively. The inclusion of a pH indicator and absolute safety contributed most to willingness to pay. There is need for formulation of a vaccine and vaccination with the preferred attributes. One-third and two-thirds of farmers would require compensation to allow vaccination of their cattle with the preferred and current vaccine and schedule. However, since the amounts of compensation were high, there should be awareness creation on working of vaccines and persuasion of farmers to vaccinate. Willingness to pay for vaccine and vaccination attributes and for the entire profiles was influenced by various farmer demographics and household characteristics. Vaccination against CBPP was economically worthwhile using all programmes investigated and should be supported for control of CBPP. Among those willing to pay for vaccine and vaccination, nearly half were willing to pay at the calculated cost for publicly administered vaccine. About a quarter were willing to pay this amount for the current vaccine and vaccination. Elective vaccination in which the farmers bear part of or the full cost of vaccination can be allowed for the proportion of farmers that would like to pay and compulsory, fully subsidized vaccination retained for those not willing to pay.

Conflict of interest

The authors declare no conflict of interests. The opinions expressed in this review article are those of the authors and do not necessarily reflect the view of the research sponsors.

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