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Determinants of agro-pastoralists' willingness to pay for improved contagious caprine pleuropneumonia vaccine in Kenya

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Abstract

Animal health care is critical for livestock production especially in arid and semi-arid areas where majority are agro-pastoralists. Contagious caprine pleuropneumonia (CCPP) is a highly contagious and fatal disease which commonly affects goats in arid and semi-arid areas. The government has been the major provider of CCPP vaccine and few large-scale farmers who are licensed and able to purchase directly from the vaccine producer. Although the vaccine is sold to farmers at a subsidized price by the government, its distribution has been characterized by scarcity, irregular and late administration by the authority concerned. It is envisioned that if the willingness to pay for the CCPP vaccine among the agro-pastoralists was high, the sustainability for the vaccine availability and accessibility to everyone will be assured. This study was conducted in Kajiado and Taita Taveta counties where 323 households were sampled; thus, 276 households who were aware of the CCPP were considered for the analysis. Double-bounded dichotomous choice contingent valuation model was used to elicit agro-pastoralists' willingness to pay for the improved CCPP vaccine with new attributes. The model revealed that off-farm income, membership to a group, previous experience on CCPP attack on goats and access to extension services positively influenced households' willingness to pay for the improved CCPP vaccine. The results implied that provision of extension services by the government through promotion of public awareness on CCPP and on the benefit of vaccination will motivate farmers to willingly pay for vaccination services. This can be done through enhanced trainings, seminars and demonstrations to the village level, encouraging formation of groups which facilitates information sharing between agro-pastoralists as awareness and knowledge can drive the demand for the improved CCPP vaccine.

Keywords Contingent valuation, Double-bounded dichotomous choice, Goats, Probability tree diagram, Willingness to pay

Introduction

A large proportion of the African population lives in the rural areas depending on agriculture for food and sale of surplus produce which they use for purchasing other basic needs. This underscores the importance of agriculture as the main contributor to household income, employment and food security. Livestock industry is one of the major contributors to nutrition security through provision of utilizable proteins at the household level (Gunaratna et al. 2019). Despite this importance of the agricultural sector, its full potential has not been realized

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with livestock productivity in most sub-Saharan Africa (SSA) states remaining very low and the progress towards attaining food security and alleviating poverty remaining elusive (Livingston et al. 2011; Otsuka 2013). Furthermore, livestock diseases lead to low productivity, translating to elevated livestock prices, thus exposing farmers to unplanned expenditures; hence, the per capita food production has been declining (Kotir 2011).

In Kenya, rearing of goats and sheep is valued in households as a source of income (Engida et al. 2015). It is estimated that 28 million goats are reared in Kenya with arid and semi-arid lands (ASALs) accounting for 80% of the total flock size (Kipronoh et al. 2016; Nyariki and Amwata 2019). Goats also provide milk, meat, skin, income and social security. The ASALs areas are characterized by low levels of rainfall (average = 400 mm per annum) with frequent prolonged dry spells leading to scarcity of feeds which predisposes livestock to diseases and death (Government of Kenya 2010). The World Organization for Animal Health (WAOH) has listed contagious caprine pleuropneumonia (CCPP) caused by *Mycoplasma capricolum* subsp. *capripneomoniae* (*Mccp*) as an important disease in goats particularly in pastoral areas. Among naïve goats, the morbidity rates can reach 80 to 100% with mortality rates of over 70%, which cause economic losses to farmers and to the goat industry (Abd-elrahman and Khafaga 2019).

Livestock health care services in Kenya over the years have been largely provided by the government with a major focus on high-potential areas while the ASALs lack adequate access (Dickson et al. 2018; Oruko and Ndung'u 2009). Agro-pastoralists' access to the CCPP vaccine has always been characterized by scarcity and untimely administration resulting in huge economic losses due to the death of CCPP-infected goats. Health care services do not only mean vaccines and antibiotics but also extension service providers (who are few in the ASAL region) to disseminate credible information to agro-pastoralists. Extension service providers create awareness which assists in reducing the risk of infectious livestock diseases (Alemayehu et al. 2021). Vaccination is an effective method of controlling CCPP. Therefore, CCPP can be contained, and goat farming becomes more profitable to agro-pastoralists if information on its control and vaccinations are done as required.

The current vaccine (Caprivax TM) is freely provided by the government of Kenya in conjunction with respective county governments. The supply and vaccine administration has been facing some challenges of inadequate supply, delay in distribution, constant power blackouts and poor storage capacity by respective county governments. These bureaucratic processes by county and the national government procurement procedures have been a major hindrance to vaccine access to the final consumers. The study sought to establish a sustainable solution to the challenges experienced with the use of the conventional CCPP vaccine such that if farmers were willing to pay for this service, then it would operate under a normal market mechanism of demand and supply equilibrium. The improved CCPP vaccine (CCPP DIVA) with desirable positive attributes to be produced by Kenya Veterinary Vaccines Production Institute (KEVEVAPI) was planned to be in the market by the end of the year 2022.

The improved CCPP vaccine has a marker (protein) introduced to help in differentiating naturally infected from vaccinated goat using a Latex Agglutination Test which had been developed to detect the two types of antibodies. This was expected to remove market barrier of goat products even in international market as a CCPP sero-positive test result may not mean a natural infection but as a result of vaccination. A strong biosecurity measures should be followed to avoid other animals being infected with the slaughter waste. The other benefit is that the DIVA vaccine being a killed vaccine if commercialized could be purchased by farmers individually or in groups with their independent experts for administration at their convenient time and place without waiting for the bureaucratic process of the government to supply the vaccine and if the national government or county government do not allocate the fund for CCPP specifically they can still access and use the vaccine.

The viability of improving availability and access of the improved vaccine through commercialization will depend on agro-pastoralists' willingness to pay (WTP) for the vaccine. Various studies have shown that consumers are willing to pay higher price premiums for a better product (Kokoye et al. 2018; Maples et al. 2018). It is hypothesized that agro-pastoralists will be willing to pay more for the service if they (agro-pastoralists) believe that a higher utility will be derived from using the improved CCPP vaccine. Maximization of utility means one has to be in a higher indifference curve when consuming a product. This study investigated factors influencing agro-pastoralists WTP for the improved CCPP vaccine specifically by employing the double-bounded dichotomous choice contingent valuation model.

Materials and methods

Study area

This study was based on survey data collected in Kajiado County and Taita Taveta County (Fig. 1). These sites were selected by the project as they were characterized by cross-boundary migration of livestock, existence

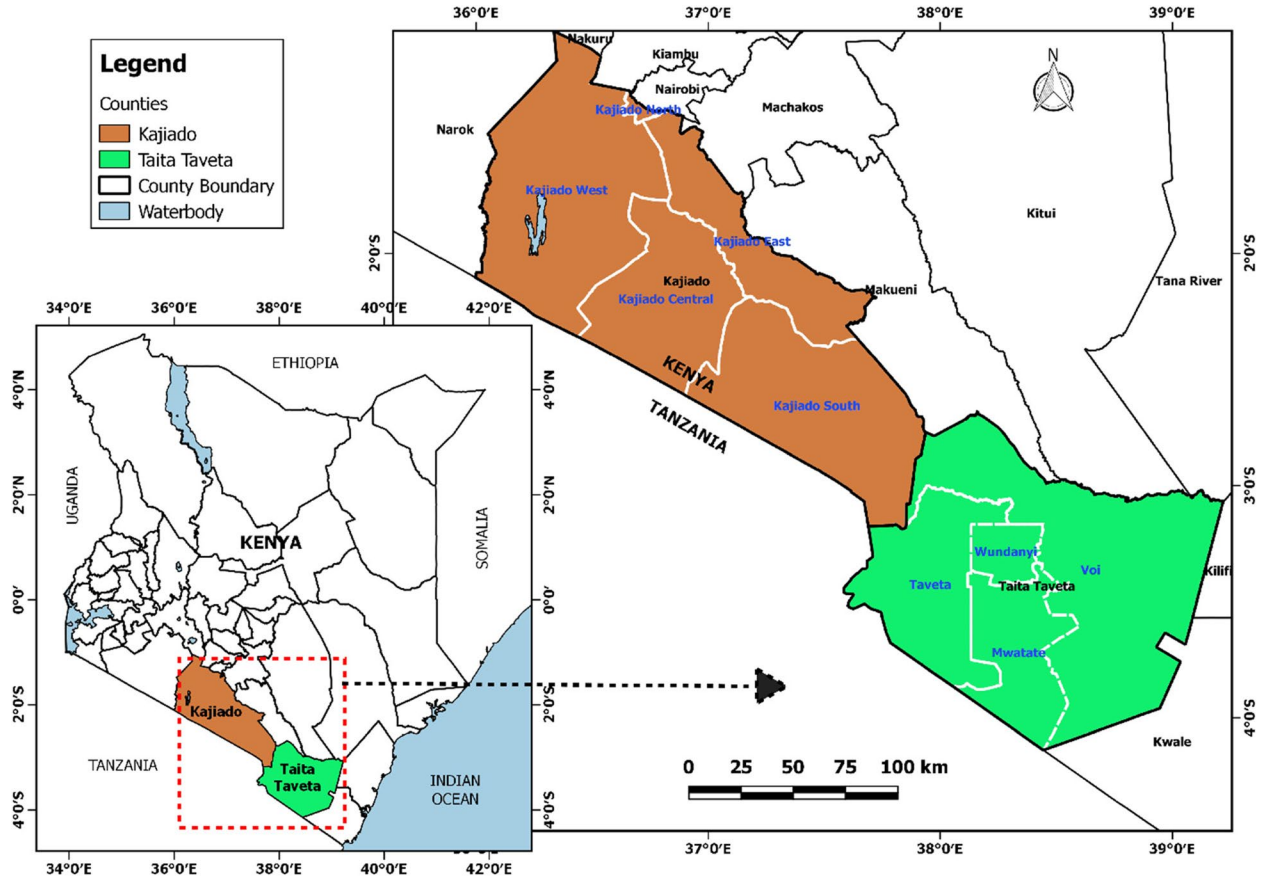

Fig. 1 Map of the study area

of communal grazing and household farmers in these regions are agro-pastoralists. CCPP being contagious in nature and with communal grazing where several livestock share grazing points and watering points, the infected goat could easily spread the disease to others. Uncontrolled movement of livestock from one country to the other due to trade, pasture and water also leads to the massive spread of the disease. In addition, these two regions are CCPP prevalent, and dissemination of the CCPP vaccine had been conducted before for more than 10 years, yet farmers' vaccine adoption rate has been low. Kajiado County has an area of approximately 21,900 km^2 according to the 2019 population census (Government of Kenya 2018a). The area is sparsely populated with high population densities recorded in major towns. The large part of the sub-county is mostly arid and semi-arid and prone to frequent droughts. It receives rainfall ranging from 300 to 1250 mm (Government of Kenya 2018a). Taita Taveta County covers a total area of 17,084.1 km^2 with 10,649.9 km^2 (62.3%) being within Tsavo East and Tsavo West National Parks. Rainfall distribution is uneven and ranges from 265 to 1200 mm (Government of Kenya 2018b).

Sample size determination and sampling procedure

The study used a multistage sampling technique. First, the two counties of Taita Taveta and Kajiado were purposively selected since these areas have in the past been strongly hit by CCPP and at the same time households in the two counties are agro-pastoralists who are sedentary, unlike in other arid and semi-arid counties where farmers move from one place to another in search of pastures, hence making household interventions through projects monitoring impossible. Subsequently in each county, two sub-counties where households keep goats were purposively selected. Simple random sampling technique was used to select two wards per sub-county. From each ward, two villages and the agreed sample of 20 households per village were selected. Villages in build-up areas (urban or peri-urban) were excluded from the lists. Household lists of respondents who had vaccinated their goats against CCPP (adopters) were collected from the sampled

villages by village elders/managers who were familiar with the boundaries and this was tallied by the list from the directorate of veterinary services from the two counties; systematic random sampling method was used to select adopters, while an equal number of non-adopters were randomly sampled from immediate neighbours of adopter as a ratio of one to one. Since the population of households was not clearly known, the study adopted Cochran's (1963) formula where 323 households were sampled. Data were collected from a total of 367 household respondents; data from 25 respondents were dropped due to incomplete responses; this left a total number of 342 respondents to represent the two counties as more is preferred to less. From the data of 342 interviewed respondents, this study considered a total of 276 households who were aware of CCPP for the analysis of WTP for the improved CCPP vaccine. For agro-pastoralists who were not aware of CCPP, the WTP questions were skipped to avoid biasness as they could not be trained on CCPP during the data collection exercise.

Research design

The study used a cross-sectional survey design to determine agro-pastoralists' WTP for improved CCPP vaccine in Kajiado and Taita Taveta counties in Kenya. These two counties are classified as CCPP hotspots due to the high frequency of disease outbreaks.

Analytical framework

Double-bounded dichotomous choice contingent valuation model was used to analyse socio-economic, farm and institutional factors influencing farmers' willingness to pay (WTP) for the improved CCPP vaccine. This model involves creating bid levels where the mean price which farmers/households were willing to pay for the CCPP vaccine is calculated. This method is an improvement of the contingent valuation model in that after the first bid, a second bid is proposed to the respondent. The bid can be higher if the first response is "Yes" or lower if the first response is "No", thus improving statistical efficiency, and is appropriate because it takes into consideration the two responses simultaneously. The initial bid (BI) was decided after a thorough consultation with partners including stakeholders in the study areas. The starting point bias was reduced by giving respondents different alternative initial bids during the pilot study. The second bid was placed on the upper and lower bound because of the respondents' unobserved true WTP (Alberini and Cooper 2000). The bids were presented as BI for initial while BU and BL were for upper and lower bids, respectively.

Four possible outcomes from the double-bounded dichotomous choice were Yy, Yn, Ny and Nn, where Yy implied that both answers were "Yes", meaning the WTP was higher than the upper bid ($BU < WTP < \infty$); Yn first answer was "Yes" followed by "No", meaning the WTP was between the initial bid and the upper bid ($BI < WTP < BU$); and Ny means a "No" answer followed was by "Yes", meaning that the WTP was between the lower bid and the initial bid ($BL < WTP < BI$). Finally, Nn means both answers were "No", meaning that the WTP was between zero and the lower bid ($0 < WTP < BL$). By accepting the first bid, the household's WTP was greater than the bid and if the farmer rejects the first bid, then WTP for the farmer was less than the initial bid. The bids were then tested for appropriateness in a pilot study and biasness was reduced by providing respondents with different alternative initial bids. By adapting Henneman et al.'s (1991) and Ireri's (2017) modelling framework, the probabilities of these outcomes were π^{yy}, π^{yn}, π^{ny} and π^{nn}, respectively. Under the assumption of utility-maximizing household, the formulas for the likelihoods would be expressed as in Eqs. 1 to 5.

$$\pi^{yy}(\mathrm{BI}_i, \mathrm{BU}_i) = \Pr(\mathrm{BI}_i \leq \text{Max WTP} \leq \mathrm{BU}_i) = \Pr(\mathrm{BU}_i \leq \text{Max WTP}) = 1 - G(\mathrm{BU}_i;\theta), \tag{1}$$

$$\pi^{yn}(\mathrm{BI}_i,\ \mathrm{BU}_i) = \Pr(\mathrm{BI}_i < MaxWTP \geq \mathrm{BU}_i) = G(\mathrm{BU}_i;\theta) - G(\mathrm{BI}_i;\theta), \tag{2}$$

$$\pi^{ny}(\mathrm{BI}_i, BL_i) = \Pr(\mathrm{BI}_i > MaxWTP \leq BL_i) = G(\mathrm{BI}_i;\theta) - G(BL_i;\theta), \tag{3}$$

$$\pi^{nn}(\mathrm{BI}_i, BL_i) = \Pr(\mathrm{BI}_i > MaxWTP < BL_i) = \Pr(BL_i > MaxWTP) = G(BL_i;\theta), \tag{4}$$

The distribution of maximum WTP can be expressed as $G(B;\theta)$ which is the cumulative distribution factor (CDF), with parameter vector θ to be estimated. With a sample size of N where B;

$$L(\theta) = \sum_i^N \{d_i^{yy}.\pi^{yy}(\mathrm{BI}_i, \mathrm{BU}_i) + d_i^{yn}.\pi^{yn}(\mathrm{BI}_i, \mathrm{BU}_i) + d_i^{ny}.\pi^{ny}(\mathrm{BI}_i, \mathrm{BL}_i) + d_i^{nn}.\pi^{nn}(\mathrm{BI}_i, \mathrm{BL}_i), \quad (5)$$

where $d_i^{yy}, d_i^{yn}, d_i^{ny}$ andd_i^{nn} are binary-valued indicator variables, where d_i^{yy}= 1 for yes-yes response 0 otherwise, d_i^{yn}= 1 for yes–no response, otherwise 0; d_i^{ny}= 1 for no-yes response, otherwise 0, d_i^{nn} = 1 for no–no response 0 otherwise.

Equation 6 is the final model for analysing the dependent variable WTP on the socio-economic, farm and institutional characteristics.

$$\begin{aligned} \mathrm{WTP} &= B_0 + B_1\mathrm{Age} + B_2\mathrm{Gender} + B_3\mathrm{Educlevel} + B_4 \\ &+ B_5\mathrm{Hhsize} + B_6\mathrm{Goatsize} + B_7\mathrm{ExtAccess} \\ &+ B_8\mathrm{Dstmkt} + B_9\mathrm{Tranno} + B_{10}\mathrm{Grpno} \\ &+ B_{11}\mathrm{Offarminc} + B_{12}\mathrm{Occpt} + B_{13}\mathrm{Site} \end{aligned} \quad (6)$$

Table 1 shows the description of factors theorized as influencing WTP for the CCPP vaccine.

Willingness to pay for improved CCPP vaccine

This study investigated agro-pastoralists' WTP for the improved CCPP vaccine from the sampled counties. Willingness to pay for the vaccine was administered as a game of bid during the study and was made enjoyable to parties, enumerators and the respondents who were goat farmers. Bidding game was first introduced to the respondent by mentioning the attributes of the vaccine before commencing the exercise; this is elaborated in a probability tree diagram in Fig. 2. The initial price of CCPP vaccine dose for the improved vaccine was determined through discussions with local experts including focus group discussions (FGDs) and key informants interviews (KIIs) conducted in the two counties.

Results and discussions

Descriptive statistics on agro-pastoralists' willingness to pay for the improved CCPP vaccine

Table 2 presents the results of the household head's main occupation, gender and education level by WTP. In terms of the gender of the household head, 71% of those willing to pay were male as compared to 29% of female who were willing to pay. Having a male as the head of the household may increase WTP because men may have access to information, land and other resources, which women may lack due to traditional/social barriers. For those farmers who were willing to pay for the improved vaccine, 60% were members of a farmer group. This can be attributed to the fact that a group allows for information sharing among its members, enlightening them on the benefits of various technologies, CCPP vaccine included, and there was a significant difference between agro-pastoralists WTP for the vaccine and those not WTP at 5% significant level.

Table 1 Description of variables used in the study in Kajiado and Taita Taveta counties

Variable	Description of the variables	Measurement	Expected sign
Dependent variable			
WTP	Willingness to pay for vaccine		
Independent variables			
Cnty/Site	County (1 = Kajiado 2 = Taita Taveta)	Binary	±
Age	Age of the household head (years)	Continuous	±
Gend	Gender of the household head (0 = female, 1 = male)	Binary	+
Educlev	Education level of the household head (1 = Illiterate 2 = literate 3 = primary 4 = secondary 5 = post-secondary)	Categorical	±
Farm_Exp	Number of years of keeping goat experience	Continuous	+
CCPP_vadpt	Vaccinated goat in the last 1 year	Binary	+
Hhsize	The number of persons in the household	Continuous	±
Goatsize	Goat herd size	Continuous	+
CCPP_attack	If the herds had been previously attacked by CCPP	Binary	-
Grp_mbr	Membership to a group (0 = No, 1 = Yes)	Binary	+
Trainum	Access to agricultural training (number of trainings)	Continuous	+
Exten_serv	Access to extension services (0 = No, 1 = Yes)	Binary	+
Distmkt	Distance to market centres in (walking minutes)	Continuous	+
Off-farminc	The number of non-farming incomes a household is engaged in	Continuous	+

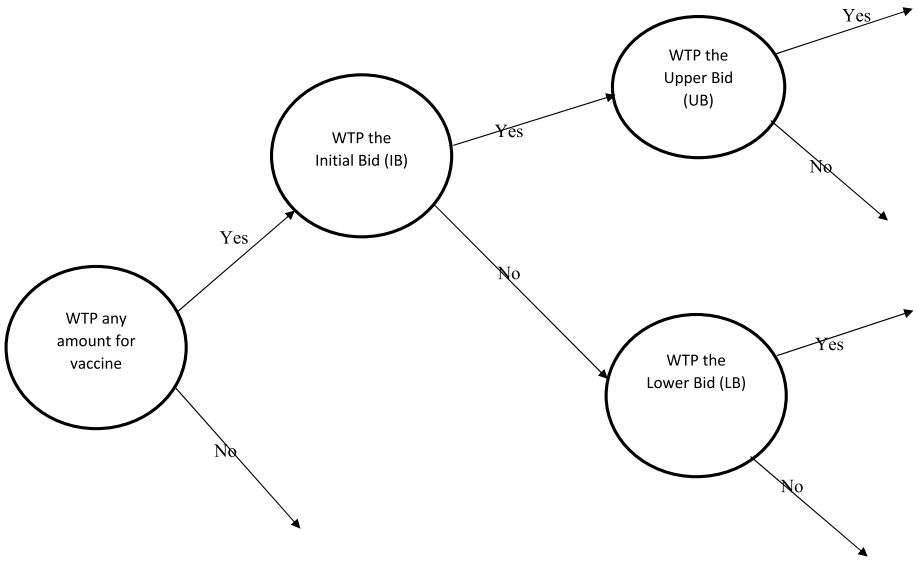

Fig. 2 Probability tree diagram for agro-pastoralists' WTP for the improved CCPP vaccine

Table 2 Socio-economic characteristics of agro-pastoral households determining their WTP for the improved CCPP vaccine (%)

Variable descriptions	Not WTP	WTP	Chi-square
Gender of the household head			
Male	84	71	3.2475[b]
Female	16	29	
Education level of the farmer			
No formal education	30	21	3.7959
Primary	34	38	
Secondary School	23	26	
Certificate level	9	5	
Diploma and University level	5	10	
Main occupation			
Farming (crop + lives)	89	79	4.5363
Salaried employment	0	7	
Self-employed off-farm	7	11	
Casual labourer farms	2	1	
Casual labourer non-farms	2	3	
Group membership			
No	20	40	6.4072[a]
Yes	80	60	
CCPP Experience			
No	24	34	1.2842
Yes	76	66	

[a] and [b] = significant at 5% and 10% level

Probabilities of the outcomes for improved CCPP vaccine

Table 3 shows that 92% of adopter farmers and 83% of non-adopter farmers were willing to pay for the improved CCPP vaccine. Most farmers who were willing to pay for the improved vaccine were from Taita-Taveta County as 95% of adopter farmers and 94% of non-adopter farmers were willing to pay for the improved vaccine while in Kajiado County, relatively less farmers were willing to pay for this improved vaccine, that is why they wanted to practically test for its effectiveness first. Those who were willing to pay were further asked if they could be willing to pay the initial bid of KES 35 per goat dose and (ProbWTP x ProbWTP35) which is (0.88 × 0.54) equals to 48% of agro-pastoralists as shown in probability tree diagram in Fig. 3. A higher bid (KES 40) was given to respondent who were willing to pay initial bid and 67% of farmers were still willing to pay the upper bid meaning they were willing to pay for an even higher amount for the improved CCPP vaccine. Farmers who were not willing to pay KES 35 were given a lower bid of KES 30, and 57% were willing to pay this much as shown in the probability tree diagram in Fig. 3.

Factors affecting agro-pastoralists' WTP for the improved CCPP vaccine

Agro-pastoralists' WTP for the improved vaccine was influenced by some of the individual, farm and institutional characteristics as shown in Table 4.

Table 4 presents factors influencing agro-pastoralists' WTP for the improved CCPP vaccine with coefficient estimates from the double-bounded dichotomous choice model result. The Wald chi-square test indicates that the model's overall goodness of fit was highly significant Prob > chi-square 0.0000 and the Log likelihood of − 335.4098 indicates a strong effect of the model choice. From Table 4, households with other sources of

Table 3 Probabilities of farmers' willingness to pay different amounts for the improved CCPP vaccine

		Taita-Taveta County				Kajiado County				Overall			
		Non-adopters		Adopters		Non-adopters		Adopters		Non-adopters		Adopters	
		N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
Willing to pay some amount?	No	8	6	2	5	9	13	21	21	17	8	23	17
	Yes	128	94	37	95	60	87	77	79	188	92	114	83
Willing to pay KES. 35 (IB)	No	28	22	16	43	34	57	51	66	62	33	67	59
	Yes	100	78	21	57	26	43	26	34	126	67	47	41
Willing to pay KES. 40 (UB)	No	21	21	4	19	18	69	13	50	39	31	17	36
	Yes	79	79	17	81	8	31	13	50	87	69	30	64
Willing to pay KES. 30 (LB)	No	6	21	4	25	19	56	27	53	25	40	31	46
	Yes	22	79	12	75	15	44	24	47	37	60	36	54

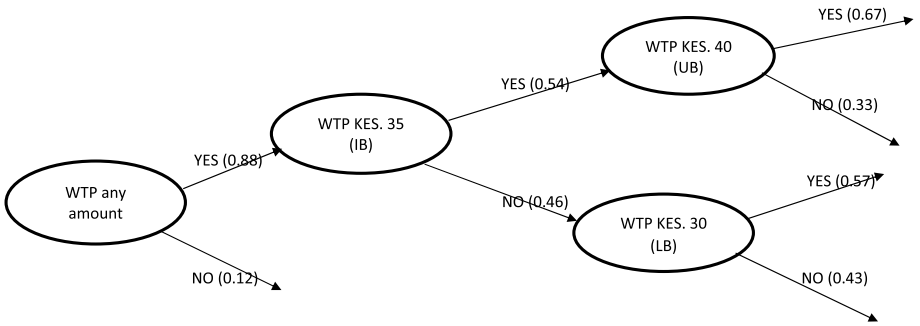

Fig. 3 Probability tree diagram for overall WTP for the improved CCPP vaccine (1 USD = KES 109)

income apart from farming were willing to pay a higher amount for the improved CCPP vaccine compared to those without off-farm income. Farmers with off-farm income had a higher WTP than those who did not have off-farm income. This was positive and significant at 10% level. This was an indication that farmers with other occupations were more likely to afford paying a higher price for the improved vaccine as they get extra income which they could use to improve their goat's health standards. This finding is in line with Dickson et al. (2018) who stated that pastoralists with off-farm income were able to afford several productive technologies for increased output. Previous studies by Akhtar et al. (2019), Jetté-Nantel et al. (2011) and Sarker et al. (2021) also revealed that off-farm income helps farmers to manage risks associated with crops and livestock failure and can influence their decisions to pay or not to pay for certain farm services. This concludes that off-farm occupation with increased income leads to a propensity for improved technologies.

The results also indicate that agro-pastoralists who previously experienced CCPP attack in their goats' herd were willing to pay more for the improved CCPP vaccine than their counterparts whose goats have never been attacked by the disease. A farmers' previous experience of the disease in their herd positively and significantly affected their willingness to pay for the vaccine ($p \leq 0.1$). Agro-pastoralists with CCPP experience are aware of the level of spread and fatal nature of CCPP; hence, they would rather prevent it even at a higher cost unlike farmers whose goats had never been attacked. The previous painful experience of losing goats is a motivation factor for the household to embrace a long-lasting solution to the problem through vaccination. According to Kairu-Wanyoike et al. (2014), farmers who had previous livestock disease experienced as well as negative post-vaccination reactions were able to pay more for improved vaccine with better attributes to save their herds.

Agro-pastoralists' access to extension services positively and significantly influence their WTP ($p \leq 0.05$). Extension services improve farmers' knowledge of the detection of the disease and methods of controlling CCPP of which vaccination is the most effective one. Through extension, information such as positive vaccine attributes was also relayed to farmers making the improved vaccine more attractive, hence improving their WTP amount. Extension services provide credible and reliable information to farmers, and this influences their preferences for a new technology. This result

Table 4 Double bounded dichotomous choice model results showing determinants of willingness to pay for improved CCPP vaccine in Taita Taveta and Kajiado counties

Variables	Coefficients	Standard error
Socio-economic		
Gender	−0.4396	1.2108
Age	0.0748	0.0495
Education level	0.3513	0.4630
Off-farm income	1.8221[c]	1.0232
Farming experience	−0.0519	0.0561
Household size	0.0907	0.1691
Adopt CCPP vaccine	−1.5648	1.0500
TLU	0.5398	0.2823
Experience CCPP attack	2.0765[c]	1.1391
Institutional		
Extension service	2.4376[b]	1.1999
Group membership	2.3171[b]	1.0667
County (Taita Taveta = 1, Kajiado = 2)	−4.9296[a]	1.2344
Constant	40.1338[a]	4.2659
Number of obs = 276		
Wald chi-square (12) = 68.23		
Log likelihood = -335.4098		
Prob > chi-square = 0.0000		

[a], [b], [c] = significant at 1%, 5% and 10% level

concurs with Kairu-Wanyoike et al. (2014) who argued that extension services to farmers provide farmers with adequate knowledge of the disease and benefits of using the vaccine and how it works as well as the right time for vaccination. This knowledge therefore builds agro-pastoralists' attitude and perception positively and amicably willing to pay more for the improved CCPP vaccine.

Membership to a group by agro-pastoralist was positively associated with WTP for a higher amount for improved CCPP vaccine ($p \leq 0.05$). Most farmers who belonged to groups had a higher WTP for the vaccine than those without groups. This is because through groups farmers were able to gain knowledge from one another about management of the disease as they normally share information about crops and livestock. Groups also provide resources for instance credit for farm inputs that a member can use in purchasing vaccine. Wairimu et al. (2016) and Ouya et al. (2020) noted that it is through groups that new technological methods of agricultural productions can appropriately reach farmers as they normally share information and ideas among members.

Agro-pastoralists from Kajiado County were less willing to pay for the improved CCPP vaccine as compared to those from Taita Tavetta County. Farmers in Kajiado and Taita Taveta counties still practise traditional farming methods for instance communal grazing. However, due to the existence of game parks in Taita Taveta County which provide grazing fodder for livestock during dry seasons, most pastoralists from different regions in Kenya especially from North Eastern region make frequent visits to the area. This normally leads to outbreak of CCPP as the disease is highly contagious. It makes goats in Taita Taveta County more vulnerable to the disease; hence, farmers were willing to pay a higher amount for the improved CCPP vaccine than their counterparts from Kajiado County. Kiprono et al. (2016) reported a similar observation while conducting a survey on the risk factors related with CCPP in pastoral areas in Kenya that CCPP sero-prevalence varies in different locations as other areas experience cross-border migration of goats from other countries.

Table 5 Mean willingness to pay for improved CCPP vaccine from the contingent valuation model for Kajiado and Taita Taveta counties

Parameter	Mean estimate (KES)[a]	Std. Err
Mean WTP (without covariates)	33.05	2.41
Mean WTP (with covariates)	33.15	2.36
Estimated mean WTP	36.65	0.49

[a] During the time of survey (I USD = KES 109)

Table 5 shows mean WTP for the improved CCPP vaccine for the two studied counties.

The mean willingness to pay for improved CCPP vaccine from the contingent valuation model without covariates and with covariates for the respondents was KES 33.05 and KES 33.15 per goat respectively. The estimated mean WTP was higher at KES 36.65 per goat. This is illustrated in Table 5 signifying that socio-economic, farm and institutional characteristics influenced positively or negatively farmer's willingness to pay for improved CCPP vaccine. Explanatory variables help in eliminating systematic variance beyond researchers' control which can result in unbiased results as everyone has unique characteristics. Variations between the amount agro-pastoralists are willing to pay for the improved CCPP vaccine per goat depend on these characteristics.

Conclusions and policy recommendations

Agro-pastoralists who were also engaged in off-farm occupation, had previously experienced CCPP attack on their goats' herds, were belonging to a group and had accessed extension services within the last 1 year were motivated positively and were willing to pay high value for the improved CCPP vaccine in Kajiado and Taita Taveta counties. County governments and the

national government should take advantage of these positive characteristics for instance expanding extension services, encouraging agro-pastoralists to form groups where members can be accessed easily. Policies should be formulated to promote other income generating activities in these regions where the locals could earn extra income, thus reducing pastoralism and building a micro-economy block encouraging other investors to invest in these regions. The government through vaccine producers should also perform free trials using the first batch of improved vaccine vials among agro-pastoralists especially lead farmers as this will positively build farmers' perception and preference to the improved CCPP vaccine. Policy should also be geared towards promoting the awareness and knowledge of agro-pastoralists on CCPP and on benefits of vaccinating their livestock should be enforced in the region. This can be done through provision of extension services by enhanced trainings, seminars and demonstrations to the village level; encouraging agro-pastoralists to form groups also facilitates information sharing; this is because awareness is the key to drive demand for the improved vaccine.

Abbreviations

ASALs	Arid and semi-arid lands
CCPP	Contagious caprine pleuropneumonia
FGDs	Focus group discussions
KES	Kenyan Shilling
KEVEVAPI	Kenya Veterinary Vaccines Production Institute
KIIs	Key informants interviews
SSA	Sub-Saharan Africa
WOAH	World Organisation for Animal Health
WTP	Willingness to pay

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Authors' contributions

MM and PN contributed to research proposal writing and overall supervision. All authors travelled to the research sites, participated in enumerators' trainings and supervised data collection exercises; FOO contributed in data cleaning, data management, analysis and article writing. FOO, EB, HL and WAA handled methodology. EB, MM, PN and SM assisted in editing and reviewing the article. The authors read and approved the final manuscript.

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Availability of data and materials

The datasets that support findings of this study are published and available online on https://data.mendeley.com/datasets/8sn5vtxftt. Alternatively one can get the dataset from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

All respondents who contributed by giving the information during the data collection willingly accepted to participate as an informed consent note was developed and included in the survey instrument. Proper introduction on the purpose of the research was adequately relayed to respondents, time the survey was to take and they were set free to stop at any time and ask for clarity or questions.

Consent for publication

All authors read and consented for the article to be published.

Competing interests

The authors declare that they have no competing interests.

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